SmartSOIL

Sustainable farm Management Aimed at Reducing Threats to SOILs under climate change

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Overview and assessment report of decision support tools and knowledge platforms

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Executive summary

The aim of the SmartSOIL project is to contribute to reversing the current degradation trend of European agricultural soils by improving soil carbon management. The project outputs aim to provide an important contribution to the understanding and management of soil carbon in the EU. One of the project's initial objectives was to develop a decision support tool (DST) based on a "simple model" to help identify practices which optimise crop productivity and soil carbon sequestration. Based on the range of different information sought by the farming community and policy makers, it became clear that a combination of different tools presented in the format of a web-based toolbox is more appropriate for the SmartSOIL outputs.

In order to inform the development of the SmartSOIL DST and toolbox, a sample of eight DSTs and seven platforms – targeting sustainable agriculture, soil and nutrient management, and/or climate change – were evaluated to identify key success features as well as problems experienced regarding implementation and use of the DST. In terms of soil carbon management, the review found that only some of the DSTs addressed this issue in small part (mostly in terms of emissions reductions from carbon sequestration due to land use change).

Some overall findings highlight that farmers are reluctant to learn, invest in, and use new tools unless the benefits are clear and documented and outweigh the costs. Thus, DSTs experienced the most widespread uptake when there was some form of external motivation driving use of the tool (e.g., incentives, supply chain requirements, certification schemes, industry guidance and environmental compliance). While there may be some interest due to environmental reasons, most farmers will lack motivation to calculate their soil carbon unless the benefits of soil carbon management are clearly indicated.

User uptake may also be limited (or abandonment may occur) if DSTs are too complex in terms of data or technological requirements, though the latter may become less of a problem as technological proficiency rises. Duplicate entry of farm data is not favourable for target users as it increases the administrative burden and lowers the user-friendliness of the tool's structure. Therefore, a tool which is integrated into existing DSTs and platforms and can use data that has previously been entered would be preferable.

Recommendations for the SmartSOIL decision support tool

In development of the DST, it is important to engage stakeholders/end-users to reveal their needs and demands, which the tool should address in order to be relevant and useful to the target group. It is also crucial to involve experienced researchers and programmers, both in terms of scientific development of the model behind the tool as well as its future integration and dissemination through other DSTs and platforms.

Built upon sufficient and reliable data, the DST should be easy to use and intuitively designed for the target users to understand and effectively utilise the different features. Sufficient guidance and support should be provided, and the tool should be easily accessible e.g., via a website or integrated as an add-on in existing and well established DSTs.

The results and recommendations provided to the user should be useful and comprehensive, and they should be presented in various formats to increase user understanding (e.g., text, graphs, videos, demonstrations, etc.). Uncertainties in the DST's outputs and assumptions made in calculating the results should be revealed to increase the transparency and users' understanding and confidence in the tool.

In order to maintain this relevance and avoid user abandonment, the DST must be continuously updated and supported in terms of current data, evolving user needs, and the tool's software. This aspect of DSTs development, however, depends on continuing capacity, funding, research objectives, etc., which is an important consideration to keep in mind during strategic planning as to the development and dissemination of the tool. Various options for updating, maintaining, and integrating the simple model and/or SmartSOIL DST on a long-term basis will be explored in the course of the project to determine the final set-up of the DST.

Recommendations for the SmartSOIL toolbox

The overall objective of the SmartSOIL toolbox will be to disseminate the relevant results from the project in a format which is easily accessible to different stakeholders and communicates complex scientific findings in a user-friendly manner. A good fit between the information and knowledge available in the toolbox and the needs of target users is a central prerequisite for effective knowledge dissemination and exchange via the platform. As with the DST development, this will require frequent consultation with potential end-users.

The platform should present the resources in a clear, logical structure, which is important for both the individual sections and the website as a whole. The platform's interface should also be designed using an appropriate and attractive format to present the various tools.

Several opportunities are available for integrating different elements of the SmartSOIL toolbox with existing platforms, which can increase dissemination of the research outputs.

Factsheets, farm case studies, technical guidance, videos and audio podcasts as well as search functions are all suitable tools for the SmartSOIL toolbox. Links to already available tools which may be relevant for users could be provided on the website. Blogging and news entries, Twitter, as well as feedback and commenting functions, on the other hand, would only be relevant if the toolbox can be maintained and updated regularly beyond the lifespan of the SmartSOIL project.

Table of contents

Tables

Figures

Boxes

1 Introduction

1.1 Background

The aim of the SmartSOIL project is to contribute to reversing the current degradation trend of European agricultural soils by improving soil carbon management. As a key output, the initial aim of SmartSOIL was to develop a decision support tool (DST) based on a simplified research model to help identify practices, which optimise crop productivity and soil carbon sequestration. The Simple Model would determine what the baseline soil organic carbon (SOC) levels are and predict the response of crop yield and soil carbon storage to change under different management practices, soil type and climate. The DST would then provide recommended practices to improve the SOC content – which could encompass management actions such as conservation tillage, crop rotation, soil cover, crop residue management, and optimal fertiliser application.

Following the first round of consultation with the farming community, farm advisors and policy makers (see Deliverable 5.1), it became clear that a single decision support tool (DST) software based on the SmartSOIL simple model would not be the most appropriate or sufficient approach for the dissemination of project results because the differing needs and expectations of the farming community would not be adequately addressed. The following were identified in the consultation process as the main expectations, questions and needs that the SmartSOIL project should address:

- What are the most cost-effective practices in terms of highest income relative to costs of practice, optimal crop productivity and carbon sequestration?
- What is the link/ relation between agriculture and climate change and the resulting need for/ benefits of increased carbon sequestration?
- What are best practice examples for how to promote a certain practice (i.e. good advisory tools or approaches)?
- How can practices be prioritised in terms of win-wins and trade-offs with other environmental objectives under regional conditions?
- How to determine where to promote a certain type of practice (i.e. where it needs to be geographically targeted to achieve maximum impact; what practices in what farming systems)?
- Visual presentation of the effects of practices (on carbon sequestration and other services) in the short and long-term

- Real life case studies of farmers using certain effective/innovative practices

The range of different information requires a combination of different tools leading to the conclusion that a toolbox approach is more appropriate for the SmartSOIL decision support outputs. The content and format of the SmartSOIL toolbox needs to be carefully defined and developed in order to ensure that it meets the balance between available scientific outputs and user needs, and maximises the usability, legitimacy and credibility[1] of the toolbox (Ingram et al. 2012b).

1.2 Objectives of the review

The aim of this report is to inform the development of the SmartSOIL DST and toolbox through an evaluation of a range of relevant existing DSTs and knowledge platforms. The specific objectives of the report are to:

- Identify the success factors as well as the main barriers to the development, implementation and usage of DSTs and knowledge platforms based on a literature review as well as a detailed analysis of a sample of DSTs and knowledge platforms
- Evaluate in more detail elements and tools (functionalities) used by the sampled DSTs and knowledge platforms, in particular in terms of which design increases the usability, credibility and user uptake
- Examine to what extent the existing DSTs and knowledge platforms address the issues of soil carbon management
- Identify types of tools (and their characteristics) that could be applied by the SmartSOIL toolbox
- Identify opportunities to link (feed in) SmartSOIL findings and toolbox with existing DSTs and/or knowledge platforms

The structure of the report is as follows. Chapter 2 explains the methodology used in conducting the review, including the choice of the sample and the types of criteria that were applied. Chapter 3 outlines the findings of the DST review, whereas Chapter 4 focuses on the results of the review of knowledge platforms. Chapter 5 concludes by outlining the implications of the review for the development of the SmartSOIL toolbox.

[1] In other words, the toolbox is accepted by users as providing useful and trusted information in a format that is suited to their needs.

2 Methodology

2.1 Multi-criteria analysis of decision support tools

A desk-based review was conducted to identify available decision support tools (DSTs) for agricultural production and soil management. A list of over 60 DSTs was compiled, five categories based on the tools' different focuses: 1) Farm GHG emission calculator, soil carbon management, climate change mitigation; 2) Fertiliser calculation/Nutrient management; 3) Agricultural pollutant management (and contamination); 4) Soil and livestock management, agricultural production and crop growth in general; and 5) Nature protection in agricultural areas.

Eight out of the 66 DSTs were selected for further analysis, taking into account the findings of the desk-based review, comments from the stakeholder consultations under SmartSOIL Task 5.1, and recommendations from the SmartSOIL consortium partners. In particular, DSTs that are available free-of-charge to the public were selected (with exception of the DLBR Mark Online tool). The selection was also restricted to DSTs that have been implemented in the EU (apart from OVERSEER), provide good-practice examples, and include a feature to calculate GHG emissions or soil carbon sequestration[2].

The sample included the following DSTs:

- Cool Farm Tool – Unilever (UK), http://www.coolfarmtool.org
- CALM (Carbon Accounting for Land Managers) (UK), http://www.calm.cla.org.uk/
- Farmscoper (UK), http://www.adas.co.uk/Home/Projects/FARMSCOPER/tabid/345/Default.aspx
- Humus balance calculator (LIZ Humusbilanz) (DE), http://www.liz-online.de/gi/dueng/liz-humusbilanz.htm
- CPLAN – Carbon Footprint Calculator (UK), http://www2.cplan.org.uk/
- OVERSEER for on-farm management and decision support (NZ), http://www.overseer.org.nz/Home.aspx
- DLBR Mark Online (DK), www.planteIT.dk
- Farm Carbon Calculator (UK), http://www.climatefriendlyfood.org.uk/carboncalc

[2] With exception of the DLBR Mark Online tool, which focuses on field operation planning and documentation, including irrigation, fertiliser, and pesticide management.

A multi-criteria analysis (MCA) was chosen as the method to analyse each DST separately, drawing from the methodologies of Whittaker et al. (2013) and Hall et al. (2010). Criteria for the MCA were also selected based on results from the stakeholder consultations and a literature review. The criteria defined for the MCA were organised by category: 1) General information, 2) Focus, outcome and methodology, 3) User-friendliness, 4) Quality of results, 5) Accessibility, and 6) Implementation process and impact. An Excel spreadsheet template was created with a row for each criterion, providing full explanations of how the DST met (or did not meet) the criterion, and an evaluation (if relevant) of the DST according to that criterion (e.g., no/not sufficient/sufficient/good). Table 1 below outlines the different criteria used to review each DST.

Table 1: Criteria used in the Multi-Criteria Analysis separated by category

Criteria	Sub-Criteria	
General information	• Country of origin • Authors/Developers/Institute • Website • Language of the DST • Year the DST was published or released • Tool type (e.g., GHG emission calculator, lifecycle analysis (LCA) tool, nutrient loss calculator)	• Interface (e.g., web-based, Excel spreadsheet) • Assessment level (e.g., farm, county-wide, catchment, regional, national) • Geographic coverage (e.g., global, region of countries, nation) • Greenhouse gases covered • Practices covered
Focus, outcome and methodology	• Description • Target group/users • Aim of the tool and results • Drivers/funders of the tool	• Concrete outputs delivered • Methodology and database • Design of the tool
User-friendliness	• Ease of use/Intuitiveness • Administrative burden • Flexibility of inputs	• Adaptable to different users/scopes • Support/guidance
Quality of results	• Informative/usability of results • Transparency	• Comprehensive/accurate results • Up-to-date nature of results
Accessibility	• Free of charge • Technological requirements	• Expert knowledge required
Implementation process and impact	• Uptake by target group • Integration or add-on potential • Process of tool development (e.g. participatory approach, including feedback from farmers)	• Problems experienced • Impact • Success features (and lessons learned)

The DSTs were evaluated based on the reviewer testing the tool and forming an expert judgment as to how well the DST met the criteria. A full literature review of sources analysing each tool was also performed. Finally, interviews were conducted with the DSTs' developers, funders, and expert users to answer lingering questions and provide personal experiences as to the tools' functioning.

Based on the different sources of information and practical experience, the initial reviewer indicated a preliminary qualitative rating for the following criteria: ease of use/intuitiveness, administrative burden, flexibility of inputs, adaptable to different users/scopes, support/guidance, informative/usability of results, transparency, comprehensive/accurate results, up-to-date nature of results, technological requirements, expert knowledge required, uptake by target group, integration or add-on potential, problems experienced, and impact.

Below is an example of the qualitative ratings/scoring assigned to the various criteria:

Problems experienced – each tool was reviewed for any problems experienced. The DST was rated as having: 'few problems = 3', 'some problems = 2', or 'several problems = 1'.

reviewer's preliminary ratings, and agreed upon a final rating for each MCA criterion (see Annex).

The highly ranked, as well as the problematic, criteria from the overall DST review were assessed and the results are provided in Section 3. It is important to note that this review was conducted to identify examples of how different DSTs are structured and focused in order to inform and feed into the development of the SmartSOIL soil carbon management DST. Therewith, the scoring results of the DSTs (see Annex) are not envisaged to be summed up into a total value and in addition, do not necessarily allow for the conclusion as to whether a DST is performing 'good' or 'bad'.

2.2 Multi-criteria analysis of knowledge platforms

A knowledge platform most generally can be understood as "a technology package that integrates a number of tools available in the marketplace (for purchase or for free) that one can acquire, install or rent, which is then tailored for the use of a targeted user group" (Wenger, White & Smith 2009, in Hammill, Harvey and Echeverria (2013)). In the context of this report, a platform is understood more specifically as a website containing different tools (functionalities) that enable the exchange of knowledge on the topic of sustainable agriculture and climate change.

One of the principal aims of the SmartSOIL toolbox will be to effectively facilitate the exchange of the specific knowledge produced by the SmartSOIL project but also more broadly knowledge on soil carbon management by establishing a knowledge platform and cross-link this platform with relevant existing websites and initiatives so as to optimise its reach. In order to achieve this aim, it is important to build on best practices in knowledge exchange and dissemination and to provide a review of opportunities for cross-linking the SmartSOIL platform with other platforms. Therefore, the second step of the research involved a multi-criteria analysis of a sample of the most relevant knowledge platforms.

The platforms were selected to ensure that a range of relevant platforms were sampled, using the following criteria:

- Platforms were already well established and visible
- They have a similar or possibly overlapping target audience as for the SmartSOIL toolbox
- Content of the platform focuses on sustainable agriculture, soil management and/or climate change
- Platform is established in Europe (with the exception of the FAO platform)

The sample included the following platforms:

- Farming for a better Climate (UK), http://www.sruc.ac.uk/climatechange/farmingforabetterclimate/
- Farming Futures (UK), http://www.farmingfutures.org.uk/
- LEAF (UK); http://www.leafuk.org/leaf/home.eb
- Food Climate Research Network (UK), www.fcrn.org.uk
- FAO Platform (global), http://www.fao.org/tc/exact/sustainable-agriculture-platform-pilot-website/en/
- Landbrugsinfo (DK), https://www.landbrugsinfo.dk/
- Adaptation platform (EU), http://climate-adapt.eea.europa.eu/

The following aspects were examined when reviewing the platforms:

- Authors and funding source
- Geographic focus and topics covered
- Structure of the website
- Tools and functionalities used (including interactive tools)
- Links to other initiatives / websites
- Funding opportunities for farmers
- Opportunities to link in with the SmartSOIL toolbox

3 Review of decision support tools

3.1 The potential of DSTs

Very often there is no easy way for decision makers to access the information available from the scientific research, so many of the decisions are made with inadequate or incomplete datasets (Elhag and Walker, 2011). Decision support tools (DST) often aim to address stakeholder needs (e.g., ranging from land users, advisory services, and enterprises to policy makers at different levels) and questions by providing appropriate information and data to help stakeholders make an evidence-based and tailored decision. Those needs and questions often tackle different factors, relationships, and processes and therewith require a very complex view and approach to analyse the problem and provide useful recommendations. In the exemplary case of identifying needs of regional managers and farmers in order to develop planning strategies that achieve maximum socio-economic and eco-environmental benefits, powerful decision-making tools are needed to analyse comprehensive background information and simultaneously to satisfy multi-period, multi-objective, and multi-user requirements (Denzer, 2005).

In the area of agriculture the literature identifies the following needs addressed by DSTs:

- **Planning needs of regional managers and farmers** (social, economic, and environmental variables concerning these user groups) in order to develop planning strategies that achieve maximum socio-economic benefits and eco-environmental quality on a macro scale through the optimisation of synthetic systems at the country level (Booty et al., 2009)
- Portfolio analysis system for farmers providing **guidance for individual investment decisions** (acting to optimise individual economic behaviours, such as how much of which crop to plant with attention to income and expenditures) (Denzer, 2005)[3]
- **Lack of agricultural competence** (Canillas and Salokhe, 2002) in specific areas[4] and
- Carrying out **mandatory monitoring requirements** correctly to ensure consistent data entry, data sampling collection, and minimise human-induced errors (Booty et al., 2009).

[3] E.g., farmers value interventions that help them to respond to challenges and opportunities arising from climate variability, given the challenges posed by change and uncertainty (Hochman and Carberry, 2011).

[4] E.g., allow land managers to predict soil quality following different management practices and help farmers and land managers to assess the likely effects of future management changes on soil quality, helping support on-farm management decisions (Lawrence et al, 2010).

“Web-based decision support systems are also playing an important role in **dissemination of technology transfer** related to crop management practices, irrigation scheduling, fertilizer application, etc.” (Mir and Quadri, 2009, p.383).

However, in designing DSTs to address one or multiple of the above issues, “the DST not only has to be developed, but also has to be taken up by the agricultural community and used” in order to maximise the return on investment in scientific research (Shepherd and Wheeler, 2010, p.193). For example, the return on investment can be measured by the improvement in environmental quality or the improvement in productivity of the agricultural sector (Shepherd and Wheeler, 2010).

The accuracy of results depends very much on the complexity of the topic, the amount and quality of data underlying the DST, the methodology and logic behind its outputs, as well as the data required from the user. Even if the results from a DST are not always highly precise, they can provide a rough indication on trends and developments and therewith help the user in the decision-making process. In the end, however, it often remains unclear what impact the DSTs actually have on the ground and to what extent they contribute, for example, to the changes in soil management.

As illustrated in the figure below, there are different phases (including different steps) to development and implementation of a DST. Analysing each phase and step on the basis of existing DSTs helps to clearly identify success factors and challenges in this process, which will inform the development of the SmartSOIL DST.

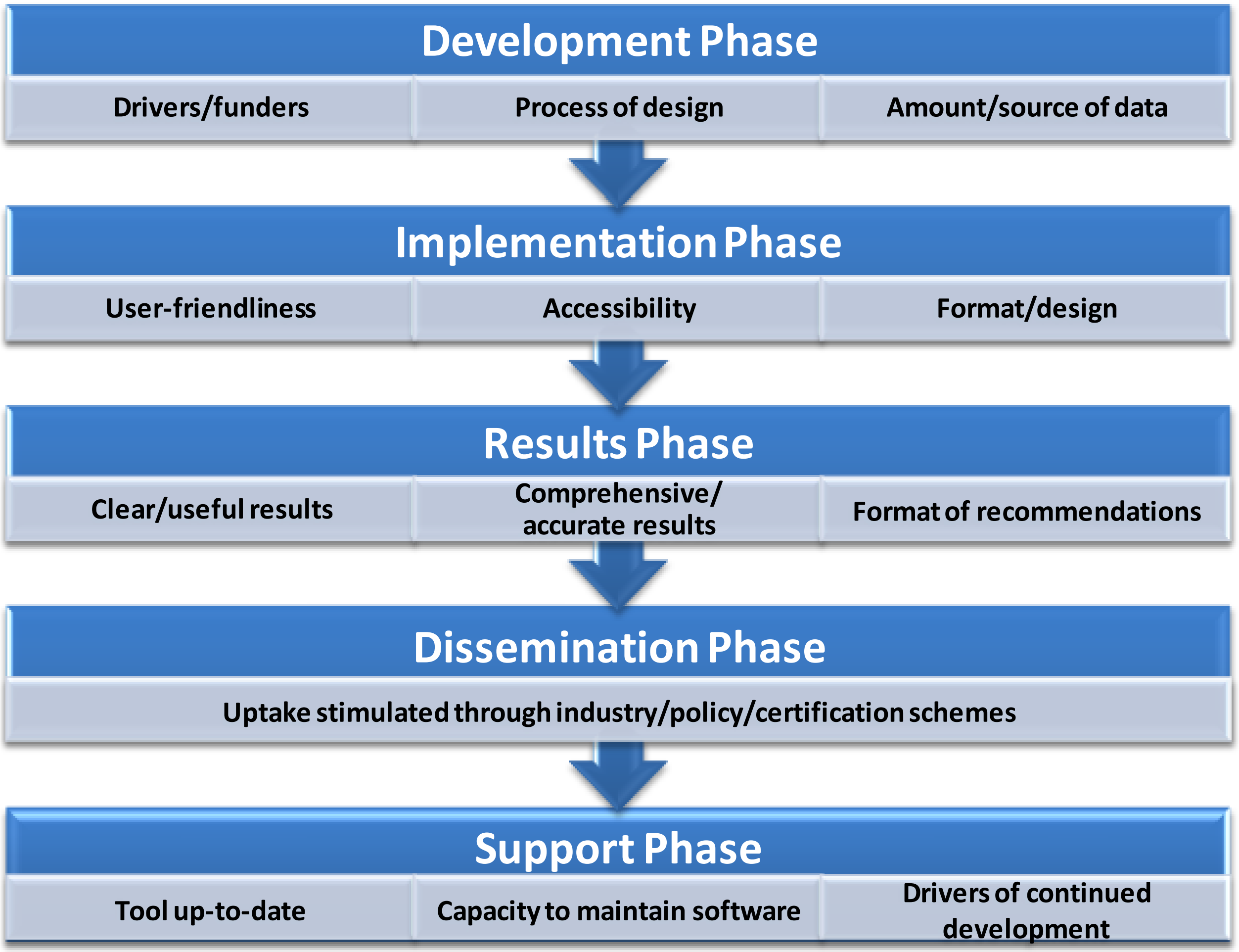

Figure 1: Phases of DST development and implementation

3.2 Overview of analysed DSTs and their link to soil carbon management

The DSTs included in the review have a variety of focuses, ranging from carbon calculators to nutrient budgets to pollutant loss calculators. They also varied in terms of target users, the driving forces behind their uptake, and how new/well established they are. The eight DSTs that were reviewed are briefly described below in Table 2.

Table 2: Description of the decision support tools reviewed

Tool	Description
1. Cool Farm Tool – Unilever (UK)	The Cool Farm Tool is a free, open source GHG calculator for farmers, as well as supply chain managers and companies, to measure the carbon footprint of crop and livestock agricultural products. The tool allows users to experiment with the different inputs to see how changing management practices would affect the

	farm's GHG emissions, which may be used to determine feasible mitigation methods for implementation (Kissinger, 2012).
2. CALM (Carbon Accounting for Land Managers) (UK)	The CALM calculator is activity-based, calculating the balance between annual emissions of carbon dioxide, methane and nitrous oxide and carbon sequestration (carbon stored in soil and trees) associated with the activities of land-based businesses (Denef et al., 2012; CLA, 2013). Developed by the Country Land & Business Association (CLA) for UK farms, the tool also highlights potential mitigation options for reducing the farm's emissions and improving efficiency (Little and Smith, 2010).
3. Farmscoper (UK)	Farmscoper is a DST used to calculate diffuse agricultural pollution from farms based on UK data of representative farming systems (Gooday and Anthony, 2010). An optimization process is performed by the tool to produce combinations of mitigation options, which evaluates the cost of implementation and the effectiveness of the mitigation method at reducing pollution (Gooday et al., forthcoming; Zhang et al., 2012).
4. Humus balance for cropland (DE)	The LIZ Humusbilanz or Humus balance for cropland DST is a free, open source organic carbon (humus) calculator for the entire farm. The tool aims to recognize changes in the humus layer balance per crop year for farmers, including inputs from livestock (manure), in order to target management responses or changes to maintain the site's productivity (LIZ, 2013).
5. CPLAN – Carbon Footprint Calculator	The CPLAN v.0 is a free online GHG calculator (another version (v.2) is available for a more detailed estimation of a farm's GHG emissions, but users are charged per calculation). The tool produces an average estimation of carbon equivalent emissions and removals based on farm-specific data, with the results table showing a breakdown of emission levels for different parts of the farm (Soil Association; Smith et al., 2010).
6. OVERSEER for on-farm management and decision support (NZ)	OVERSEER® is a nutrient budget calculator that estimates the annual average nutrient use efficiency of Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), and Sodium (Na) within a farming system (MPI et al., 2012). The tool calculates a farm's nutrient losses, resulting from run-off, leaching, and greenhouse gas emissions, from which 'hotspots' posing potential environmental risks can be identified (OVERSEER, 2013).
7. DLBR Mark Online (DK)	The DLBR Mark Online is a Farm Management Information System that includes various DST modules, such as irrigation management, field operation planner, and documentation and verification of pesticide and nitrogen use to regulatory authorities. It offers a comprehensive database into which a farmer can input and store data on cropping history, inputs, soil conditions, among other farm-specific information (DLBR, 2013).
8. Farm Carbon Calculator (UK)	The Farm Carbon Calculator (previously Climate Friendly Food) tool is a free farm management tool that calculates GHG emissions and carbon sequestration from organic farming activities to encourage changes in practice to reduce carbon footprints (Farm Carbon Calculator, 2013). The DST, designed by farmers for farmers, offers estimates of cost savings and advice on how to minimise carbon emissions (Denef et al., 2012).

Soil carbon management is only addressed by half of the analysed DSTs and refers mainly to soil carbon sequestration through land use changes as one feature to calculate GHG emissions. The CFT estimates the amount of kgCO2-eq accumulated and sequestered through above- and below-ground biomass based on the user's inputs regarding land use change, management change, and trees or bushes added or removed on-farm. CALM provides GHG calculations for emissions released from land use change and other on-farm activities and balances them against stored carbon in soil and trees. CPLAN also provides data entry boxes for land use changes in the form of "woodland/moorland to farm grass", "woodland/moorland to arable", "farm grass to arable" conversions, as well as the inverse of these three categories. Based upon the user's information, such land use changes would signify either a rise in emissions through decrease of above- and below-ground biomass or tillage for arable production, or overall emissions would fall as users move toward land uses that cause fewer emissions and sequester more carbon (e.g., woodlands/moorlands).

The only tool that focuses solely on soil organic matter is the LIZ calculator, which aims to determine the humus carbon balance on cropland and recognise negative changes in the humus situation at an early stage. The user enters his or her farm data regarding crops planted, number of hectares, organic fertiliser added, and tonnes of crop residue incorporated per hectare, and the tool calculates the humus carbon balance in kilograms per hectare of soil.

In addition to the fact that soil carbon management is often not represented in existing tools, a link between land management and cost-effectiveness of measures is often missing (except for Farmscoper).

3.3 Development phase

The **rationale and drivers** behind the development of new DSTs can be manifold and reflect different stakeholder needs and demands as well as interests of different actors, who stimulate and provide funding for the development of DSTs. The analysed DSTs are aimed at:

- **Improving product marketing** and a company's image in terms of Corporate Social Responsibility by calculating and reducing the emissions profile of products and/or offering low-carbon food certification (e.g., the Cool Farm Tool, which was funded and promoted by private multinational companies, or the Climate Friendly Food initiative (Farm Carbon Calculator), which was stimulated by the NESTA's Big Green Challenge[5]);

[5] £1 million challenge prize designed to stimulate and support community-led responses to climate change.

- **Raising awareness** of climate change and the role of agriculture among farmers, empowering them to be able to calculate their own emissions, and encouraging them to take actions to reduce their emissions (such as CALM, whose development was enhanced by private and public organisations; CFT, which was created by a private company and university researchers; and CPLAN, which was developed by farmers / farmer consultancy);
- **Supporting enforcement of legislation** such as Farmscoper, which aims to lower the amount of diffuse air and water pollution from agriculture in accordance with European and national policy requirements and whose development was stimulated by the environmental ministry (DEFRA);
- **Providing a reporting tool,** e.g., to support compliance with environmental legislation (DLBR Mark Online) or to achieve an efficient use of nutrients and mitigate nutrient loss and pollution (the OVERSEER tool calculates nutrient and GHG budgets – supported by the Ministry of Agriculture and Forestry, research institutes, and industry).
- **Identifying environmental, resource and efficiency challenges/shortcomings,** e.g., to help maintain an optimal humus content on cropland, the LIZ tool detects negative changes in the humus balance at an early stage so that farmers can react appropriately and apply sustainable soil management practices – the DST was developed by an agricultural information service.

DSTs might also pursue more than one aim and will, for example, raise awareness for climate change issues while also encouraging action and strengthening compliance with regulations, policy targets, and more sustainable farming or low-carbon practices.

These results also reflect the findings from Colomb et al. (2012) classifying the aims of DSTs as: awareness raising (to inform farmers and farming consultants on climate change and its link with agriculture); reporting (to analyse specifically the current situation to make comparisons between countries or farms); project evaluation (by comparing a baseline to a “with project” situation); and providing product and market-oriented information (calculating GHG emissions per product).

The **definition of the target group** anticipated to use the DST is closely linked to the different aims of the tool. In the majority of cases, farmers and farm advisors are expected to use the DST since they work on the farm level and are able to have an impact on the GHG, nutrient, and soil carbon balance by adopting the respective soil management practices. Therefore, it is very important to define and **involve the end users** (beneficiaries) in the conceptual phase, incorporating frequent feedback loops from the very beginning (Mir and Quadri, 2009). If farmers are the anticipated beneficiaries, for example, it is necessary to analyse what are their important decisions and how do they approach those decisions, rather than analysing how researchers would approach the problem (Keil et al., 1995). It is therefore essential to work closely with the beneficiaries, thus fostering ownership and personal investment in the DST, which increases the likelihood it will be used. Mir and Quadri (2009) suggest including a researcher who knows something about DSTs and a programmer who knows something about the real-world problem being addressed by the DST along with participation by focused end-user groups in order to develop a 'usable' decision support system.

However, the literature also says that "the involvement of different groups expressing different priorities and views of the problem can complicate the selection of criteria and their evaluation. Criteria evaluations are translated into sets of relative weights that allow for trade-off between factors and that might heavily influence the final outcome. Thus, special care must be devoted to transferring a sufficient level of knowledge to the local actors involved in the process and the social aspects of the issue should be taken into consideration" (Dragan et al., 2003, p.866).

As revealed by the DST analysis, **different approaches for participatory development processes** were applied. Most commonly, the developers held workshops and conducted testing phases throughout the development process, which served to elicit feedback on the usability of the interface, the veracity of the results, and the viability of the mitigation suggestions (cost and practicability) (e.g., Farmscoper, CALM, CFT). However, there seems to be a trend to start with a science-based model and/or scientific assumptions in developing the first tool prototype and then consult the target group, namely farmers and farm advisors, at a later stage to test the prototype. Feedback from the user group does not only help to adjust and modify the DST (in terms of design, results, and visual presentation), but also to complement missing data and information, to conduct thorough improvements of particular sections, and to improve the user-friendliness for greater potential uptake of the tool. In general, the literature and developer interviews suggest that involving end users in the process of development rather than retroactively can potentially avoid DSTs that are scientifically robust but not useful due to low user-friendliness.

However, DSTs differ in terms of complexity, so the importance of involving users in development may not be as necessary for very simple tools. In the case of the LIZ Humus calculator, the development did not include any participation of third parties. Given the very simple calculation method and its ability to provide evidence for the humus carbon balance required by legislation, however, no negative impact on the adoption of the tool has been noticed. There was positive feedback from users highlighting that only a few steps are needed to get to the results.

The **methods and data sources** underlying the DSTs vary. Their parameters or system boundaries are based on country-specific datasets and/or farm-specific data inputs, national GHG emissions methodologies, IPCC Tier 1 or Tier 2 approaches, as well as peer-reviewed and non-peer-reviewed research carried out over many years. In some cases data on agricultural management practices is simulated using a large sample of representative farm types (e.g., the Farmscoper tool is parameterised based on multiple UK-scale spatial input datasets). Whatever method or data source is used, the DST developers should provide sufficient information for the user and, if possible, access to the assumptions and process behind the calculations and recommendations made (discussed further in Section 3.5 in terms of transparency of the results).

3.4 Implementation phase

User-friendliness

In the implementation of DSTs, user-friendliness is one of the key design features that should result from the development phase (described above in Section 3.3). The literature review of various DST analyses emphasised the importance of user-friendliness (McIntosh et al., 2008; Nguyen et al., 2006; Robinson, 2004; Freebairn, 2002). Hall et al. (2010) designed its multi-criteria analysis to include "usable" as one of six themes of criteria for analysing GHG tools in Scotland. The methodology states that to be usable, "tools should be easy to access and understand". Building on that methodology, Whittaker et al. (2013) performed an analysis of various carbon accounting tools for UK arable crops and identified "user friendly" as one of four criteria to assess the DSTs. In order to achieve the success factor of "Design for ease of use", McIntosh et al. (2011) offer the best practice recommendations that DSTs should be designed with "user-friendly interfaces based on elucidating the user's needs and capabilities" and be "adaptable to different types of users, based on their knowledge/expertise".

The SmartSOIL DST review drew from these examples to develop its own user-friendliness criteria. DSTs were rated positively if they were easy to use, intuitive, low in administrative burden, flexible in terms of inputs required, adaptable to different users/scopes, and provided support/guidance. Some findings as to what constituted user-friendly DSTs are outlined below.

- **Easy to use and low administrative burden:** The review identified the web-based tools, including CALM, CPLAN, LIZ, and Farm Carbon Calculator, as being very positive in terms of "Ease of use/Intuitiveness" and "Administrative burden". Since these tools are easy to use and relatively simple, less "Support and guidance" is required and provided.

- **Multiple types of support and guidance provided:** The tools CFT, Farmscoper, DLBR Mark Online, and OVERSEER demonstrated multiple different options for support and guidance to users completing the DST, which becomes more necessary as tools become more complex in data requested and results provided.

- **Flexible tools facilitated data entry by providing users with input options:** The CFT provides multiple different options for data entry, e.g., drop-down menus, default values, suggested ranges, and exact values. DSTs were not considered user-friendly (in terms of flexibility in handling inputs) if the only option provided is to enter farm-specific numeric values (e.g., CPLAN).

- **DSTs' user-friendliness increased if the tool still functioned regardless of the user or scope of inputs:** The CFT, CALM, Farmscoper, and CPLAN were rated highly in "Adaptable to different users/scopes" because they still function even if all data sets are not complete. DSTs should minimise the occurrence of error messages due to a lack of recognised values and allow results to be generated.

Box 1: CALM tool as example of a DST with a high degree of user-friendliness

The CALM tool was rated positively in terms of overall user-friendliness. It is easy to use and intuitive with a step-by-step guide to help the user navigate the calculation process. The CALM tool also has a very low administrative burden, which the literature revealed should take only 30-45 minutes to complete if the user has the information available. The tool functions and generates results even if the user does not complete every section – rather, farmers can simply fill out the calculation sections that are relevant to or desired for their farm. Support is also provided to the user for each category of farm emissions underneath the heading, as well as initially as the user is creating a farm and saving different calculations. (See below for an example of the CALM Calculator report.)

Calculation: Test1

Whole Farm

Crops and grass

Field	CO2 (Kg)	Methane (Kg)	Nitrous Oxide (Kg)	CO2 (tonnes) equivalent
Oilseed Rape NOTES: Oilseed rape residues			0.00	0.000
S Barley NOTES: S barley residues			0.00	0.000
Potatoes NOTES: Potato residues			0.00	0.000
TOTAL				**0.000**
SECTION TOTAL				**0.000**

Calculation Test1 - total: 0.000 (tonnes CO2 equivalent)

Accessibility and technical requirements

In the SmartSOIL review, all but one of the DSTs were offered to users free-of-charge. The DLBR Mark Online tool requires users to pay a one-time fee and annual service charge – covering regular improvement and update of the system and its components (e.g., compliance with changing environmental legislation) and including a hotline service. If the tool is very useful and relevant to regulatory compliance schemes, for instance, the fact that the user must pay for the DST may not necessarily impact its uptake (e.g., very large uptake of DLBR Mark Online by Denmark's arable farmers), but it may restrict the user group and exclude smaller farmers for example.

Accessibility was also reviewed based on the "Technological requirements" of the DSTs. The tools were rated "Low (3)" if they were web-based and can be directly accessed via the developer's website, requiring only a computer and internet. The "Medium (2)" rating was applied if the DST required something to be downloaded from the internet (e.g., standalone Excel files). The tools were rated "High (1)" if they required some type of special programme or software to function.

The DST review found that half of the tools had "Low" technological requirements (CALM, CPLAN, LIZ, and Farm Carbon Calculator), and the remaining DSTs were rated as "Medium" (CFT, Farmscoper, DLBR Mark Online[6], and OVERSEER).

The fact that some DSTs must be downloaded could be a barrier for users with very low computing skills. In extreme cases, online registration to access either a web-based or downloadable Excel version of the tools could be burdensome or prevent some users from accessing the tool, especially those who may not have an email address, which is required for some registration processes. However, providing DSTs in an electronic format allows materials to be kept up to date and farm-specific models to be generated and experimented with based on the user's data inputs. Moreover, farmers may have the opportunity to import farm data from an already existing farm register (in electronic format).

The CPLAN v.0 tool is an example of a DST that was reviewed as being very accessible overall. It is a single webpage into which users enter data for calculation of GHG emissions. No download or registration is necessary. The user simply enters information into the boxes and the results are immediately shown below in a small table. This format is accessible to any user and has very low technical requirements.

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[6] The DLBR Mark Online is noteworthy as a central database driven tool, the .NET smart client programme, which is a downloaded by the user the first time and automatically checks for updates via internet every time it is opened.

Another criterion by which accessibility was determined was "Expert knowledge". The DSTs were reviewed based on the target users of the tool. If the tool was indicated to be user-friendly for farmers, advisors, and policy makers, for instance, feedback was analysed to determine whether expert assistance was necessary for the target users to effectively use the tool. The reviewer also tested the DST to determine whether a non-expert user would be able to understand, complete, and interpret the tool.

Farm Carbon Calculator provides an example of a tool that was clearly intended for organic farmers as target users, and it scored highly since expert knowledge or assistance was not required. Tools were rated lower if information derived from the literature and interviews indicated that farmers need advisory assistance to effectively complete the tool.

For DLBR Mark Online, farmers are one of the target users of the tool but they can (and often do) authorise access to their farm-specific data for an advisor to help with use of the planning and regulation tools. Some farmers claim the system is rather complex, while the advisors (using the system on behalf of the farmers) want increasingly detailed calculations and features. The structure of the program thus reflects the rather complex nature of national and EU rules and regulations which farm management operations have to comply with (e.g., it produces a warning if an unauthorised pesticide or a certain level of nitrogen is selected).

Format and design

DSTs should be designed in a way that promotes "user-friendly interactions between the complicated model and the non-technical user" (Narayanan et al., 2000). DSTs are not useful if they focus on irrelevant issues or the information is too general and not specific to farmers' decision-making processes (Nguyen et al., 2006).

The reviewed DSTs are web-based and downloaded database or Excel spreadsheets that require users to enter farm data regarding inputs and management techniques (at least the farm type, size, and climatic information). A certain output is then calculated, such as GHG emissions, nutrient efficiency, or diffuse pollutant loss. All of the tools separate the farm into different categories or by different tabs in Excel spreadsheets to guide the user in completing the relevant sections.

Below is the data entry screen of the LIZ tool, which is a web-based DST. The LIZ tool was rated positively on its straightforward, simple design for users to enter their farm data and receive calculations regarding the humus balance of their soil.

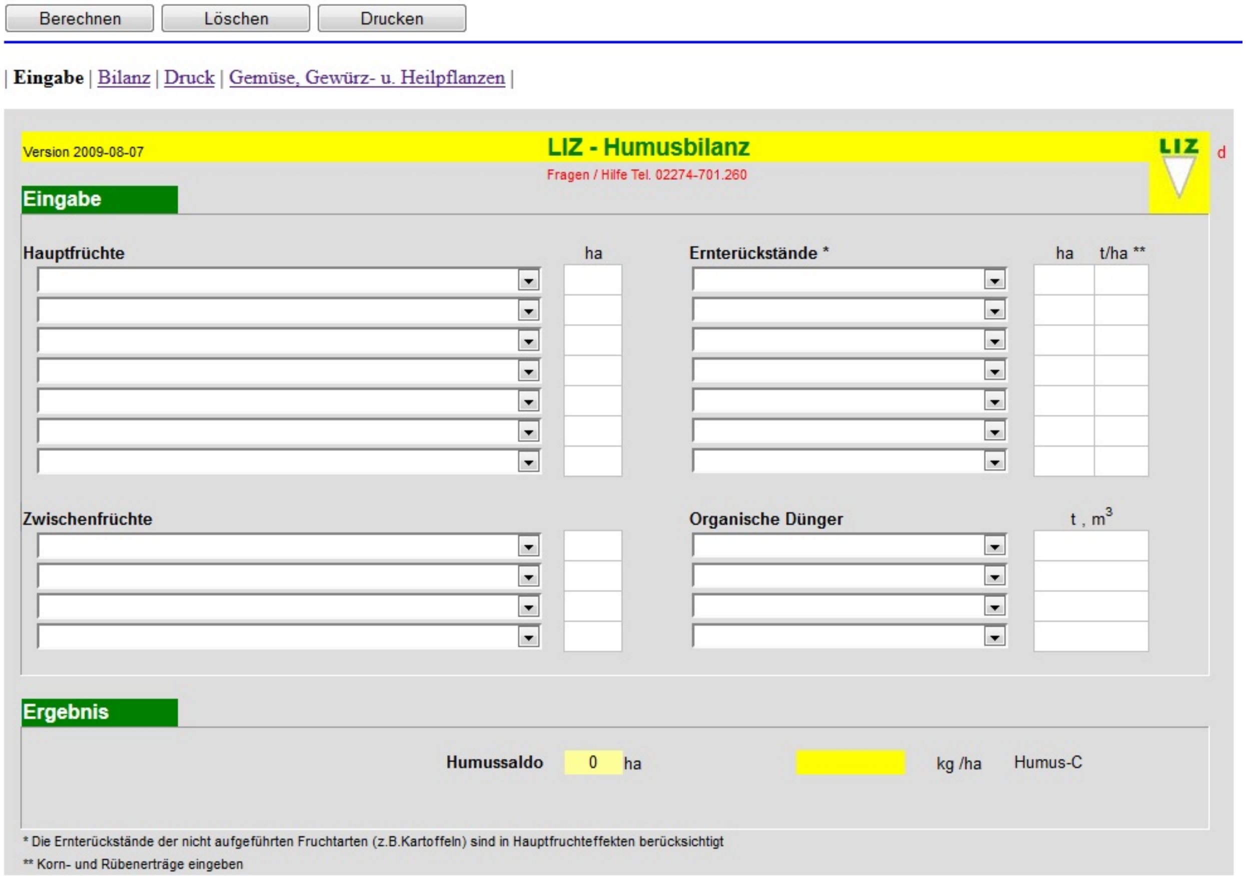

Figure 2: Input window for data and presentation of result (LIZ calculator)

The CFT is currently offered in Excel format with different tabs for each part of the farming operation included in the GHG calculation. From a design perspective, the review found that, upon first impression, the Excel format is overwhelming and potentially could be confusing for users. For example, the tables go beyond the screen from left to right and the data entry/results tables extend past the bottom of the screen, so the user has to scroll over and down to determine whether all data has been entered or to view extra information. However, multiple sources report that the tool is very easy to use in practice. For instance, the boxes for data entry are colour-coded and follow logically down the page, so that users can see where to enter specific data. The CFT is now switching to a web-based format intended to further enhance user-friendliness (the web-based version has been piloted and they are currently receiving feedback on it).

Below is a section of the CFT – Crop Management tab with the data entry boxes. Information tables extend off the right side of the screen and the results boxes are provided if the user scrolls down past the bottom of the screen.

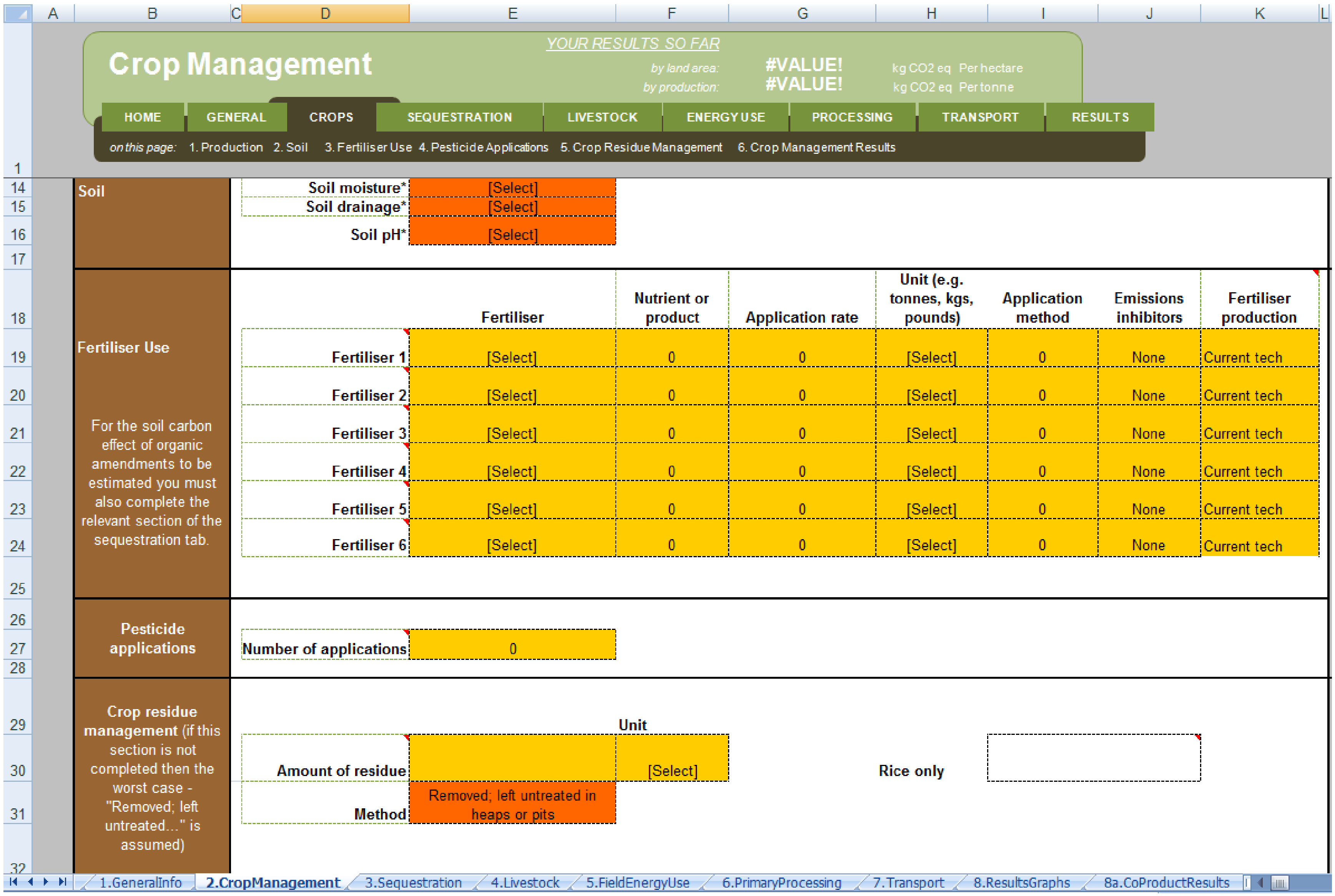

Figure 3: Cool Farm Tool (CFT) design incorporating multiple inputs, outputs and detailed information

One of the issues identified with standalone tools is that users have to manually update the software, whereas online tools are automatically updated by the developer. This may affect the up-to-date nature, user-friendliness, and administrative burden of the DST. Additionally, DSTs can be designed for compatibility with other farm management software. This would help avoid duplicate data entry and lower administrative burdens (Stewart and Purucker, 2011; Denzer, 2005; Smith et al., 1997). OVERSEER, for example, is connected to the fertiliser companies' recommendations for application as well as national policies and regulations. DLBR Mark Online can be updated with new data through smartphones (Mark Mobile) and it offers a module which even allows data to be exchanged with the user's tractor computer.

Duplicate data entry requirements are likely to increase DSTs' administrative burden and thus reduce their user-friendliness. Online tools, such as CPLAN v.0, might not store users' information, in which case users would need to re-enter their farm data for each calculation. The CFT is designed to provide calculations based on one crop at a time, so for diversified farms with various crops, the tool may have to be filled out more than once. The Farm Carbon Calculator, on the other hand, allows users to logout during a data entry session and return to their saved information at a later time, preventing duplication of data entry and potentially reducing users' administrative burden.

3.5 Results phase

Provide clear and useful results

Nguyen et al. (2006) stress that DSTs "should support a decision and not merely provide information" so that the tool considers a range of options available to farmers and "the economic, environmental, and social factors that might influence the decision or the choice of an option." The interface of the DST should communicate the options and information in an appropriate and useful way for the users, whether through text, graphs, videos, demonstrations, etc. (Nguyen et al., 2006).

The DSTs varied in terms of how the results were presented, but generally the results were more useful if they were detailed, farm-specific, and provided some type of assistance to users in terms of potential management changes. The DSTs' results were presented in the following ways:

- **Calculation results in tables or graphs** – the user can experiment with their data to see how the results would differ by using alternate input amounts or management strategies.

- **Recommendations for changes in management practices** – mitigation options or recommendations for changing farming practices were presented in tabular format, in some cases with cost-effectiveness estimates.

- **Category-specific calculations** – all of the DSTs' results were broken down by different categories on the farm, but they varied in terms of specificity regarding separate GHGs, nutrients/pollutants, and sources.

OVERSEER rated highly for usefulness of the results, which are models and indices (e.g., for nitrogen conversion efficiency) targeted at farm advisors to help farmers comply with nutrient loss standards and policies. Extremely high rates of uptake and continuing support and use by policy makers imply that these results are very useful. The CPLAN v.0 tool provided much more basic results with the calculation simply indicating the GHG emissions level for the different sections of the farm, which were not broken down by source or gas.

Clarity of the results also relates to the **transparency** of the tool's information base and calculation formulas used to produce the results (Whittaker et al., 2013). The DSTs rated lower if they did not specify on which basis the calculations were made and did not allow users to access any of the original formulas. The CFT rated positively in terms of transparency because as an Excel file it allows users to see the original formulas. Many of the web-based tools received low scores in this criterion because they only provide a place for users to enter data and give results without explaining what assumptions or calculations were made to arrive at those results.

Provide comprehensive and accurate results

DST adoption depends on building user trust, which is influenced by the credibility, reliability, certainty, relevance, and completeness of the information provided by the tool (McIntosh et al., 2011). The multi-criteria analysis in Whittaker et al. (2013) included "comprehensiveness" as one of the four criteria for assessing DSTs, which considers the different sources and emissions/pollutants included in the tool's scope (e.g., land use change was not included within the scope of some of the tools reviewed under that study). Hall et al. (2010) also included "complete – tools should cover a wide range of emissions sources and different farm types" as a criterion of the multi-criteria analysis.

The SmartSOIL review included "comprehensive" in its multi-criteria analysis of the DSTs. An important component within this criterion was the accuracy of the results provided by the tool. Accuracy in this instance, however, is not referring to the results being right or wrong or mirroring the exact circumstances on the farm. Rather, as explained by Mark Shepherd of AgResearch (New Zealand) during an interview about OVERSEER, results produced by DSTs will contain varying levels of uncertainty. Such uncertainty is to be anticipated when modelling research and scientific valuation of processes and farming systems (McIntosh et al., 2008). Tools also have to make assumptions and cut corners in order to extrapolate smaller parts of the farm up to farm-scale estimations. Resulting uncertainty needs to be managed through protocols (e.g., default values to use if the data you have is not meeting necessary levels for comparison and assessment (Sheperd 2013)[7].

Tools which explained the inherent level of uncertainty behind their results rated higher than tools which did not address potential inaccuracies or uncertainties. “An absence of uncertainty suggests a lack of comprehensiveness as this can provide some information on the robustness of the data sources used and detail any temporal or spatial uncertainty” (Whittaker et al., 2013, p.7; Guo and Murphy, 2012). The analysis looked at what farm-specific information was requested and what assumptions were made by the tool to come up with the results.

The CFT rated positively under the criterion for comprehensive/accurate results because it includes multiple GHG, a broad range of different sources at farm level (e.g., cropland, livestock, energy use, transport/fuel use, etc.), as well as the ability to calculate lifecycle emissions for farm products beyond the farm gate. Farmscoper also received a high rating under this criterion, in part because it explicitly recognises the uncertainties in its calculations of pollutant losses and impacts of its mitigation recommendations. Tools which used very low amounts of farm-specific data and made multiple assumptions, sometimes without indicating which assumptions were made, were considered less comprehensive/accurate (e.g., CALM). For the most part, the tools relied on farm-specific data, such as Tier 2 data from the Intergovernmental Panel on Climate Change (IPCC) rather than its Tier 1 simple default values, as the basis for their calculations, which increased the comprehensiveness and accuracy of the results.

Provide useful recommendations for end users

DSTs are intended to be used in support of the decision-making process, but “simply supplying more information will not necessarily result in improved management, or even necessarily address the ‘right’ set of issues” (McIntosh et al., 2008). Whittaker et al. (2013) indicate that a DST’s results reflect the main goal and scope of the tool, thereby changing the context of what successful use of each DST entails. One of the goals of the tool may be to encourage changes in management practices in order to achieve different farm-level results regarding GHG emissions, nutrient efficiency or pollutant losses. Thus, DST results may take the form of recommendations in order to accomplish this goal.

[7] Interview with Mark Sheperd, AgResearch (30 July 2013)

Tools' results must be useful and comprehensive in order to make an impact and be relevant enough for farmers to actually use the DST. Stewart and Purucker (2011) refer to this as the DST's validation – did the DST achieve the project's stated purpose? However, it is noteworthy that increasing the level of detail of the results may cause trade-offs for the DSTs in other criteria (e.g., making it less easy to use, having a higher administrative burden, or increasing the technical requirements).

Farmscoper, OVERSEER, and the CFT provide detailed results, including mitigation options to reduce diffuse pollutant loss, estimates of nutrient use and efficiency (i.e., amount applied versus losses from runoff), and GHG calculations for the farm, respectively. The LIZ, CALM, CPLAN, and Farm Carbon Calculator tools do not offer recommendations as to how users should change practices to achieve different GHG emissions or humus balances on their farms but instead allow users to manually experiment with "what if" scenarios. The DLBR Mark Online tool allows users to track their input of fertiliser and pesticide and report the results for regulatory and compliance purposes.

The Farmscoper tool was the most proactive DST in terms of recommendations for management changes. Based on farm-specific data entry, the user can see which options exist for decreasing diffuse pollutant loss according to the farm, soil, and climate type. Multiple mitigation options are presented in a general list, but the tool goes a step farther and provides a combination of specific recommendations based on a cost-effectiveness assessment. In terms of effectively implementing the recommendations, however, either advisory or expert assistance would be necessary for farmers to interpret the mitigation options and determine which combination to implement (Gooday et al., forthcoming). The image below shows how Farmscoper presents mitigation options and recommendations.

	Fixed Cost	Variable Cost	Total Cost	Nitrate	Phosphorus	Sediment	Ammonia	Methane	Nitrous Oxide	Pesticides	Biodiversity	Water Use	Energy Use
	£	£	£	Kg	Kg	Kg	Kg	Kg	Kg	Units	-	-	-
Baseline Value	0	0	0	2.133	57	698	4.550	21.496	1.294	0,5	-	-	-
Prior Implementation Value	0	0	0	2.133	57	698	4.550	21.496	1.294	0,5	0,0	0,0	0,0
Impact (Change from prior situation)	£	£	£	%	%	%	%	%	%	%	-	-	-
Set 1	11.151	-1.733	9.418	17,0	75,5	52,2	17,1	-4,1	24,4	6,3	54,4	0,0	-3,4

Method lists for each set

Method IDs: Set 1	Description
8	Cultivate compacted tillage soils
9	Cultivate and drill across the slope
10	Leave autumn seedbeds rough
11	Manage over-winter tramlines
13	Establish in-field grass buffer strips
14	Establish riparian buffer strips
15	Loosen compacted soil layers in grassland fields
16	Allow field drainage systems to deteriorate
19	Make use of improved genetic resources in livestock
20	Use plants with improved nitrogen use efficiency
21	Fertiliser spreader calibration
22	Use a fertiliser recommendation system
23	Integrate fertiliser and manure nutrient supply
25	Do not apply manufactured fertiliser to high-risk areas
26	Avoid spreading manufactured fertiliser to fields at high-risk times
27	Use manufactured fertiliser placement technologies
31	Use clover in place of fertiliser nitrogen
331	Reduce dietary N and P intakes: Dairy
35	Reduce the length of the grazing day/grazing season
37	Reduce field stocking rates when soils are wet
38	Move feeders at regular intervals
52	Increase the capacity of farm slurry stores to improve timing of slurry applications
570	Minimise the volume of dirty water produced (sent to dirty water store)
571	Minimise the volume of dirty water produced (sent to slurry store)
60	Site solid manure heaps away from watercourses/field drains
61	Store solid manure heaps on an impermeable base and collect effluent

Figure 4: List of mitigation options presented in Farmscoper results

3.6 Dissemination phase

Uptake by target group

Measuring the uptake and use (including information on the user groups) of a DST is often very difficult and requires monitoring or surveying, as well as taking into account feedback from users or registration records. However, some of the DSTs analysed seem to be widely used. More than 80% of all arable farm land in Denmark, for example, is administered by the fee-based DLBR Mark Online system, either by the farmer himself or by the farm advisors on behalf of the farmer.[8] OVERSEER (NZ) is used by the majority (ca. 90%) of the dairy industry as well as

[8] The number of farmers using the program personally is approximately 3,000, yet an additional 20,000 farmers have their farm and field planning, budgeting, and nitrogen and pesticide use calculated via extension consultancy services.

the fertiliser industry due to its ability to calculate nutrient budgets and provide fertiliser recommendations. Both tools are supporting the compliance with environmental regulations and also being officially recognised and promoted as such tools. In some areas, use of OVERSEER to measure compliance is even mandatory for farmers.

The Cool Farm Tool has also had extremely large uptake; it has been used for over 25 crops in 28 countries in the EU and developing countries. This DST in particular has been endorsed by many organisations and companies as the chosen tool for estimating GHG emissions, which can be seen as one major driver of its development. Therewith, the mandatory use of the DST by farmers who are parties to internal supply agreements with food companies has increased the uptake of the tool. Further extension of the use of DSTs in certification schemes to demonstrate that products have met a low-carbon standard, for example, could drive uptake as well (though this may be influenced by consumer demand for such products, food labelling, etc.).

There are also positive indications that the German humus calculator (LIZ) and the British CALM calculator have been used by a large share of farmers (measures via the online accesses and surveys).

It can be concluded that in general the uptake of a DST by end users can be stimulated and increased through industry adoption (e.g., fertiliser guidelines, supply agreements, and certification schemes), which requires the producer (farmer) to apply the tool, or promoted / mandatory tools (for farmers) to prove compliance with environmental legislation. However, in such cases there is also a certain risk that while a positive impact on the environment can be noticed, there is no real re-thinking and awareness raising among the target groups for a more sustainable farming management. On the other hand, uptake of DSTs have also produced the desired effect through changes in management practices, which may cause the tool to become redundant for those users if it does not evolve to help with new decisions.

Despite the fact that several tools are used by farmers, farm advisors, and/or policy makers, it remains unclear how much impact the tools have on changes in farming practices towards more sustainable management and/or adjusting policies to promote and award sustainable practices.

Means of dissemination

The uptake and use of a DST can be stimulated and enhanced through a variety of factors, including inter alia the design and user-friendliness of the tool, geographical and thematic focus, quality and applicability of results, but also several means of dissemination to increase awareness of the tool and its services and to help the target user group apply the DST. Some successful examples are listed below:

- Establishing effective communication and training (in part, workshops) of users to overcome initial resistance to the information requested
- Endorsement/promotion of the tool by well established and recognised organisations and companies
- Using (digital) newsletters, well-established agricultural journals and agricultural websites to inform the targeted user group about the tool
- Presentation of the tools at consultation meetings with farmers, farm advisors, etc.
- Integration of the DST into other relevant tools, platforms, and websites (providing an added value to existing DSTs)
- Delivering the DST (if useful and relevant) in different languages

More information on this topic can be found in the subsequent section 3.7.

3.7 Support and maintenance phase

DSTs must undergo continuing verification of the data, calculations, assumptions, etc. in order to be functional and useful to users (Stewart and Purucker, 2011). To be relevant, DSTs must be able to respond to new developments and incorporate scientific findings, such as climate change and the uncertainties it poses for agriculture (Hochman and Carberry, 2011). Mir and Quadri (2009) identify the problem that DSTs often fail even after users have accepted them because:

- the DST might “fail to keep pace with the user’s needs” and/or
- unsolved problems with the model/technology might prevent users from obtaining results.

Nguyen et al. (2006) also stress that DSTs risk becoming obsolete if the developer does not: have the “incentive or the inclination to keep it up to date”, keep “it consistent with changes in computing hardware and software technology”, or alter it according to changing user needs.

Therefore, Shepherd and Wheeler (2010) stress that development of DSTs must include a sustained effort “to encourage and maintain use of the decision support system (DSS)” so that implementation does not fail and tangible benefits are delivered. This is accomplished through:

- Support and guidance for users to be able to effectively use the tool (as mentioned above for user-friendliness in Section 3.4)
- Continual updates of the underlying data and development to address current problems/future needs

- Maintenance and ongoing software support.

Support/guidance for effective use

The various DSTs provide support and guidance in different forms for their users. **Error! Reference source not found.** below identifies the different options in accordance with the tools.

Table 3: Various formats for support and guidance provided by the DSTs

Support and guidance format	Corresponding DSTs
User guides – e.g., tool functions, data required, how to enter inputs, outputs expected, mitigation options, etc.	CFT, Farmscoper, OVERSEER, LIZ, DLBR Mark Online
Case studies – e.g., practical application at the farm level and by supply chain customers	CFT
Webinars	CFT
Online and in-person training sessions and workshops	CFT, DLBR Mark Online, LIZ
Manuals	CALM
FAQs and troubleshooting	OVERSEER, DLBR Mark Online
Help tabs in the spreadsheet – to assist the user with creating, evaluating, or generating results	Farmscoper
Information/explanations – methodological issues involved in the tool's calculation	CPLAN, Farm Carbon Calculator
Interpretation assistance – link to toolkit from results page	Farm Carbon Calculator
Data collection forms – PDF or spreadsheet for manual or electronic data collection	Farm Carbon Calculator
Guidance videos – available for download from website	DLBR Mark Online
Newsletter (weekly) – in digital format	LIZ

Updates and further development of the DST

DSTs must be updated and apply to farming systems to be relevant for users, which involves keeping pace with evolving scientific findings, practices, products, regulations, etc. However, further development of the DST to model new information or processes must consider whether there is sufficient data available to provide an adequate model and results that users will depend on to varying extents. The developer must strike a "balance between adding [] new features because of user demand and having adequate information to ensure that the new feature is scientifically robust" (Shepherd and Wheeler, 2010, p.197).

Updating the data underpinning the tool in its current form is important in order for the results to be relevant to the user. The DLBR Mark Online tool provides a good example of a DST, which is up-to-date in terms of data on which the calculations are based and changes to the tool itself. It is a .NET Smart client programme connected to a centralised field database via Internet, so the tool is automatically updated to the latest version when the user opens it.

OVERSEER is another example of a DST undergoing continual development in order to stay relevant and useful to industry and farmer stakeholders. Growing fodder crops and use of a nitrification inhibitor on paddocks was becoming common practice on New Zealand farms, for example, so OVERSEER expanded its scope to include these two practices (Shepherd and Wheeler, 2010). Additionally, the Farmscoper tool is undergoing development by ADAS UK Ltd in response to stakeholder feedback, namely in an effort to improve user-friendliness, and to increase the farm-specific nature and accuracy of the cost-effectiveness data for the DST's results (Gooday et al., forthcoming). As mentioned in Section 3.4 discussing the implementation of the different DSTs, the CFT is being revised into a web-based format intended to increase its user-friendliness.

Maintain software and provide ongoing support

User uptake and continuing confidence in the DST will depend upon reliability and lack of technical issues with the software or tool's functions. If the tool frequently crashes or provides an error message to the user, this could result in frustration and abandonment. Inclusion of more elements or features in the model will result in a more complex structure, which requires greater emphasis on software development (Shepherd and Wheeler, 2010).

In testing the OVERSEER tool, the reviewer encountered frequent error messages preventing generation of a farm report. However, results would likely improve based on the number of different blocks or categories included in the farm calculation (e.g., fewer blocks would require less data entry which would reduce the likelihood of error) and use of more accurate data (rather than test data that was not specific to New Zealand). A positive response to this potential for errors in generating reports is the fact that OVERSEER provides troubleshooting guides and contact information for the developers so that ongoing support is readily accessible.

The DLBR Mark Online tool is another example of a DST that provides extensive ongoing software support for its users. During business hours, there is a remote help desk available for users with further problems or concerns.

Maintenance and regular updating of DSTs to keep them relevant and useful to stakeholders can exhaust a lot of resources, so a balance should be sought between the scientific robustness and the focus on developing a reliable tool (Shepherd and Wheeler, 2010).

4 Review of knowledge platforms

4.1 Overview of analysed platforms

The platforms that were reviewed have different origins and focus areas. Their target groups range from farmers, to farm advisors, policy makers and researchers, to the general public. These platforms all receive continuous funding for maintenance, including of their interactive features. Most are structured in thematic pages. Not all aspects of these platforms were examined in detail. Rather the focus was on identifying good examples and lessons that can be learnt for the SmartSOIL project. A brief description of the platforms and their main elements is given in **Error! Reference source not found.** below.

Table 4: Sample of platforms

Name	Short Description	Main elements
Farming Futures (UK)	Hosted by the Center of Excellence for UK Farming, http://www.ceukf.org/ Communications partnership on climate change & sustainability in UK farming and food supply. Emphasis on knowledge exchange directly with farmer, drawing upon research and development within founder institutes. The main focus points: • ''Profitable business in a changing climate'' • "Farming Futures can help you prepare for the impacts of climate change and the opportunities for your business."	The main tabs on Home Page include: Home, your sector, events, library, renewable, future skills, blog Home page: farmers' weekly newsfeed, Latest news and blog entries, podcast application at bottom left, UK farming maps, link to videos, a twitter feed running across the top under the tabs, Case Studies, Upcoming events. Sectors covered include: Crops, dairy, horticulture, livestock, poultry, potatoes and pigs
Farming for a Better Climate (UK)	Run by Carbon Management Center at SRUC, Scotland, since 2010. Acts as an information source on mitigation in agriculture, including newsletter, factsheets, and a project Focus Farms which combines information and advisory work around different types of farms where regular meetings are organised to explore possible mitigation options. The meetings are open to all farmers with reports available online.	First page includes an introduction. Two subsections are available: Climate Change Focus Farms, and Improve Farm efficiency. Farm Efficiency categories include: Energy& Fuels, Fertilisers & Manure, Locking in Carbon, Management of livestock, Renewable Energy, Manure management, carbon sequestration.
FAO Platform (global)	The purpose of the platform is to "guide and help farmers in implementing climate-smart agriculture practices through the support and cooperation between farmers' networks, institutions and inter-governmental organizations"	Guides and manuals are available for the following topics (tabs): Global approach, Papers covering several topics, Erosion management, Nutrients and soil fertility management, Water and irrigation management, Soil salinity management, Integrated Pests management, Pasturelands management, Wetlands management, Livestock management, Fishery and aquaculture management, Energy management, Post-harvest losses management
Linking Environment and Farming (LEAF) (UK)	LEAF, is a UK-based charity promoting sustainable food and farming by building public understanding of food and farming. Their approach includes LEAF Marque certification which requires farmers to apply high environmental standards, Open Farm Sunday, Let Nature Feed Your Senses as well as year round farm visits to a national network of Demonstration Farms. Their target groups are farmers, consumers, and the supply chain actors.	The main page has three main boxes separating the platform's topics. 1) For Farmers –links to Management tools and Marketing & Communication opportunities 2) For Consumers – giving suggestions on "What you can do as a consumer" 3) For Food Chain – promoting the use of the LEAF Marque

Name	Short Description	Main elements
		Home page also includes sections: “Latest News”, the LEAF Blog, “Latest Resources” (guidance and a video library), and LEAF’s Tweets.
Food Climate Research Network (UK)	The FCRN’s focus is broad, encompassing technological options, behaviour change and the policy dimension of the food climate nexus. It examines the role of technology in reducing food-related emissions, explores required behavioural changes, as well as the role of government, community, non-governmental organisations and individuals in addressing food related emissions. Finally, it explores the implications of reducing GHG emissions for other issues such as human food security, animal welfare, and biodiversity. Its target groups are: Individuals interested in the food climate nexus. Government, the food industry, non-governmental organisations and the academic and research communities, whose collective expertise includes everything from soil science, to life cycle analysis, human nutrition, the psychology and sociology of human behaviour, to food packaging.	Research & Publications, Network Members domain, Forum for discussion, About and Home are the main tabs on the home page. Research Library, upcoming events, Newsletter and Easy searching are the other main elements.
ClimateAdapt platform (EU)	An initiative of the European Commission, the European Climate Adaptation Platform (CLIMATE-ADAPT) aims to support policy makers at EU, national, regional and local level in the development of climate change adaptation measures and policies.	It provides information on: Expected climate change in Europe, current and future vulnerability of regions and sectors, national and transnational adaptation strategies, adaptation case studies and potential adaptation options and tools that support adaptation planning.
Landbrugsinfo (DK)	Hosted by Knowledge Center for Agriculture, Aarhus, Denmark. Since 1996 www.LandbrugsInfo.dk has been the direct communication line for knowledge generated or transferred by the Knowledge Centre for Agriculture. In addition to holding a large database with documents, Landbrugsinfo disseminate decision support i.e. weather information for agriculture, decision support systems e.g. weather based harvest forecast – time, yield and quality, cereal disease surveillance and monitoring and a Web based Farm Management Information System (FMIS) including Mark Online, Irrigation Management system, Soil Analysis online, AgroGIS and Field Mobile. The extension system includes a comprehensive field trial and experimental work that generate new knowledge and test results and theories from Danish and international research.	Construction, Energy, Livestock, Plant production, Organic production, Farm Management, Machinery, Agriculture and Environment, Extension, Weather information to agriculture and Economy.

4.2 Types of tools / functionalities available

The platforms use a range of tools to disseminate knowledge. The most relevant tools in relation to the SmartSOIL toolbox include:

- Written documents (factsheets / technical guidelines/case studies/newsletters)
- Videos and audio podcasts
- Search tools and databases
- Blogs and news entries
- Twitter
- Feedback and commenting

Below, the main considerations related to the use of these tools are discussed, including ease-of-use and content design, as well as features that make the tools innovative and relevant for the SmartSOIL toolbox.

Written documents – 'traditional' outputs

The SmartSOIL consultation indicated that potential SmartSOIL toolbox users would prefer at least some of the outputs to be in traditional, written formats. The benefits of printed materials were summed up by a respondent: "hard copy technical notes are still the most useful as they are tangible and familiar to farmers and can be discussed with an advisor in the field." (Ingram et al., 2012a, p.25).

A recent study of user behaviour of online knowledge brokering platforms for climate change and development found that written formats (reports, articles, policy documents) were the primary reason for accessing the platforms among policy makers, researchers, and project managers (the primary users of these platforms) (Hammil, Harvey & Echeverria 2013). Written documents are the standard tool applied by all the websites in our sample.

Factsheets are commonly used to introduce general issues as well as specific questions and case studies of farms or other actors and how they implement solutions. Factsheets tend to be short (2 to 3 pages) and use general, introductory language, focusing on basic information. The main elements of factsheets are:

- Why a certain practice is valuable to the farm (highlighting key facts, win-win reasons for adoption, including regionally or country-specific information (e.g., Why soil carbon management matters to farmers in Scotland?)

- Simple, clear graphic layout (not too crowded or “squeezed” with overwhelming amounts of information)
- Further links and resources
- Images that illustrate a practice, or show the case study farmer (including, for example, before and after images)
- Information on cost-savings and efficiencies (e.g., diesel, number of passages), yield benefits (yield increase, yield maintenance in times of drought), immediate and longer-term impact on farm profitability
- Use of boxes and colour schemes to highlight key messages

A number of factsheets related to soil management, including soil carbon sequestration, are already available.[9] The SmartSOIL toolbox could build on or complement these by incorporating updated information from SmartSOIL research results, as well as additional regional information in case study countries.

Practical guides (brochures) are longer documents, which provide more extensive explanations and guidance. A number of practical guides are already available for soil management that aim to increase awareness of the importance of soil quality and what farmers can do. For example, LEAF *‘Simply sustainable soils*’ focuses on steps that farmers can apply to safeguard their soils, including steps related to maintaining Soil Structure, Soil Organic Matter Status, Drainage, Soil pH & Nutrients, Compaction, and Biological Health[10]. Figure 5 show an extract from the ‘*Simply Sustainable Soils’* guide focusing on the Soil Organic Matter Status section.

[9] http://www.sruc.ac.uk/downloads/file/648/practical_guide-improving_soil_quality, http://www.eea.europa.eu/signals/signals-2010/soil, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=616

[10] http://www.leafuk.org/resources/000/595/601/LEAF-Simply_Sustainable_Soils.pdf

Nutrient Balance & Exchange

Step 4 – Soil Organic Matter Status

The soils organic matter contains dead organisms, plant matter and other organic materials in various phases of decomposition. Humus, the dark-coloured organic material in the final stages of decomposition, is relatively stable. Organic matter and humus serve as a reservoir of plant nutrients and water; they also help to build soil structure and provide a good growing environment.

Testing for organic matter status can be undertaken in a laboratory. You can also assess the organic matter content visually – soils that are dark brown/black generally have 'high' organic matter levels and light brown coloured soils 'low' levels.

Organic matter is important in all types of soils, so when you see that there is a lack of organic matter in a soil/visual test, consider adding more organic inputs. You can improve the organic matter status of your soil by adding organic materials (e.g. livestock manures, biosolids, composts etc.), incorporating crop residues and growing green manures.

Step 4 soil score

Indicator	Poor (0)	Medium (1)	Good (2)
Nutrient Balance & Exchange			
Soil Organic Matter Status (f)	Organic matter levels are low, soil is crusty, cloddy, hard. Light brown in colour	Organic matter levels moderate, some crusting and clods. Brown in colour	Organic matter levels are high, soil is friable, with good structure. Dark brown in colour

Figure 5: Extract from the Simply Sustainable Soils guide

The guide has step-by-step instructions on how to address the different problems in relation to these areas, supplemented with numerous images and a logical structure. A template for a score table is available that can be used by the farmers for different fields in order to evaluate soil health.

Moreover, farmer case studies enable a personalised view of specific environmental issues that farmers face and how farmers are addressing them. They are commonly used on farming websites, including the platforms that were reviewed for the purposes of this report. The case studies tend to be short, introductory documents, with very general information, but tailored to the specific type of farm that is introduced. The text is complemented with a photo of the farmer along with a photo of a specific practice that is discussed in the case study. The case studies do not provide much detailed information about specific issues or practices, with the assumption being that the issues need to be followed up with a farm advisor, or explored further by consulting other resources.

Alternatively, case studies can also be presented in the form of interviews with stakeholders other than farmers. For example, the FCRN website includes interview transcripts with local practitioners, as well as researchers.[11]

Box 2: Climate Change Focus Groups

The Scottish Farming for a Better Climate supports an initiative called Climate Change Focus Farms. Four different types of farms were included in the project (arable, dairy, upland cattle & sheep, and dairy with demonstration and diversification activities). Although not explicitly stated, it appears the project ran from 2010 – to at least March 2013. Each farm hosted a number of meetings per year, supported by Scottish Agricultural College (SAC) specialists, and addressing different topics related to actions that farmers can take to reduce greenhouse gas emissions while increasing farm efficiencies. The emphasis is strongly on the positive side-effects of GHG reduction for farm economy. The topics discussed were co-determined by the participants attending the meetings, ensuring that their interests and needs were addressed. Soils were one of the themes addressed, most frequently at the organic dairy farm. For each meeting, summary notes are prepared.

Videos

Short videos provide an opportunity to enhance the communication of contents, in particular since they can complement and enhance the perception of written and audio contents. They can be especially useful for illustrating long-term processes, such as carbon storage in soils, as well as practical examples of effects of carbon on plant health and crop growth. They are not commonly used across the different knowledge platforms that we examined with the exception of two websites.

Farming for a Better Climate and FCRN do not include videos. Farming Futures, on the other hand, has a large selection of videos[12]. The LEAF UK includes farming-related videos, with a number of interviews as well as demonstration videos on soil topics. The Adaptation Platform includes some videos, however, only few related to agriculture and intended for a more general public. A selection of the most relevant videos is presented in

below.

[11] http://www.fcrn.org.uk/interviews/2011/re-localising-food-within-context-our-climate-and-cultures

[12] http://www.farmingfutures.org.uk/resources/videos

Table 5: Examples of relevant videos

Title	Content, length	Comments
Visualizing Carbon – no mean feat! – Emissions, sequestration and quantities of carbon on an upland farm http://www.farmingfutures.org.uk/resources/videos/visualising-carbon-no-mean-feat	Illustrates quantities of carbon in soils/ atmosphere 2:49 Min. length	Video starts with naming institutions instead of the issue. Dimensions are meaningless to non expert audience. How much are 1500 ha? Are 4.2 thousand tonnes of CO_2 eq. a lot? Could be compared to a dimension familiar to the audience (e.g. driving one km in a passenger car). Examples of good practices for carbon sequestration could be briefly mentioned to make it more tangible. The video could have visualized the stored carbon as a "negative volume" going into the ground to visualize the difference to the emitted CO2 eq.
Better Returns – taking a soil sample http://www.farmingfutures.org.uk/resources/videos/better-returns-taking-soil-sample	Shows a person taking soil samples for sending them to laboratory for analysis.	Description on youTube is missing The W-shape for taking 30 samples could be visualized. How to use the sample device could not only be shown but also briefly described. Is it clear to a farmer where to get this tool from? Sound quality is somewhat disturbed but this makes the video very realistic and authentic.
Carbon accounting for farmers: explain the benefits of using carbon calculators http://www.farmingfutures.org.uk/resources/videos/carbon-accounting-farmers	Video shows the example of CO2 eq. sequestration measures taken on a dairy farm after using the carbon calculator.	Very good, realistic and authentic. Motivates to use the carbon calculator. Figures could be visualized by infographics. They are only mentioned by the speaker and are difficult to grasp quickly. Would be good to give URL of carbon calculator in the video's end and clickable in the video description. Now it only gives URL of CLA homepage. The calculator could not be found there.
Rainwater harvesting http://www.farmingfutures.org.uk/resources/videos/rainwater-harvesting	Shows benefits of rainwater harvesting (environmental and economic) using an example of a poultry farm. Five minutes long.	Rainwater harvesting in this case is used for supplying water to the chicken farm, rather than watering crops. Large-scale investment is needed for this type of harvesting system. The video title does not make it clear that the focus is on large-scale investment.
Farmers' footprints: carbon footprinting potatoes	Illustrates best practices to decrease the carbon footprint	Starts off with a family meal, illustrates the sources of emissions, and hints at best

Title	Content, length	Comments
http://www.farmingfutures.org.uk/resources/videos/farmers-footprints-carbon-footprinting-potatoes	of potato production and supply. Animated film.	practices. Intended for the general public.
Creating a profitable and low carbon dairy farm http://www.farmingfutures.org.uk/resources/videos/creating-profitable-and-low-carbon-dairy-farm	Illustrates a Farming Futures event style, and gives ideas for best practices. Interview focused. Four minutes long.	Main points include: need clearer messages and good soil management; consumers want to know more about the footprint, footprinting is an opportunity for farms also for profitability and efficiency (win-win situation); at the end the video gives links to other resources
Carbon farmers: Environmental Atlas of Europe — Italy http://www.eea.europa.eu/atlas/eea/carbon-farmers/video/carbon-farmers-environmental-atlas-of/view	7.5minutes long, portrayal of an organic / bio-dynamic family farm in Italy. Soil as a basis of sustainable agriculture, adding soil organic matter, increasing soil carbon sequestration. Afforestation, solar panels, packaging and transport.	Title “carbon farmers” is a bit misleading. It is more on organic farming and for a beginner audience. Professional video, good music. English with Italian accent somewhat difficult to understand. Subtitles would help.
Selwyn's Soil Secrets: Cultivations http://www.youtube.com/watch?v=AP0csGMtvA8&feature=youtu.be	A LEAF-UK video with a central message that good cultivation practices are the key to good soil management. Soil scientist standing in a field explaining basic characteristics of cultivation that benefits soil structure and health. Emphasizes minimizing compaction, minimum cultivation increasing organic matter, and characteristics of healthy soil. Five and a half minutes long.	Basic, introductory video, presented by an experienced soil scientist. The video focuses on providing simple tips. It does not go into much detail. It would benefit from graphic inserts illustrating the conditions of soils that he describes, providing additional visual clues. This way it is rather static, although the presenter’s enthusiasm makes the video interesting. There is a summary of key points at the end which is beneficial.

Some observations can be made about the use of videos, the way they are embedded in the two platforms, and their design.

http://www.farmingfutures.org.uk/resources/videos

- Overview of the videos with short description of content is useful
- Thumbnail pictures make videos more recognisable
- Hosting videos on youTube makes them more visible and easier to find

- Keywords could be added to the youTube description of video; some videos do not have a description on youTube
- Overview of videos could indicate lengths of videos
- Videos should be more integrated in and linked from other contents, for example in the area “dairy” no link is given to the video “Carbon accounting for farmers: explain the benefits of using carbon calculators“

http://climate-adapt.eea.europa.eu/

- Hosting videos on vimeo and youTube enhances their visibility
- Video overview could give more details on each video (than only the title).
- The descriptions could improve the use of keywords. For example, “Carbon farmers: Environmental Atlas of Europe — Italy” is not found searching for “carbon sequestration”.
- Integration of video content with other contents and search could be improved. For example, advanced search restricted to sector “agriculture” (http://www.eea.europa.eu/help/advanced-search#c6=agriculture&c8=&c0=10&b_start=0) gives 0 videos as result

A general rule of thumb suggests that online videos should not be longer than five minutes, although the interests of the target groups need to be taken into consideration.[13]

Audio Podcasts

Podcasts that can be downloaded and used offline, especially on portable devices, are an additional means of knowledge dissemination. In the SmartSOIL toolbox, they could, for example, complement a written guide for in-field assessment, which would include visual clues. They could also be used for presenting interviews with farmers, and would likely incur fewer costs to produce. The disadvantage with respect to videos is that podcasts would potentially require more resources to translate them into the different languages (i.e., each podcast would need to be recorded separately, whereas videos could be translated with subtitles). The costing

[13] http://thevideoeffect.tv/2013/05/08/online-video-attention-span-how-long-should-a-video-production-be/

aspects would need to be weighed carefully along with how each of the formats can best address a specific purpose.

LEAF UK includes a number of audio podcasts, which users can subscribe to via iTunes. However, their last update appears to have been made in 2010, which leaves open the question why more recent additions have not been made (one possibility is that these podcasts may not have been used much). **Error! Reference source not found.** gives a short review of two examples of podcasts.

Table 6: Examples of podcasts

Title	Content, length	Comments
Climate Week http://www.leafuk.org/leaf/mediacentre/podcasts/podcasts2.eb	A discussion with three farmers plus the moderator on the outcomes of a debate on synergies and trade-offs in the context of climate change. Based on a few guiding questions, the interviewees summarized their main impressions from the debate and views on the pressing issues facing agriculture in view of climate change. The management of trade-offs and synergies require careful planning and structured discussions among different stakeholders in the agriculture and food sectors, each with their own perspective and non-negotiables. 17.39 Min. length	Soil management that leads to soil health emerged as a core theme. Farmers should not underestimate the importance of soil health to help with water holding capacity and crop productivity, especially in the context of climate change. This podcast is more of a round table discussion summarizing the main points from an event. The conversational style makes the topic, which might otherwise be quite dry, more engaging.
Water Quality and Run-off http://www.leafuk.org/leaf/mediacentre/podcasts/podcasts2.eb	Discusses measures that can be taken in wet conditions, reducing sediment and pollutant run-off and thus reducing diffuse pollution. 9:50 Min. length	The podcast starts with a brief introduction to heavy rainfall conditions and the issue of water quality, followed by an interview with a demonstration farmer involved with the Sustainable Drainage System project which is run the Environment Agency. The farmer explains the experiences so far with the project, emphasizing that the steps taken have been simple and easy to implement, without leading to any significant costs. He discusses how the project might continue further (i.e. what other potential actions could be taken). At the end the host also refers to another demonstration farmer, and an event and further resources available on

Title	Content, length	Comments
		the website.

Search tools and databases

Search tools can include search functions at different levels on the website. For example, CLIMATE-ADAPT website has a case study search tool which provides geographical access to case studies, as well as an interactive map showing the geographical location of case studies and their characteristics. Typically, websites also include searches for libraries of publications (for example, the FCRN and FAO websites). The search function needs to allow for different types of search terms, rather than being too restrictive. For example, adding the 'keyword' search in addition to title or category search significantly increases the usability of the search function. If the search function only allows for a limited sorting of items as per given category, without an open-ended search, this restricts its usefulness.

Blogs and news entries

Blogs tend to be used as news entries. The LEAF and Farming Futures websites allow members to subscribe and receive email notifications when new postings are available. The Farming Futures blog appears to function as a partial direct chat for farmers who can apply to post their own contributions on this blog.

Twitter

Twitter is a popular social media tool applied by websites. It is not possible to deduce how widely this tool is actually accessed as this data is not always available on websites. The tool requires continuous maintenance which makes it less suitable for SmartSOIL website given that it is not clear how, or if, the website can be maintained after the project is completed.

Feedback and commenting

An interesting tool that can be used to increase engagement of users with the website and exchange (rather than one-direction dissemination) is the possibility for users to upload new information. The CLIMATE-ADAPT website allows for this possibility. The users register with an EIONET account and provide a title, website link as well as a short description of information to be uploaded, after which the submissions goes through a quality control step before it is available. Moreover, users can also recommend case studies which are available on the website by clicking on 'like it' or 'don't like it' buttons.

Moreover, the website can offer an interactive forum or direct chat functions on the website. On the FCRN website, mailing list members can communicate with each other over the website, share comments and views, and highlight work that they have done.

4.3 Success features of knowledge platforms

Fit between supply and demand

A good fit between information and knowledge available on platforms and the needs of target groups is a central prerequisite for effective knowledge dissemination and exchange via platforms. One criticism of online knowledge platforms is that they "run the risk of being supply-driven, established and managed with the assumption that making more knowledge available online will result in evidence-based policy and practice" (Hammil, Harvey & Echeverria 2013: v). The alignment between knowledge supply and demand increases the effectiveness of platforms and requires a clear understanding of the needs, preferences and priorities of target groups. The SmartSOIL project will work to ensure that the project outputs meet the needs of potential users by carrying out several rounds of consultation with policy makers and the farming (farm advisory) community. In the initial SmartSOIL consultation, an important theme emerged about the need to encourage thinking about soil carbon management as an element of sustainable soil management.

Clear and logical structure

Clear, logical structure of the platform is important in order to make the resources readily accessible. Good structure is important both for the website as a whole, as well as the individual sections.

Even when a platform is complex in content and information, good navigation through the platform and linkage of tools can make the content easily accessible (a good example of this is CLIMATE-ADAPT platform shown below).

Figure 6: Main navigation page for the CLIMATE-ADAPT knowledge platform

Tagging and search functions improve accessibility. In some cases, websites offer numerous resources, which are not organised and clearly tagged (for example, Latest News section of LEAF UK website where articles are simply listed in chronological order). A smaller number of key themes / topics to which all items on the website can be related helps to focus the website and increase accessibility.

Appropriate and attractive format

The format of written or video/audio outputs can increase the usability of the tool. Pictorial and outcome-focused guidance has been shown to be preferred by farmers. If printed materials are produced for use by farmer, then these should also be printed on water proof paper (Ingram et al., 2012a).

Linkage of platform (download) functions and direct interaction / meetings

Linking online resources with one-to-one advice, focus groups or group meetings, practical demonstrations or open days, is an effective means to offer a complementary package of information and increase the likelihood that users will engage with the website. This requires that the website is linked to ongoing advisory work, or has sufficient financing to offer independent events.

Farming for a Better Climate (FFBC) "provides practical support to help reduce our impact on the climate. Taking action as a sector, both to reduce greenhouse gas emissions and to adapt to a changing climate, will secure farm viability for future generations." It offers a useful example of combining online resources with on-the-ground events and advisory work. Focus farms were volunteer farms that hosted open meetings where opportunities to reduce emissions, problems, and solutions to overcome them were discussed. The SAC offered support for farms with preparation of baseline data, identifying potential for savings, and providing support for the organisational aspects of the farm meetings. Results from these meetings were then made available online in the form of notes on different topics.

If the SmartSOIL toolbox were to facilitate regular exchange of information and practical experience beyond the lifespan of the project, several issues need to be clarified and considered in the design of the toolbox itself – in particular, funding, maintenance, and technical format. Alternatively, the SmartSOIL toolbox can simply offer a repository of findings from the project, with the toolbox a freely available resource to be integrated into other relevant platforms.

Links to further websites

When further links to other websites are given, they should be clickable. Farming Futures has a category "useful websites" (see http://www.farmingfutures.org.uk/resources/websites/cla-calm-calculator).

4.4 Opportunities to link in with the SmartSOIL toolbox

The SmartSOIL project is expected to deliver a SmartSOIL toolbox including a DST based on a "simple model", which predicts the response of crop yield and soil carbon storage to change under different management practices (switching crops, catch crops, tillage, and fertilisation practices), soil type, and climate. The model will not predict actual yield level, but merely the response of the yield to changes in management. The simple model will be implemented as a visual basic component that can be turned into flexible dissemination tools, such as:

- A web-based DST available on the SmartSOIL website as a part of the SmartSOIL toolbox

- A standalone web component (DST) that can easily be embedded in any website, including different languages options of the web interface text strings
- A web service where partners can apply input data, receive output data in XML, and then integrate the results into other programs or tools

Integration of the simple model DST and SmartSOIL toolbox will be possible with other DSTs and platforms – below are some selected examples.

LandsbrugsInfo (DK)

The most promising opportunity to integrate SmartSOIL findings with another platform is the case of the Danish LandsbrugsInfo, due to the existing contacts and interest on the side of the LandsbrugsInfo managers. In particular, there is a strong interest to integrate the SmartSoil “Simple model” and the related C-TOOL (developed by AU) with DLBR Mark Online and a theme website area on Soil fertility and soil carbon management. The general idea is to test integration of the “Simple model” and “C-Tool” at AU. The interface should be available in DLBR Mark Online (initially a standalone web interface). The user would accept use of his or her own data from the DLBR Mark Online central database – the model would calculate and return a rough index on soil carbon build-up and an index on change in soil fertility (initially as a thumps up, neutral, or thumps down for the field level or rotation system). The model would return XML data or a graphic as the output. Other tools from the SmartSOIL project could be integrated into a themed webpage in LandbrugsInfo on soil fertility and soil carbon management.

FAO Sustainable Agriculture Platform: pilot website

The SmartSOIL toolbox could be included in the Nutrients and Soil Fertility Management topic page (in addition to the listed subtopics) with an icon and a link to a tool that would assist with the topic heading.

That would be the best place for the SmartSOIL toolbox because it does not really fit under any of the subtopics but rather serves as sort of the step before. The Simple Model would figure out what the SOC levels are and then the DST would provide recommended practices to improve – which could encompass all of these subtopics. The subtopics are:

- Conservation tillage
- Crop rotation + use of legumes
- Soil cover
- Crop residues
- Organic fertilisers

- Fertilisers’ application

Linking Environment and Farming (LEAF, UK)

This platform promotes integrated farm management and provides an Audit Tool as well as a brief questionnaire about water management (without making farm-specific recommendations), so there would be a very significant opportunity to place the SmartSOIL Toolbox within the Farmer resources page.

There are many links provided to external websites (though many are still within the LEAF umbrella, e.g., Let Nature Feed Your Senses), so if SmartSOIL could point to the link between SOC management and their promoted IFM, adding a link to the SmartSOIL toolbox would be a natural enhancement of their resources.

Other websites

Moreover, general findings on soil fertility and soil carbon management could be integrated or linked to:

- Farming Futures: SmartSOIL factsheets or videos could be integrated into the platform under case studies or the video library
- Food Climate Research Network: would provide a dissemination outlet for SmartSOIL results, using their already well established network of researchers and practitioners
- EU Adaptation Platform: SmartSOIL findings on the benefits of soil carbon management on agricultural productivity could be disseminated through this website

5 Summary of recommendations and implications for the development of the SmartSOIL DST and toolbox

The following section presents the main findings of the DST and platform review (in terms of success features and recommendations) to inform the subsequent development of the SmartSOIL DST and toolbox.

5.1 Recommendations and implications for developing the SmartSOIL toolbox

- The toolbox needs to meet the actual needs of potential users, which further reinforces the value of SmartSOIL consultations in case study areas.
- The messages for the toolbox have to be specific and careful consideration needs to be given to which formats best fit which message. A number of positive examples are available which can be used as a basis for SmartSOIL tools, including factsheets available on Farming for Better Climate, and video and audio podcasts on Farming Futures and LEAF UK websites.
- The design of the toolkit should consider the possibilities for how the toolkit could be used in direct interaction with farm advisors and farmers. The toolkit could be used by advisory services to facilitate meetings with farmers (for example, introductory video(s) on soil organic matter management, or excerpts from technical guidance could be used to introduce the subject matter and facilitate discussions).
- Several opportunities are available for integrating different elements of the SmartSOIL toolbox with existing websites, in particular with the LandsbrugsInfo platform or resource sections of the Farming Futures, LEAF, CLIMATE-ADAPT websites.
- It needs to be clarified as soon as possible what the lifespan of the SmartSOIL website and potential for toolbox maintenance are. This will enable the selection of the most relevant tools to be used.
- This review identified positive features of several tools. These can be taken up in the design of the prototype and tested with the target groups. Factsheets, farm case studies, technical guidance, videos and audio podcasts as well as search tools are all suitable tools for the SmartSOIL toolbox. Blogging and news entries, Twitter, as well as feedback and commenting functions, on the other hand, would only be relevant if the toolbox can be maintained and updated regularly beyond the lifespan of the SmartSOIL project.
- Integration and synergy with other similar ongoing projects, e.g., Catch-C.

5.2 Recommendations and implications for developing the SmartSOIL DST

For each of the different DST development phases, recommendations are provided below.

Development phase

- Define end-user group at the beginning of the DST development, selecting a reasonable number of end-users to avoid too many different priorities and views of the problem
- Involve the anticipated end-users from the beginning (starting with the conceptual phase) and on a regular basis to reveal their needs and demands and address those, and to develop an ownership of the DST (e.g., via stakeholder workshops, demonstration, and testing phases applying real farm data and farm trials)
- Analyse the key questions and decisions of the user group and approach these on behalf of the users' perspective (rather than selecting a scientific approach)
- Take into account social issues and transfer a sufficient level of knowledge to the local actors involved to validate the DST
- DST should not be so complex so that it is difficult to use (including the underlying calculations)
- Involve experienced researcher and programmers to develop the DST
- Need for sufficient and reliable data to build on
- Provide access to the assumptions and process behind the calculations and recommendations made

Implementation phase

- DSTs should be easy to use and intuitively designed for the target users to understand and effectively utilise the different features
- The amount of data required for input by the user should be easily accessible and/or known to the user in order to lower administrative burdens
- Time and effort required to use the DST should not be overwhelming
- Flexibility of the tool can be augmented by providing users with various options for data entry (e.g., drop-down menus, default values, suggested ranges, exact values)
- Tools should still be able to function regardless whether the data entered is more limited than the scope of the DST or which target user is operating the tool (i.e., target users should be able to use the tool without requiring expert assistance)

- Guidance and support becomes increasingly more necessary as the complexity of the tool increases (often corresponding with the detailed nature of the outputs)
- DSTs should be directly accessible via the website for enhanced user access, lower technical requirements, and ongoing updates by the developer
- DSTs should avoid making users perform double entry of data (e.g., allow DST to link to other software programmes, electronic upload from other sources, information saved from previous data entry sessions)

Results phase

- Results should be provided in various formats to allow for detailed and comprehensive breakdowns of the various components of the data entered (e.g., text, graphs, videos, demonstrations, etc.)
- Farm-specific calculations increase the usefulness of the results – in consequence, DSTs should reduce reliance on general default values to provide a more in-depth basis for decision making
- Providing recommendations to the user based on the data outputs assists with interpretation, implementation, and usefulness of the results
- Transparency of the DST's data on which calculations are based, assumptions made, uncertainties, calculation formulas, and results should be maintained to increase user confidence in the tool's outputs
- The tool should cover major elements of the issues being addressed by the DST (which can be modelled and for which there is sufficient data) in order to be comprehensive. For example, if the tool is intended to measure GHG emissions, including land use change increases the comprehensiveness of the results
- Trade-offs may result from trying to increase the detailed and useful nature of the results (e.g., cost-effectiveness calculations and recommendations as to mitigation options may decrease the tool's intuitiveness or ease of use and increase the need for assistance by expert users). Developers should strive to find a balance between what is scientifically possible to model and what will be useful and relevant to farming systems.

Dissemination phase

- Develop tailored and easy to understand training materials in the respective languages
- Endorsement and/or required use of the DST by well established and recognised organisations, regulatory schemes, and companies can greatly increase uptake and continued relevance of the tool

- Integrating the DST into other existing and relevant tools, platforms, and websites would broaden the scope of potential users and increase the uptake
- Use different means of dissemination (newsletter, journals, workshops, and training sessions) to inform the target group about the tool

Support phase

- Uptake of the tool and its ability to impact decision making will only be effective if use is sustained over a long period of time, so the DST must be flexible enough to cope with evolving on-the-ground issues, new scientific developments, and changing user needs in order to stay useful and relevant
- Problems with the software if not maintained or ongoing support is not provided may frustrate users and cause the tool to be abandoned
- Support should be provided for users to effectively use the tool, and it can be provided in many different ways (e.g., user guides, webinars, training sessions and workshops, FAQs and troubleshooting, case studies, newsletters, etc.)
- New features and models should consider whether there is sufficient data available on which to base calculations and whether it is scientifically robust enough to provide reliable results on which users can base decisions
- The data on which the DST is based must continue to be updated – it is easier for users if the data is automatically updated (e.g., DLBR Mark Online) rather than having to manually update downloaded standalone versions of the tool

6 References

Adaptation platform (EU), http://climate-adapt.eea.europa.eu/.

Audsley, R., Reid, G., Topp, K. (2013) Mitigating emissions from livestock: Assessing the effectiveness of the Farming for a Better Climate Initiative, http://www.sruc.ac.uk/downloads/file/1242/mitigating_emissions_from_livestock.

Booty, W., Wong, I., Lam, D., Resler, O. (2009) A decision support system for environmental effects monitoring. Environmental Modelling & Software, 24: 889-900.

CALM – Carbon Accounting for Land Managers (UK), http://www.calm.cla.org.uk/.

Canillas, E., Salokhe, V. (2002) A decision support system for compaction assessment in agricultural soils. Soil & Tillage Research, 65: 221-230.

CFT – Cool Farm Tool, Unilever (UK), http://www.coolfarmtool.org.

Colomb et al. (2012) Review of GHG Calculators in Agriculture and Forestry Sectors: A Guideline for Appropriate Choice and Use of Landscape Based Tools. Report by Ademe (French Environment & Energy Management Agency), IRD (Institut de recherche pour la développement), FAO, and French Ministry of Ecology, Sustainable Development and Energy.

CLA – Country Land & Business Association (2013) CLA CALM Calculator, http://www.calm.cla.org.uk/.

CPLAN – Carbon Footprint Calculator (UK), http://www2.cplan.org.uk/.

Denef, K., Paustian, K., Archibeque, S., Biggar, S., Pape, D. (2012) Report of Greenhouse Gas Accounting Tools for Agriculture and Forestry Sectors. Interim report to USDA under Contract No. GS23F8182H.

Denzer, R. (2005) Generic integration of environmental decision support systems – state-of-the-art. Environmental Modelling & Software, 20(10): 1217-1223.

Deutscher Verband für Landschaftspflege (German Association for Landscape Management) (DE), http://www.lpv.de/.

DLBR Mark Online – Dansk Landbrugsrådgivning Mark Online (DK), www.planteIT.dk.

DLBR Dansk Landbrugsrådgivning (2013) DLBR Mark Online, http://it.dlbr.dk/DLBRPlanteIT/DLBRMarkOnline/DLBR_Mark_Online.htm.

Dragan, M., Feoli, E., Fernetti, M., Zerihun, W. (2003) Application of a spatial decision support system (SDSS) to reduce soil erosion in northern Ethiopia. Environmental Modelling & Software, 18: 861-868.

Elhag, M., Walker, S. (2011) A Decision Support Tool to Assess Desertification Condition in Arid and Semi-Arid Regions. International Journal of Water Resources and Arid Environments, 1(5): 378-381.

FAO Platform – Food and Agriculture Organisation of the United Nations (global), http://www.fao.org/tc/exact/sustainable-agriculture-platform-pilot-website/en/.

Farming for a better Climate (UK), http://www.sruc.ac.uk/climatechange/farmingforabetterclimate/.

Farming Futures (UK), www.farmingfutures.org.uk/.

Farmscoper (UK), http://www.adas.co.uk/Home/Projects/FARMSCOPER/tabid/345/Default.aspx.

Farm Carbon Calculator (UK), http://www.climatefriendlyfood.org.uk/carboncalc.

Farm Carbon Calculator (2013) Introduction to the Carbon Calculator, http://www.cffcarboncalculator.org.uk/calculator-introduction.

Food Climate Research Network (UK), www.fcrn.org.uk.

Freebairn, D.M., Robinson, J.B., Glanville, S.F. (2002) Software tools for learning and decision support, http://www.apsru.gov.au/apsru/Projects/wfs/pdffiles/ (accessed 6 April 2005).

Gooday, R.D., Anthony, S.G., Chadwick, D.R., Newell-Price, P., Harris, D., Duethmann, D., Fish, R., Collins, A.L., Winter, M. (forthcoming) Modelling the cost-effectiveness of mitigation methods for multiple pollutants at farm scale. Science of the Total Environment, http://dx.doi.org/10.1016/j.scitotenv.2013.04.078.

Gooday, R., Anthony, S. (2010) Mitigation Method-Centric Framework for Evaluating Cost-Effectiveness, Defra Project WQ0106 (Module 3). ADAS UK Ltd, http://www.adas.co.uk/LinkClick.aspx?fileticket=eQhJ6FC_680%3d&tabid=345.

Hall, P., Holmes-Ling, P., Stewart, K., Sheane, R. (2010) A Scottish farm-based greenhouse gas accounting tool for Scotland. Report for the Scottish Government by Laurence Gould Partnership Ltd. and Best Foot Forward.

Hammill, A., Harvey, B., Echeverria, D. (2013) Understanding Needs, Meeting Demands: A user-oriented analysis of online knowledge brokering platforms for climate change and development. International Institute for Sustainable Development.

Hochman, Z., Carberry, P.S. (2011) Emerging consensus on desirable characteristics of tools to support farmers' management of climate risk in Australia. Agricultural Systems, 104: 441–450.

Ingram, J., Mills, J., Frelih-Larsen, A., Davis, M. (2012a) Uptake of soil management practices and experiences with decision support tools: Analysis of the consultation with the farming community. Deliverable 5.1 of SmartSOIL Project, http://smartsoil.eu/fileadmin/www.smartsoil.eu/WP5/D5_1_Final.pdf

Ingram, J., Mills, J., Frelih-Larsen, A., Naumann, S. (2012b) Is the SmartSOIL project decision support tool (DST) a boundary object? Using stakeholder consultation to enhance salience, credibility, and legitimacy of the DST. Paper presented at the 10th European IFSA Symposium, 1-4 July 2012, Aarhus, Denmark.

Keil, M., Carmel, E. (1995) Customer-Developer Links in Software Development. Communications of the ACM, 37(5): 33-44.

Kissinger, G. (2012) Corporate social responsibility and supply agreements in the agricultural sector: Decreasing land and climate pressures. CCAFS Working Paper no. 14, http://www.coolfarmtool.org/reports/ccafs-wp-14-csr_ag-web.pdf.

Landbrugsinfo (DK), https://www.landbrugsinfo.dk/.

Lawrence, E., Beare, M., Tregurtha, C. (2010) Development of a soil quality decision support tool to identify and support best management practices. 19th World Congress of Soil Science, 'Soil Solutions for a Changing World', 1–6 August 2010, Brisbane, Australia.

LEAF – Linking Environment and Farming (UK), http://www.leafuk.org/leaf/home.eb.

Little, T., Smith, L. (2010) Carbon footprinting for farm businesses. Better Organic Business Links (BOBL), http://www.organiccentrewales.org.uk/uploads/carbcalcfull_report_a4.pdf.

LIZ Humusbilanz – Humus balance calculator (DE), http://www.liz-online.de/gi/dueng/liz-humusbilanz.htm.

McIntosh, B.S., Ascough II, J.C., Twery, M., Chew, J., Elmahdi, A., Haase, D., Harou, J.J., Hepting, D., Cuddy, S., Jakeman, A.J., Chen, S., Kassahun, A., Lautenbach, S., Matthews, K., Merritt, W., Quinn, N.W.T., Rodriguez-Roda, I., Sieber, S., Stavenga, M., Sulis, A., Ticehurst, J., Volk, M., Wrobel, M., van Delden, H., El-Sawah, S., Rizzoli, A., Voinov, A. (2011) Environmental decision support systems (EDSS) development – Challenges and best practices. Environmental Modelling & Software 26: 1389-1402.

McIntosh, B.S., Giupponi, C., Smith, C., Voinov, A., Assaf, H., Crossman, N., Gaber, N., Groot, J., Haase, D., Hepting, D., Kolkman, R., Matthews, K., Monticino, M., Mysiak, J., Quinn, N., Scholten, H., Sieber, S. (2008) Bridging the gaps between design and use: developing tools to support management and policy. In: Jakeman, A.J., Voinov, A., Rizzoli, A.E., Chen, S.H. (eds.), Environmental Modelling, Software and Decision Support: State of the Art and New Perspectives. Amsterdam: Elsevier.

Mir, S.A., Quadri, S.M.K. (2009) Decision Support System: Concepts, Progress and Issues – A Review. In Lichtfouse, E. (ed.), Climate Change, Intercropping, Pest Control and Beneficial Microorganisms: Springer, pp.373–400.

MPI – Ministry of Primary Industries (formerly MAF), Fertiliser Association of New Zealand (FANZ), AgResearch (2012) Quick Start Guide, http://www.overseer.org.nz/Portals/0/Release%20notes/Quick%20start%20guide%20jan%202013.pdf.

Narayanan, M., Reddy, J.B., Burckhard, S., Gustafson, D.A., Erickson, L.E., Kulakow, P., Leven, B.A. (2000) Vegetated Treatment of Vehicle Wash Sediments: Designing a Graphical User Interface. Proceedings of the 2000 Conference on Hazardous Waste Research.

Nguyen, N., Wegener, M., Russell, I. (2006) Decision support systems in Australian agriculture: state of the art and future development. Proceedings of the 26th Conference of the International Association of Agricultural Economists, Gold Coast, Australia.

OVERSEER for on-farm management and decision support (NZ), http://www.overseer.org.nz/Home.aspx.

OVERSEER (2013) Why produce nutrient budgets?, http://www.overseer.org.nz/.

Robinson, J.B. (2004) Understanding and applying decision support systems in Australian farming systems research. PhD Thesis, University of Western Sydney, NSW, Australia.

Shepherd, M., Wheeler, D. (2010) OVERSEER® Nutrient Budgets – Thoughts on Developing a Decision Support Tool. AgResearch Ltd, http://www.overseer.org.nz/LinkClick.aspx?fileticket=0ZZecZ-af7k%3D&tabid=81.

Smith, J.U., Dailey, A.G., Glendining, M.J., Bradbury, N.J., Addiscott, T.M., Smith, P., Bide, A., Boothroyd, D., Brown, E., Cartwright, R., Chorley, R., Cook, S., Cousins, S., Draper, S., Dunn, M., Fisher, A., Griffith, P., Hayes, C., Lock, A., Lord, S., Mackay, J., Malone, C., Mitchell, D., Nettleton, D., Nicholls, D., Overman, H., Purslow, J., Scholey, A., Senior, S., Sim, L., Taylor, P. (1997) Constructing a nitrogen fertilizer recommendation system using a dynamic model: what do farmers want? Soil Use and Management, 13(4): 225-228.

Smith, R. et al. (2010) Mitigating Greenhouse Gas Emissions from Scottish Farms. In Crighton, K., Audsley, R. (eds.) Agriculture and the Environment VIII -- Climate, Water and Soil: Science, Policy and Practice, Proceedings of the SAC and SEPA Biennial Conference, Edinburgh, 31 March–1 April 2010.

Soil Association: Producer Support, Carbon footprinting on farms, Information sheet, http://www.soilassociation.org/LinkClick.aspx?fileticket=8pChoXbFOtk%3D&tabid=1482.

Stewart, R., Purucker, S. (2011) An environmental decision support system for spatial assessment and selective remediation. Environmental Modelling & Software, 26(6): 751-760.

Whittaker, C., McManus, M., Smith, P. (2013) A comparison of carbon accounting tools for arable crops in the United Kingdom. Environmental Modelling & Software, pp.1-12, http://dx.doi.org/10.1016/j.envsoft.2013.03.015.

Zhang, Y., Collins, A.L., Gooday, R.D. (2012) Application of the FARMSCOPER tool for assessing agricultural diffuse pollution mitigation methods across the Hampshire Avon Demonstration Test Catchment, UK. Environmental Science & Policy, http://www.avondtc.org.uk/Portals/0/Literature/Avon%20Farmscoper%20paper%20%20.pdf.

Wenger, E.C., White, N., Smith, J.D. (2009) Digital habitats: Stewarding technology for communities. CPsquare, http://technologyforcommunities.com.

7 Annex

Table 7: Assessment criteria and scoring of DSTs

Criteria	Description	Evaluation scores	CFT	CALM	Farm-scoper	CPLAN	LIZ	Over-seer	FCC	DLBR
User-friendliness and flexibility										
Ease of use/ Intuitiveness	How easy or difficult is the DST to use? How intuitive is its use? (e.g., impractical, overly complex, excessively time-consuming, or requiring an advanced knowledge base can make DSTs hard to use)	1 - low 2 - medium 3 - high	2	3	2	3	3	2.5	3	2
Administrative burden	Is there an estimate of how much time it would take to fill out the DST? Is the time investment significant to interpret the results? Can the farmer do it him/herself or would an advisor have to help?	3 - low 2 - medium 1 - high	1.5	3	2	3	3	2	2.5	2
Flexibility of inputs	Are there drop-down menus, default values, or suggested ranges to simplify entry of data for the user? Does an exact value need to be entered?	1 - low 2 - medium 3 - high	3	2	2	1	2	2	2.5	2
Adaptable to different users/ scopes	Can tool still function effectively if all data sets are not filled in (e.g., small-scale producers, limited scope of farm emissions desired)?	1 - low 2 - medium 3 - high	3	3	3	3	1	1.5	1	2
Support/ guidance	Support and/or guidance for the use provided (e.g. one-to-one advice on farm and in workshops to help with understanding and implementing the DST results)	1 - not sufficient 2 - sufficient 3 - good	3	2	3	1	2	3	2	3
Quality of results										
Informative/ usability of results	The DST is considered informative if its results are easy to analyze and clear. This criterion can vary based on specificity, making the DST less informative if the results are not farm-specific, further broken down into different categories, shown spatially, etc.; How useful are the results? Can they be applied by the target group?	1 - low 2 - medium 3 - high	2	2.5	2.5	1	2	2.5	3	3

Criteria	Description	Evaluation scores	CFT	CALM	Farm-scoper	CPLAN	LIZ	Over-seer	FCC	DLBR
Transparency	Clarity on what inputs were used, user or evaluator access to the original calculations, and clarity on how the different methods employed affect the outputs	1 - low 2 - medium 3 - high	3	1.5	1	2	1	2	1	2
Comprehensive/ accurate results	Has the DST a broad scope in the amount of relevant data covered and relevant output delivered? How accurate are the results (are they based on farm data)?	1 - low 2 - medium 3 - high	3	1.5	2.5	1	2	2.5	2.5	2.5
Up-to-date nature of results	Is the tool up-to-date with the models providing the basis for calculations (e.g., new versions)? Do users need to update the software? Is this complicated?	1 - low 2 - medium 3 - high	3	1.5	3	1	1.5	3	3	3
Accessibility										
Free of charge	Is the tool free of charge or require a fee?	Y - Yes N - No	Y	Y	Y	Y[14]	Y	Y	Y	N
Technological requirements[15]	Internet access, specific software	3 - low 2 - medium 1 - high	2	3	2	3	3	2	3	2
Expert knowledge required	Based on the indicated target group, was additional expert knowledge required to be able to use the DST effectively?	3 – low 2 - medium 1 – high	1.5	2	2	3	3	2	3	2.5
Uptake, integration potential and impact										
Uptake by target group	How many farmers, farm advisors etc. have used the tool? In which regions and/or countries is the tool used	1 - low 2 - medium 3 - high	3	3	1	n/a	2.5	3	2	3
Integration or	Is the DST used by farmers or advisors as an add-on to another DST? Or have they integrated results from the DST into another DST? Based on	1 - low	3	1.5	2	2	2.5	2	n/a	3

[14] More specific results are available by using v.2, which requires users to pay a fee per emissions report.

[15] As clarified in the Excel spreadsheet for each DST review, the tool was rated 'low' if only internet access was required (i.e., web-based), 'medium' if the tool required downloading from the internet, and 'high' if there was some specific programme or software that had to be installed.

Criteria	Description	Evaluation scores	CFT	CALM	Farm-scoper	CPLAN	LIZ	Over-seer	FCC	DLBR
add-on potential	the format, is this a possibility to integrate the results or use it as an add-on? Were there complications arising if the DST or its results were used for this purpose?	2 - medium 3 - high								
Problems experienced/ weaknesses	Which problems have been experienced in implementing and using the tool?	3 – few 2 - some 1 - several	2	2	2	1.5	3	2	2	2
Potential Impact *(as no information on the actual impact is available)*	What impact does the tool have (e.g., on change of practices, income, initiating further projects, reduction of GHG emissions)	Environmental positive: 1 - low 2 - medium 3 - high	2	2	2.5	1.5	1.5	3	2	3
		socio-economic; positive: 1 - low 2 - medium 3 - high	2.5	2	2.5	1	1	2	2	2.5
Soil carbon management	Does the DST address the issue of soil carbon management?	1 - low 2 - medium 3 - high	1	1	–	1	3	–	–	1

n/a – no information available