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

Managing Soil Organic Carbon: A Farm Perspective

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Summary

Farming practices that lead to declining returns and inputs of carbon to soils pose a threat to key soil functions. The EU FP7 interdisciplinary project SmartSOIL is using scientific testing and modeling to identify management practices that can optimise soil carbon storage and crop productivity. A consultation with advisors and policy makers in six European case study regions seeks to identify barriers to, and incentives for, uptake of such practices. Results from preliminary interviews are reported. Overall advisor and farmer awareness of management practices specifically directed towards soil carbon is low. Most production related decisions are taken in the short-term, but managing soil carbon needs a long-term approach. Key barriers to uptake of practices include: perceived scientific uncertainty about the efficacy of practices; lack of real life 'best practice' examples to show farmers; difficulty in demonstrating the positive effects of soil carbon management practices and economic benefits over a long time scale; and advisors being unable to provide suitable advice due to inadequate information or training. Most farmers are unconvinced of the economic benefits of practices for managing soil carbon. Incentives are therefore needed, either as subsidies or as evidence of the cost effectiveness of practices. All new measures and advice should be integrated into existing programmes to avoid a fragmented policy approach.

The multifunctional nature of soils is responsible for a diverse suite of ecosystem goods and services. Soils support the production of plants, thereby satisfying a wide range of needs, including food, feed, fibre and energy for a growing human population. At the same time they provide a range of regulating and supporting functions related to climate change and removal of greenhouse gases. The majority of these functions are closely linked to the stocks and flows of soil organic carbon (Smith, 2012). The carbon content of soil affects both physical and chemical properties of soil and is a major factor in its overall health and productivity. Current interest in soil carbon relates to its role, or potential, as an atmospheric carbon sink. In the context of climate change, maintaining soil carbon stocks and reducing carbon dioxide emissions contributes to mitigation.

Farming practices that lead to declining returns of carbon to, and loss of carbon from, soils pose a threat to these soil functions. There is a need, therefore, to identify agronomic and soil management practices that can optimise soil carbon storage and crop productivity. This is the aim of **SmartSOIL** (**S**ustainable farm **M**anagement **a**imed at **R**educing **T**hreats to **SOIL**s under climate change), an interdisciplinary project funded by EU Framework 7 (see Box). The SmartSOIL project is using meta-analyses of data from European long-term experiments to model the impact of different farming practices on soil organic carbon in arable and mixed farming systems. This modelling will identify those practices that increase carbon stocks and optimise carbon use (flows). However, farmers need to be willing and able to implement any practices identified as optimum by this scientific modelling. As such, understanding the socio-economic context is an integral part of this project. This understanding is being achieved through consultation with the farming and policy community and is the main focus of this article.

There is an extensive literature on farmer decision-making in the context of adopting agronomic practices and innovations (Knowler and Bradshaw, 2007). This has shown that a range of interacting social, cultural and economic factors influences farmers, and that they have heterogeneous motivations. Farmer behaviour with respect to managing soil carbon has not, to date, been widely researched. However, studies have shown that individual farmers are often interested in short-term financial gains from increasing productivity and less concerned about the long-term sustainability of agricultural practices. These insights are relevant to soil carbon, which responds to crop management changes very slowly and thus offers no obvious benefits in the short-term. Equally farmers are known to be reluctant to change cropping practices if there are risks or possible financial penalties. Limited market incentives for farmers to improve soil carbon services, together with the role soil carbon plays in climate change mitigation, has lead policy makers to consider soil carbon largely as a public good, and as such is a key policy concern. SmartSOIL aims to identify practices that can optimise soil carbon storage *and crop productivity* and thus offer some private benefit to farmers, and some alternative approaches for policy makers.

There is large uncertainty with regard to the efficacy of different management practices to enhance soil carbon across different soil types and climatic conditions. Equally, the total carbon changes may be relatively small for many agricultural management practices and thus long periods may be required to measure small differences in carbon accumulation. However, there is general agreement that managing the amount and quality of organic matter inputs in soil and reducing the intensity of tillage can positively influence soil carbon stocks and flows, and thus have the potential to offset some carbon emissions. For the purposes of the consultation five sets of management practices were identified as having the potential to increase soil carbon stocks: planting catch (cover) crops, crop rotations, residue management, reduced tillage operations, and fertilizer and manure management. These were selected by drawing on project partner expertise and on an extensive review of research (Flynn *et al.*, 2007; Smith *et al.*, 2007). While these agronomic practices can be considered as soil carbon management practices they also provide a range of other important functions.

Objectives of SmartSOIL www.smartsoil.eu [INSERT SMARTSOIL LOGO HERE]

The aim of SmartSOIL is to contribute to reversing the current degradation trend of European agricultural soils by improving soil carbon management in European arable and mixed farming systems. This entails two overall objectives:

- To identify farming systems and agronomic practices that result in an optimized balance between crop productivity, restoration and maintenance of vital soil functions (fertility, biodiversity, water, nutrient cycling and other soil ecosystem services) and soil carbon sequestration and storage.
- To develop and deliver a Decision Support Tool (DST) and guidelines to support novel approaches, techniques, and technologies adapted to different European soils and categories of beneficiaries (farmers, farm advisory and extension services, and policy makers).

In a preliminary consultation 60 interviews were carried out with selected agricultural advisors (from public extension and commercial services) and policy makers in six case study regions across Europe (Table 1). These regions have been selected in SmartSOIL to represent a range of biophysical, farming system and socio-economic contexts. Advisors were interviewed both to represent farmers and to give an informed and broad view about farming activities. Project partners in each case study conducted these face-to-face interviews using a semi-structured template. They identified respondents with some expertise in soil management using local contacts and a snowballing technique (a small pool of initial informants identifies, through their social networks, other participants with the specific expertise that could contribute to the study). Respondents were firstly asked about the policy context for promoting the management of soil carbon with a focus on the practices that can potentially enhance soil carbon, listed above. They were then asked about current awareness of soil carbon management and about the extent to which associated practices were implemented. Finally, they were consulted more generally about barriers to, and incentives and advice for, the uptake of practices that can enhance soil carbon stocks.

Current promotion of soil carbon management

There are currently no specific government policies or programmes for promoting soil carbon management in any of the case study regions. Soil carbon management is rarely a subject of advice on its own, but it is an integrated part of other programmes, such as cross-compliance and agri-environmental schemes of the CAP, and fertilizer and manure management programmes under EU Directives (Water, Nitrates) where the focus is water quality. Moreover, measures specifically relating to climate change mitigation in agriculture do not address soil carbon storage.

Currently, the EU cross-compliance measures represent the most active legislative tool dealing with soil management in the case study regions. Here, the focus is on soil protection and the legal requirements of Good Agricultural and Environmental Condition (GAEC) and, to a lesser extent, on practical and technological agronomic information. Crop rotations, fertilizer management, residue management (arable stubbles being popular) and reduced tillage practices were commonly mentioned by respondents. These are promoted as part of an overall approach to good soil management practices through cross compliance, other regulatory measures and voluntary initiatives. Dissemination of knowledge relating to soil protection problems, however, lags behind that of other environmental issues. Table 1 summarises the main practices currently promoted in each region and country.

Table 1: Current promotion of management practices that potentially enhance soil carbon in six case study regions

Case study region	Practices promoted and barriers
Denmark Sjælland	*Promoted*: Soil management is an integral part of an overall crop production strategy aimed at gaining the best economic output, and soil carbon management is a part of this. Practices, promoted as part of an overall approach to good soil management, include: planting catch crops, crop rotations, residue management, managing perennial grasses, manure and fertilizer management and reduced tillage. *Barriers*: Lack of visual evidence that these practices benefit soil health, are cost effective and enhance crop yield in the long-term.
Hungary: Közép-Magyarország	*Promoted*: Advice on soil management practices focuses primarily on degradation and nitrate pollution issues. There is an emphasis on reducing greenhouse gas emissions and fostering bio-energy production and use in the climate change mitigation context. Practices, promoted as part of an overall approach to good soil management, include: appropriate crop rotations, organic manure input, restricted management options on steep slopes, reduced-tillage and grass or mulch layers in orchards. *Barriers*: Innovative practices are subsidy driven. Farmers are mostly concerned about complying with regulations. Commercial advice conflicts with advice on soil management concerned with the supply of ecological services (public goods).
Italy: Tuscany	*Promoted*: Practices in cross compliance measures which can contribute to improving soil carbon in the soil: minimum tillage, stubble management, green manure, crop rotation, and minimum soil cover and terracing maintenance. *Barriers*: Farmer reluctance to take up unfamiliar practices and to integrate them into consolidated farm management systems. New practices are not supported by practical evidence of effectiveness.
Poland: Mazowieck	*Promoted*: Practices promoted relate to cross compliance requirements and include: cover crops, crop rotations and manure and fertilizer management. *Barriers*: Farmer (and administration) awareness of environmental/climate threats is low. This, together with low profitability of the agricultural sector, impedes implementation of soil management practices. Moreover, many farmers have limited education; and the quality of (free) state advisory services is inadequate.
Scotland: Eastern Scotland	*Promoted*: Measures are mostly focused on tackling farm efficiencies and farm productivity by reducing waste and greenhouse gas emissions. Soil carbon management is promoted within the Farming for a Better Climate initiative. Measures promoted include: nutrient planning and management of rotations as part of Nitrate Vulnerable Zones. Cover crops are not grown due to a short growing season. *Barriers*: Markets and commercial imperatives override good intentions

	and practices. Regulations and agri-environment scheme prescriptions are not always compatible with beneficial soil management.
Spain: Andalucía	*Promoted*: Practices, promoted as part of an overall approach to good soil management, include: reduced tillage, erosion safe cultivation, catch crops, fallow fields, residue management, manure and fertilizer management, crop rotations and extensive farming, pasture, and organic farming. *Barriers*: Lack of consensus on 'best practice' in Mediterranean/semi-arid climates. Measures exist but there is no process for tailoring them to farms. The high number of tenant occupied farms is a barrier to uptake.

Awareness and implementation of soil carbon management

The extent to which farmers are aware of practices that contribute to soil carbon varies considerably across the case study regions. Equally, there is wide variation in how farmers understand the issue and implement measures. As soil carbon management is relatively new, awareness amongst farmers is generally limited. In some countries, for example, Denmark and Scotland, there is a growing interest in the issue, particularly amongst organic farms and large agri-businesses. In other countries, notably Poland, awareness remains low. There is also variation in the extent of awareness within countries reflecting farmer age, educational background and farm type.

Farmers implement practices in response to regulatory measures and take voluntary initiatives but, in the case of reduced tillage, potential savings on costs (fuel) and time (labour) are driving farmer interest. The extent to which practices are implemented seems to depend on the level of farm economic security. Many farmers (and some advisors) are unconvinced of the economic benefits of managing soil carbon. The expectations of farmers also dictate what advice is provided. Many farmers are only concerned with complying with regulations, as one advisor remarked: *'Farmers do not expect advisors to provide them with technological information. They want support on how to fulfill the EU requirements'*.

Whilst advisors in most of the case study regions have a good knowledge of cross compliance soil protection requirements, their knowledge of managing soil for carbon tends to be low. Both farmers and advisors in Denmark and Scotland are better informed than in other study countries. In Poland it appears that advisors are generally unaware of the need for soil carbon management, or indeed more generally of the role of farming in climate change mitigation. This is attributed in part to poor advisor training. Policy makers in Poland and Hungary are also largely unaware of soil carbon management issues, and current policy is primarily focused on meeting EU soil management obligations through cross compliance.

Barriers to the promotion and uptake of soil carbon management

One of the main concerns expressed by respondents was the perceived scientific uncertainty about soil carbon management. Although they were aware of debates about the efficacy of different practices, they believed that there is no consensus about what is the best practice for storing carbon under certain conditions. There is a sense that scientists themselves do not yet fully understand soil carbon dynamics, and this reduces the credibility of the practices they recommend. Respondents also felt that systematic assessment of different practices was missing. For this reason advisors felt ill equipped to respond to farmers' needs. One acknowledged that even ‘experts’, like himself, do not know which practice to recommend when farmers ask for advice. They also lack information on the cost effectiveness of practices. The ability of advisors to provide credible soil advice is also constrained by inadequate training, and limited staff and financial resources in advisory services were mentioned in the cases of Hungary and Poland.

In Spain it appears that the real problem is that scientists do not fully understand the farming context and fail to take local farm conditions and practices into account. One advisor remarked: *‘Even if the scientific community come to a consensus on best practice, it is likely that the practices defined will be so far removed from current practice that they [farmers] won’t implement it.’*

Most production-related decisions are taken in the short-term but managing soil carbon needs a long-term approach. A range of factors affects farmers’ capacity to act in the long-term including uncertainty about the weather, policy and market developments in addition to internal farm factors (such as debt, tenure, and family status). Linked to this respondents highlighted the difficulty of demonstrating the positive effects of soil carbon management practices. They pointed to the lack of evidence that certain practices benefit soil carbon in terms of cost effectiveness and crop yield over a long time scale.

Respondents in Spain and Italy raised the issue of geographical heterogeneity, within regions, countries and across Europe, with respect to providing evidence of effective measures. The problem of translating appropriate measures to the farm scale was also identified. This issue of regional and farm level diversity was raised by one advisor who commented: *‘You have to be aware of different areas and different practices. What might apply to one farm will not be appropriate for another’*. There are also specific farm factors that can hamper uptake of practices. In Spain, for example, a high proportion of tenant farms were identified as a barrier, as tenant farmers tend not to manage their land for long-term benefits.

There were also barriers identified in relation to farmers’ perceptions, priorities and knowledge. Soil carbon is of low importance to farmers and they lack knowledge or familiarity of soil carbon management practices. In Italy, farmers described as having an ‘agricultural heritage’ were considered as knowledgeable about soil conservation practices, soil organic matter and soil fertility, but not specifically about soil carbon management. Conversely in Hungary, there are many new farmers (re)turning to the land after the transition who have no agricultural tradition in the family. These farmers were described as being unaware of established soil management practices. In Scotland, although farmers tend to have a good understanding of soil management, managing soil carbon is a relatively new and unfamiliar issue.

Practices that potentially increase carbon stocks are often regarded as uneconomic or expensive to implement because of a perceived requirement to invest in new technology. Absence of financial incentives or subsidies to motivate or compensate farmers for possible yield losses compounds this problem. Some of these practices are also considered impractical and farmers encounter difficulty in integrating them into farm management systems. Moreover, farmers do not want to risk non-compliance with cross compliance conditions or with agri-environment scheme prescriptions by changing or introducing new practices. Indeed, in some regions advisors regard the agri-environment scheme prescriptions as potentially in conflict with managing soil carbon, specifically with regard to the dates set for grass cutting and ploughing.

Commercial imperatives are also perceived to conflict with good soil management overall. Demands from the market, either through high prices or time-specific contracts with processors and retailers, can mean that good practice is compromised. For example, in Scotland the harvesting of high value vegetable crops, such as carrots, to meet supermarkets demands causes soil compaction in wet weather. Linked to this there was some suggestion that commercial companies and advisors can provide production-oriented advice which contradicts 'good practice' advice with respect to soil management. Table 1 above lists the specific barriers for the case study regions.

Incentives and advice to encourage uptake of soil carbon management

Respondents agreed that farmers are largely motivated by economic factors and thus tend to have a short-term outlook. In addition, taking mitigating action against climate change is currently not enough of a priority for farmers to adjust their practices without financial incentives. As one respondent in Spain said: *'You cannot just walk up to farmers and tell them to change their practices without any kind of incentive'*. Although financial incentives were mentioned, respondents agreed that demonstrating how practices can potentially improve farm profitability and productivity are equally important for encouraging uptake. However, respondents stressed that that there needs to be a better scientific understanding of the processes and more confidence in any practices recommended before farmers are approached. Scientific clarity and evidence on good practice are very important and real life 'best practice' examples are key to effective demonstration. Equally, the measures promoted need to take account of farm scale conditions. Regulations or sanctions were less popular suggestions than financial incentives for farmers to improve soil carbon management.

The message provided to farmers should, where possible, quantify the impact of soil management measures. This could be in terms of savings and losses, particularly with respect to the level of investment required. Being sensitive to farmers' economic concerns appears to be a key factor, as one policy maker said: *'If the messages we want to communicate do not convey economically viable ideas, then they will be worthless'*. There was also consensus that complex messages should be avoided, and that simple messages, using the 'right' language, make the most impact. Respondents suggested targeting advice and reaching out beyond those farmers who always engage with advice. Integrating messages into existing advisory programmes, policies and regulations to deliver good joined-up advice is seen as very important. As one advisor pointed out: *'information which is too specific (i.e. soil carbon) and communicated as an isolated issue is doomed to failure'*. Finally, improving advisory mechanisms and the quality of advice and advisors was proposed, acknowledging that in some countries lack of resources has led to a limited advisory capacity.

Socio-economic insights are important

These results provide preliminary insights into the socio-economic context of soil carbon management activities in six case study regions, which span a range of biophysical, farming systems and socio-economic contexts across Europe. Although the sample size is limited, a range of informed stakeholders were interviewed in each country. Furthermore, the qualitative in-depth interviews used proved invaluable in revealing details, and explanations, of respondents' perspectives.

The consultation reported here was undertaken as an exercise within the SmartSOIL project to ensure that socio-economic insights are taken into consideration when using scientific modelling to identify optimum practices for soil carbon storage. However, the results are of wider interest with respect to informing future research and policy.

The interviews have shown that there are no policies that specifically address soil carbon management in the case study regions. Aligned to this, advisor and farmer awareness of management practices directed towards soil carbon tends to be low. There is wide variation in how farmers understand the issue and implement practices. Although there is growing awareness of soil protection measures, the narrow focus on meeting cross compliance obligations tends to restrict interest in (and resources available for) other soil management activities. Furthermore, the quality of the advisory services in some countries has an impact on advisor awareness and competence.

A barrier common to all case studies was the perceived scientific uncertainty with respect to optimal practices and measuring soil carbon change. This leads farmers and advisors to question the credibility of scientific recommendations. The need to understand farmers' economic motivations is also clear. Farmers and many advisors remain unconvinced of the economic benefits of managing soil carbon. The difficulty in demonstrating the long-term benefits of practices that enhance soil carbon stocks is compounded by farmers' short-term outlook.

In terms of encouraging uptake of practices, the general view of respondents is that farmers will require financial incentives as increasing soil carbon stocks is regarded more as a public good than a private benefit to farmers. However, providing evidence of benefits to soil, and demonstrating cost effectiveness of practices are seen as equally important in encouraging farmers to implement practices. If private good benefits to agricultural productivity can be demonstrated this may remove or reduce the need for financial incentives. Using long-term experimental sites for this would be one option, although farmers prefer 'real life' cases studies and do have concerns about translating scientific findings to the farm scale. With respect to advice, a common message was that this needs to be delivered using simple language and integrated into existing advisory programmes.

A further key finding from this study is that, although case studies share some common issues, country specific contexts need to be considered. Barriers to uptake of practices can be diverse and related to a number of factors such as biophysical conditions, farmer knowledge and experience, land tenure and the quality of the advisory service. This needs to be taken into account in developing management recommendations, policy and advisory programmes.

This consultation enhances understanding of perspectives about soil carbon within the farming and policy community revealing some areas of interest for future research (scientific and socio-economics) and policy development. It also contributes towards the body of work on farmer behaviour. There will be further consultation activities in the SmartSOIL project, which will refine this analysis and present stakeholders with scientific evidence about the efficacy and cost effectiveness of selected soil carbon management practices. Feedback from this consultation will also help to shape the Decision Support Tool (DST), guidelines and policy recommendations being developed in the project. The research will be complemented by a large-scale farmer survey undertaken in a sister FP7 project Catch-C.

Further Reading

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For more information consult project web sites:
SmartSOIL project www.smartsoil.eu
CATCH-C project http://www.catch-c.eu

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