SoilCare
SOILCARE FOR PROFITABLE AND SUSTAINABLE CROP PRODUCTION IN EUROPE

Review of soil advice

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4	University of Gloucestershire	UoG	United Kingdom
5	University Hohenheim	UH	Germany
6	Research Institute for Knowledge Systems	RIKS	Netherlands
7	Technical University of Crete	TUC	Greece
8	Joint Research Centre	JRC	Italy
9	University of Bern	UNIBE	Switzerland
10	Milieu LTD	MLTD	Belgium
11	Norwegian Institute of Bioeconomy Research	NIBIO	Norway
12	Bodemkundige Dienst van België	BDB	Belgium
13	Aarhus University	AU	Denmark
14	Game & Wildlife Conservation Trust	GWCT	United Kingdom
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Task 8.2 Review of soil advice

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Contents

1 Introduction

1.1 Review aims

This review is undertaken as part of Task 8.2 which states:

Task 8.2 Review of soil related advice landscape at different scales (Lead partner 4, partners: Study Sites, WPs3,7)

Drawing on existing literature and stakeholder knowledge, a review will be undertaken of the advice landscape with respect to soil improving CS. The review will consider the current dissemination and advisory activities with respect to soil and identify how farmers currently obtain information about soil improving techniques distinguishing differences for FMLS 1, 2 and 3. It will inform the development of the dissemination strategy (Task 8.3) by identifying current gaps in advice and dissemination, examples of best practice and key principles for effective knowledge exchange of soil improving CS. Critically it will ensure that SoilCare's outputs are integrated into existing activities and translated into practice, in line with the aims of EIP-AGRI. The review will take place at the European, national level as well as local, regional study site level.

As such this review will consider the current dissemination and advisory activities with respect to soil management in the agricultural context and so help WP8 to plan and implement the project's dissemination activities as effectively as possible (the term soil management is used in its widest sense and incorporates crop and soil management). The review will assess:

- soil management topics already being supported with advice
- advisory services and how farmers currently obtain information about soil management
- gaps in advice and dissemination
- examples of effective advice/best practice
- key principles for effective knowledge exchange of soil improving cropping systems (SICS) (previously called soil improving cropping practices)

Drawing on a number of sources the task will produce the following outputs:

a) This report comprises a review examining the general topic of advice for soil management at the farm level and is structured around the five key issues outlined above. This reviews European and national support and advice, with particular reference to the study site countries where information is available. There are few/no academic papers that specifically examine advice for soil– the review will therefore draw on papers and reports that consider i) advice and information in the context of adoption of broader best management practices (BMP); ii) advice as it relates to policy measures relevant to soil in European countries, concerning all aspects of soil management in arable agriculture i.e. not just SICS; iii) advisory systems and services in European countries primarily referring to the EU Proakis project[1] (Kania et al., 2014); iv) recent relevant research and reviews

[1] Prospects for Farmer Support: Advisory Services in European AKIS http://www.proakis.eu/

conducted in the EU funded projects such as SmartSOIL. The policy review conducted in WP7 (Deliverable 7.1) complements this assessment of the advice landscape for soil. Here the focus is mainly on advisory systems and services, not methods, and draws largely on evidence from arable systems.

b) Individual country summaries initially prepared using the updated recent soil inventory (Frelih-Larsen, 2016), Proakis country reports and other relevant material. These are presented separately. They are being verified with study site partners through completion of semi-structured questionnaires asking specifically about advice for crop and soil management in their countries and regions. These summaries will be supplemented with information gathered in WP3 activities with stakeholders. Specifically responses from the Q methodology interviews conducted with experts (Q11. What role does information (e.g. scientific evidence, agricultural advice and extension) play in supporting/encouraging adoption of soil improving practices); and responses to questions added to the exit questionnaire for the third stakeholder workshop (month 8 to 12; October 16–February 17). In addition the policy review conducted in WP7 will be used to confirm and add to these summaries.

In line with the task's description, the review has informed the development of the dissemination strategy (Task 8.3) by identifying current gaps in advice and dissemination, examples of best practice and key principles for effective knowledge exchange of soil improving CS. These principles will be shared with the study sites and used as basis for developing their site dissemination plans and materials.

2 Contextual issues

There is increasing attention given to the role of soil management and protection in meeting the many challenges of sustainable agriculture, food security, climate change etc., and in addressing the multiple threats to soil (Rojas et al., 2016, Hartemink, 2008). This is reflected in policy development, policy reviews and academic debates concerned with issues of soil security and governance (Weigelt et al., 2015, McBratney et al., 2014, Montanarella, 2015, Montanarella et al., 2016, Montanarella and Vargas, 2012, Turpin et al., 2017, Paleari, 2017). At the same time there has been a resurgence of interest within the farming community in the notion of soil health in some countries (Briggs and Eclair-Heath, 2017, Wood and Litterick, 2017), and in cropping systems that benefit soil (e.g. conservation agriculture, reduced tillage) both in Europe and internationally (Kassam et al., 2014). As part of this interest, the need to provide appropriate information, advice and support to land managers about sustainable soil management (SSM) has been identified at the international[2], European[3] and national levels (McIntire et al., 2009, Frelih-Larsen, 2016, FAO, 2017, Campbell et al., 2017). This interest is

2 Global and European Soil Partnership Pillar 2 aims to encourage investment, technical cooperation, policy, education awareness and extension in soils.

[3] At the EU level the Thematic Strategy for Soil Protection[3] (2006) devotes one of its four pillars to raising public awareness of the need to protect soils, similarly the new established European Soil Partnership's Pillar 2 concerns extension. The Communication as a policy document with no mandatory authority

set against a background of a changing context for advice, firstly in the farming sector and secondly in the wider Agricultural Knowledge and Innovation System (AKIS)[4], which has implications for effectively delivering soil-relevant advice.

Firstly, farmers[5] are facing multiple drivers which steer their business and farm (and therefore crop and soil) management decisions. In response to policy and market signals they are simultaneously intensifying production and having to increase efficiencies (cost cutting and raising productivity) in the face of a volatile and competitive marketplace and falling farm gate prices (Assefa et al., 2016, Smith et al., 2016); while also being urged to innovate or follow diversification strategies in their farm businesses. As well as producing food, feed and other marketable (private) goods, farmers are also now required to preserve natural resources and to deliver a broad range of environmental public goods (ecosystem services) i.e. reduce pesticide and fertiliser use, adapt to climate change etc (according to concepts of sustainable intensification, multifunctional agriculture etc). Cross compliance, a universal mechanism enforced by MS which stipulates GAEC for soil, is accompanied by other regulatory and voluntary programs delivered at national and regional level. These imperatives bring a complex set of demands for farmers, and the need to access credible information and advice has never been greater. Advisory and extension services which disseminate information play an important role in supporting the agricultural sector in meeting these challenges.

Secondly, there has been a transformation in advisory systems[6] and services in countries across Europe with a trend towards more privatised and decentralised extension services (more marked in some countries than others). This change in advisory services is part of a wider shift in AKIS which has led to both vertical fragmentation, impacting research-advice-practice links, and horizontal fragmentation, creating a plethora of public, private (and public-private partnership), NGO and farmer-based advice providers. This has resulted in pluralistic advisory systems comprising a diverse range of actors with differing sets of skills, priorities and delivery approaches often operating in informal communication networks, (Faure et al., 2012, OECD, 2015, Garforth et al., 2003). The rationale for such a shift from supply-led to demand-led advisory services is to put the farmer at the centre of his own information system and to fit their own needs. The negative and positive implications of this shift towards pluralistic systems on the delivery of public good advice have been widely examined (Garforth et al., 2003). All these changes have implications for the soil knowledge systems and soil advice (Kibblewhite et al., 2010, Ingram and Morris, 2007), as discussed later.

This transformation has been accompanied by an evolution in the way Agricultural Knowledge Systems (AKS) are described and understood, from traditional linear models to complex systems of networks (EU, 2013, EU, 2015)[7]. In line with this, farmers are regarded, not as

[4] AKIS a system of diverse actors from the private, public and non-profit sectors that links people and organisations to promote mutual learning, to generate, share, and utilize agriculture-related technology, knowledge, and information.

[5] The term farmers is used here to represent all land managers such as contractors, farm management companies and their managers, smallholders etc who all make management decisions effecting soil.

[6] See Box 2 for definitions

[7] The concept of an AKS implies the integration of agricultural research, agricultural extension, and agricultural education. The evolution to an Agricultural Knowledge and Innovation System (AKIS), as well as the concept of

passive recipients, but as active knowledge producers. Facilitation of learning, rather than information dissemination alone, is now seen to be important, often supplied by a wider range of innovation support services and arrangements (Kilelu et al., 2014, Knickel et al., 2009) . There is now recognition in some countries that if knowledge and innovations are to support the scientific input to sustainable intensification of agriculture then they must also be matched with an understanding of the practices and contexts in which they are to be deployed (e.g. Royal Society, 2009). This is reflected in the European Innovation Partnership's (EIP-AGRI) understanding of innovation (EU, 2013).

Thirdly, there are a range of other contextual changes and trends in European agriculture that are relevant to the delivery of advice about crop and soil management, including:

- The global narrative that in order to meet increases in food demand, crop production will need to increase by 70-110% by 2050 (Smith et al., 2016) provides a powerful justification for many farmers and associated supply chain actors to intensify.
- However, at the same time the value of soil resources is increasingly being recognised by farmers, and there is increasing societal value placed on soil and the wider ecosystem services provided by soils (IEEP, 2016).
- The audience for advice is changing, land managers who make farm and cropping system decisions that impact soil are no longer 'typical family farmers' but comprise a range of differentiated land managers - producers, smallholders, large commercial farm companies and their managers, contractors, all with varying tenure arrangements, supply chain contractual agreements, decision making autonomy, information seeking habits, and stewardship ethic/commitment to the land, both within countries and across Europe.
- At the same time the demographics of the farming population are changing and this has implications for delivery channels and uptake of advice. There is an aging and shrinking population of farmers in many countries, but also in some countries the emergence of a younger generation of innovative 'tech-savvy' farmers, graduates and entrepreneurs who are professionalising farming. There is regional variability, for example in some Eastern Europe countries new entrants with limited knowledge and experience are turning to farming, while in other contexts lifestylers are now managing farms.
- Market pressure on farmers has led to farm restructuring. In western European countries there has been a trend towards amalgamation of farms into larger holdings (economies of scale), a decline in middle sized family farms, with a coincident rise in contracting. This is accompanied by changing systems or approaches, for example, there has been a shift towards simplified tillage practices in larger arable farms (Techen and Helming, 2017). In France these are growing more popular and represented 34 % of the main crop areas in 2006 (20.5 % in 2001) (Louwagie et al., 2009)[8]; UK has seen a similar increase (Townsend et al., 2016).

the "Agricultural Innovation System" (AIS), implies a wider range of organizations and stakeholders involved in agricultural innovations along agricultural value chains.

[8] The Sustainable agriculture and soil conservation (SoCo). *Final report* reports on soil relevant policy measures in ten case studies were carried out, during spring and summer 2008, in Belgium, Bulgaria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain, and the United Kingdom (Louwagie et al., 2009)

- A distinction between Western and Eastern Europe contexts has become apparent in terms of farm structure, institutional capacity, advisory capacity and farmer professionalistion. While intensification is the focus in some counties, in others land abandonment is an issue.
- New ways of accessing knowledge have emerged in response to AKIS changes. There is more networking, new players (e.g. knowledge brokers and intermediaries), and new private-public partnerships for knowledge exchange removing some of the previous hierarchies/roles. This is part of a wider democratisation of knowledge enabling farmers to access scientific and technical information; together with transdisciplinary approaches in research becoming more popular. However, conversely the commodification of knowledge by larger private institutions and corporations has also occurred, limiting access.
- In line with the above, new digital technologies enable access to information from multiple sources, disrupting the old hierarchies and formalities of expert advice provision.
- Governments have different approaches towards balancing regulation and voluntary action. Public advice often supports governmental regulation and subsidy payments, sometimes at the expense of other advisory services. In some countries however there is more emphasis on encouraging voluntary behavioural change (rather than regulation) or best farming practice. Deliverable 7.1 provides a comprehensive review of relevant policies.
- New powerful supply chain players now influence and impact farming practices e.g. food retailers with both specifications and 'private regulation' (Richards et al., 2013) through food assurance schemes, retailer protocols etc; but equally there is an informed population of consumers critical of conventional agriculture.

The implications of these multiple contextual factors need to be considered when reviewing and assessing the effectiveness of advice about SCIS. These many interacting factors illustrate how farmers and advisory services are embedded in and influenced by a wider dynamic AKIS.

3 SoilCare SICS –implications for advice

3.1 Soil improving cropping systems

In SoilCare it is understood that cropping systems can be considered soil-improving if they result in an improved soil quality, i.e., durable increased ability of the soil to fulfil its functions, including food and biomass production, buffering and filtering capacity, and provision of other ecosystem services. Soil improving cropping systems (SICS) prevent and/or mitigate soil degradation, and contribute to restoring and improving degraded soils.

The term 'cropping system' refers to crop type, crop rotation, and the agronomic management techniques used on a particular field over a period of years (Nafziger, 2012). Soil improving cropping systems encompass soils/land, crops, inputs, and management. Inputs refer to labour, machines, irrigation, pesticides, fertilizers, manures. Soil improving cropping systems include crops (crop types, crop rotations, cover crops, fallows, etc.), inputs and agro-management techniques. Inputs (nutrients, water, energy, pesticides, etc.) and agro-management techniques and are not easily separated (Oenema, 2016, Oenema et al., 2017)

In SoilCare profitability and sustainability of the cropping systems is understood to be central and soil quality defined briefly as ‘the capacity of the soil to function’, is translated with respect to cropping systems to ‘the capacity of the soil to sustain high crop yields with minimal environmental impacts’.

WP2 selected promising SICS, these are a combination of crop rotations (1:≥3), integrated nutrient management, enhanced efficiency irrigation, controlled drainage, reduced tillage, integrated pest management, smart weed control, smart residue mulching, controlled trafficking, and integrated landscape management (Oenema, 2016, Oenema et al., 2017).

3.2 Soil improving cropping systems - implications for advice

Formulating the right sort of advice to support farmers needs to take account of different SICS, soil functions, scales (spatial and temporal), and FML[9]. Advice has different requirements depending on the extent of change involved (cropping system, agro-management techniques). Some practices may involve discrete seasonal operations such as applying manure (nutrient management) and can be supported with nutrient management guidelines/decision support tools, or with training/demonstration about using particular techniques or piece of equipment. Some systemic changes e.g. conservation agriculture are based on sets of principles rather than bolt on technologies. **These require wider adaptation not adoption, and strategic longer term support**. As noted for complex trajectories like sustainable intensification farmers will need to develop situated knowledge that is complex, diverse and local (Leeuwis 2004). Such changes are knowledge and management intensive and entail learning, they need to be supported with facilitation of learning and networking, not just by providing technical support, as noted for transition to conservation/reduced tillage (Ingram, 2010, Coughenour and Chamala, 2007).

According to WP2 the process of selecting promising SICS followed the law of the optimum which is implicitly expressed by the term ‘integrated’ (integrated pest management and integrated nutrient management) and by the terms ‘controlled’, ‘enhanced’ and ‘smart’ (Oenema et al., 2017). Such systems are inherently knowledge intensive, as information about all crop production factors and soil quality impacts, and good support for decision making are required. As mentioned above, the literature concerning farmer implementation of more demanding practices and transitioning to new systems, emphasises the importance of farmer observation, experimentation and experiential learning (Ingram, 2010).

[9] SoilCare also identifies 3 FMLs. FML1 farming systems (traditional, conventional, precision, conservation and organic farming systems) FML2 and FML3 levels are distinguished in recognition that soil can be managed differently according to different farming or *cropping systems* approaches (conservation agriculture, precision farming) (FML2) , and different *agronomic techniques* or cropping practices used for management of soil, water, nutrients and pests (FML3).

3.3 This review

The term '*soil improving cropping systems'* (SICS) is not used in the literature, and there are no studies of how advice can support SICS. However there are studies about adoption (and the relationship between adoption and dissemination of information and advice) of cropping systems and agronomic techniques that lead to improvement of soil characteristics which this review can refer to. Collectively these are often grouped under the generic terms sustainable soil management (SSM)[10] , best management practice (BMP)[11], soil health practices (Carlisle, 2016) which comprise a number of options or adhere to a number of principles (and are associated with different functions) (Baird et al., 2016). Baumgart-Getz et al. (2012) for example listed a range of practices in their overview of BMP[12] studies: no-plow tillage, nutrient management, precision agriculture integrated pest management, integrated farm management, improved irrigation, conservation tillage, conservation agriculture, minimum tillage, fertilizer management etc.

This review therefore considers advice (and information) in the context of all farming systems and agronomic (crop and soil management) practices that potentially benefit soil with particular reference to those that improve both profitability and sustainability, and where relevant, focusing on the selected promising integrated SICS identified in WP2. This is in line with looking at general SICS based on the notion that all soils in agriculture need good management, so as to improve soil quality, and that taking a soil threat[13] based approach is not always appropriate for farm advice (Oenema, 2016).

4 Existing soil management advice –objectives and provision

4.1 Introduction

Advice to farmers concerning soil management can cover a number of topics, address a number of objectives, and be delivered by different providers using varying approaches, methods, tools (Table 1). This diverse soil advice landscape reflects the context described above, i.e. farmers having to deliver both marketable and environmental public goods combined with a typically pluralistic and fragmented advice landscape whereby farmers are influenced by multiple priorities, interests and actors (environmental, agronomic, innovation, technological, food assurance etc).

[10] SSM defined as: Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity (FAO, 2017).
[11] The application of BMPs in the United States grew out of the Soil and Conservation District movement of the mid 1930s). A BMP is generally considered "a farming method that minimizes risk to the environment without sacrificing economic productivity" Baird et al. (2016)

[13] SoilCare identifies 11 soil threats across multiple pedo (soil type)-environmental zone (Z1 .. Z13).

4.2 Soil management advice: multiple objectives and interpretations

Current provision of advice to land managers concerning soil is broad ranging in nature. This is a reflection of soil's multiple functions (and ecosystem services) and the multiple threats that affect these functions (and the soil as natural capital). **A broad distinction** can be made **between advice supporting protection of soil regulating functions** (water quality, mitigation) and **advice supporting (food) provisioning functions** (soil fertility and crop productivity) (Coulter et al., 2008). In very general terms, the former is associated with policy delivery of public goods and the latter with both national agricultural policy (e.g. food security, competitive agriculture) and commercial private interests. With respect to regulating functions, this is primarily the remit of governments. Policy (EU, national and regional) soil, as a cross cutting issue, is subject to a range of cross sectoral regulations, measures and voluntary programmes. Consequently associated advice concerning soil management is incorporated into a raft of programmes delivered at national and regional level addressing, for example, water quality, GHG mitigation, and operating at different scales. Advice supporting provisioning functions and commercial farming interests (and associated national policies) concerns agronomic techniques and innovations, management and operations that improve soil productivity, and soil quality with a view to both enhancing yields and minimising costs (e.g. tillage, nutrient management etc). These are predominantly the foci of advice from farmer based (FBOs) and private organisations (Table 1).

In practice synergies are often sought between the two strands of advice, as described in the concept of sustainable intensification (Buckwell et al., 2014), and it is often the role of public-private partnerships and FBOs to deliver advice on this basis. However, there are some inherent tensions (Struik and Kuyper, 2017), according to Powlson et al. (2011) for example, in many cases changes that are beneficial for food production are detrimental for other ecosystem services, so there is a tension between the different functions of soils. When delivering advice, messages are often framed as win-win in the understanding that any advice needs to engage farmers at the level of the farm business, however, in reality trade-offs are often required in terms of which soil function to protect/manage at the farm level. Indeed Struik et al. (2014) argued that **win-win situations are scarce in agronomy, while trade-offs** (between the use of different resources, between different objectives, and between different values) **are abundant**.

Equally, **optimal soil management is interpreted and operationalised differently** in different contexts (e.g. best management practice, sustainable soil management, soil conservation, soil protection. sustainable land management, good soil husbandry or stewardship). It is framed by different notions (e.g. natural capital, soil functions, ecosystems services); associated with different approaches and farming systems (agro-ecological farming, sustainable intensification, ecological intensification, climate smart agriculture, carbon farming, smart and precision farming), and outcomes are assessed with reference to different concepts (soil health, soil quality, soil fertility, productivity, resilience etc) and indicators (Sherwood and Uphoff, 2000, Buckwell et al., 2014). Furthermore these concepts, together with other drivers on the farm, mean that **qualitatively different sorts of information and advice are required.**

Furthermore the research basis for advice is still being formulated. Although there is broad agreement on what is meant by terms like 'soil health', and 'soil quality', there is still no clear direction in terms of what to measure (Wood and Litterick, 2017). Also key issues and research priorities for soil functioning are still being discussed with respect to whether the application of current knowledge is sufficient to enhance understanding as the basis for improved management (Powlson et al., 2011). **Thus, there are multiple understandings of what constitutes sustainable soil management/SICS which are or could be promoted and supported with advice; and consequently there is no single message or set of advice that is relevant to all contexts.**

In addition cropping systems and soil types vary greatly across (at multiple scales) due to different biophysical, land-use and socio-economic conditions. Soil threats are also often site- and region-specific due the different biophysical conditions and socio-economic pressures and the differences in the vulnerability of soil types. These spatial variations mean that soil management is highly site and cropping system specific, and this suggests a differentiated spectrum of SICS. A recent study on sustainable intensification suggested that from a soil perspective only 40% of Europe's agricultural land has potential to be used intensively and that local conditions have to be considered for any decision on sustainable intensification in agriculture (Buckwell et al., 2014); **blanket advisory approaches are therefore inappropriate. In support of this a recent survey found that stakeholders require a fine resolution of soil information and data** (Campbell et al., 2017). **Due to the complex and inherently variable nature of soils and their management, it is unlikely that a simple prescriptive message can be developed with wide applicability** (Palmer et al., 2006).

4.3 Soil management advice provision

As mentioned above, advice concerns the regulating and provisioning functions of soil, the former associated more with the delivery of cross sectoral mandatory/incentives based policy measures, and advice and awareness raising initiatives; and the latter associated more with the delivery of agronomic information and support. The extent to which there are synergies and tensions between these approaches, is a function of the orientation of the national agricultural policies, and how the knowledge and advisory system operates overall.

The provision of advice is structured in a number of ways. Although national and regional organistion of advisory systems and services are characterised by a diversity of individual and collective actors, organisational forms, methods and institutional structures, they do tend to be dominated by one of the following: public, private, non-governmental (NGO) or farmer-based organisation (FBO). This categorisation is used in the SoilCare country summaries and refers to previous work (e.g. the Proakis project inventory for MS which describes AKS and the dominant providers (Kania et al., 2014)). It is noted that, whilst technical advice to solve problems relating to production is generally satisfactorily provided through conventional advisory services, provision of integrated sustainable farm management advice to support learning relating to 'public goods' has been insufficient. Governments have to provide this, however they will contract private advisers for this service and sometimes tensions emerge (Laurent et al., 2006; Botha et al., 2008). Table 1 sets out the main institutions/actors, drivers and topics relevant at a national and regional scale.

Table 1 Main institutions/actors, drivers and advice topics relevant at a national and regional scale.

Institutional environment and providers of advice	**Interest/scope - Driver/orientation**	**Advice topic**
Delivering European Directives, national policies at national, provincial, regional levels by government deps and agencies and local municipality administrations programmes and catchment partnerships; also though FAS	Policies, legislation and strategies to protect soil, air and water and environment at different levels Main soil function- regulating	Soil protection advice (cross cutting and agricultural) and support at all levels. soil and environmental (water, nature conservation, ecosystem services); nutrient management (nitrogen, phosphorus) Principles set out in Codes of Good Practice
EU CAP Pillar 1 and 2 FAS (combinations of public and private agencies) – supports mandatory measures RDP programme -national and regional delivery agencies and AES advisers and facilitators	Cross compliance and GAEC (includes complying with Directives); Greening and EFA AES incentives based measures; operational groups Main soil function- regulating	Maintain minimum soil cover, ameliorate erosion; retain levels of organic matter, improve uncultivated land, fallow, buffer strips, catch crops/green cover, agroforestry and short rotation coppice (SRC), nitrogen-fixing crops Field features and arable reversion
Government deps and agencies deliver EU (e.g. Bioeconomy priorities) and national agricultural policies (e.g. sustainable intensification) through public extension service, FBOs, private organisations	Agricultural innovation and research (food security, competitive markets, crop productivity) policies; Agronomic productivity and sustainability (sustainable intensification) Main soil function- provisioning	Soil fertility/productivity/quality Efficient use of inputs - fertilizer rates, tillage systems, nutrient management, SOM, soil health Varieties, cropping and rotations decisions
Private consulting companies, independent agronomists	Business; Agronomic; Environmental - productivity and sustainability; Marketing Main soil function- provisioning	Efficient use of inputs - fertilizer recommendations, tillage systems, soil health, SOM Varieties, cropping and rotations decisions
Private sector (distributer agronomists) - upstream industries- agrochemical, farm machine companies, seed companies Partnership with government agencies and FBOs	Business; Agronomic; Environmental; Marketing Agricultural innovation; Productivity and sustainability Main soil function- provisioning	Fertilizer rates, nutrient management Tillage and compaction advice through machinery companies; cover crops through seed companies; Compliance and support for AES applications

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Downstream industries - / retailer protocols	Agronomic; Environmental; Productivity and sustainability; Marketing	Food assurance schemes /protocol environmental specifications; Fertilizer rates; Tillage; Cropping and rotations decisions) e.g. Unilever Sustainable Soil management protocols)
Farmer-based organisations (FBOs) : farmers' unions and associations, farmers' cooperatives, levy boards, agricultural chambers	Agronomic; Environmental; Productivity and sustainability; Marketing Main soil function- provisioning	Agronomic techniques; Soil health
Gov/industry partnerships Voluntary initiatives– eg UK Greenhouse Gas Action Plan, Campaign for Farmed Environment LINK, SARIC in UK	Environmental; Agronomic; Productivity and sustainability Main soil function- regulating	Mitigation advice; SOM in soil
NGOs, membership organsisations	Environmental Main soil function- regulating/provisioning	Organic farming; Agro ecology, IFS - Soil health

4.3.1 Soil management advice and support linked to EU policy instruments

The Deliverable 7.1 provides a comprehensive review of policies and policy instruments (EU and country level) that impact soil management in agriculture. This review of advice therefore provides a brief summary of the policies and instruments with respect to how they underpin advisory mechanisms. Although there are some 35 European policies[14] that indirectly affect soil protection and management (Frelih-Larsen, 2016, Vrebos et al., 2017), the main policies and instruments (regulatory and economic instruments) that are directly relevant to agricultural soil management advice at the farm level are the CAP and the Nitrates and Water Framework EU Directives. The European Thematic Soil Strategy (TSS)[15] includes an awareness raising element, but there is no specific mention of farm advice.

At the farm level, CAP instruments and associated support and advice are most relevant for soil and crop decisions. These are cross compliance regulations (good agricultural and environmental conditions – the GAEC standards), Greening Payment Requirements under Pillar 1 and RDP agri-environment schemes supported under Pillar 2 (Box 1). For the former, each Member State has been legally obliged since 2007 to set up a national Farm Advisory System (FAS)[16]. The FAS has to at least support the statutory management requirements and the GAECs. FASs are created by a set of different operating bodies in each MS such as public or semi-public agricultural advisory organisations, research institutions and colleges, private non-profit and profit firms, individual consultants, farmers' unions, associations, cooperatives, agencies (see country summaries). They chose what mechanisms and channels to use to disseminate information and advice (ADE, 2009). Typically these provide broad scale blanket information through leaflets, websites, soil/agricultural codes, although events, demonstrations, and sometimes face to face advice are used (see country summaries). All farmers who claim a 'basic payment' are eligible and can receive this advice in some form. A recent review identified two major groups of MS in terms of how they implement the FAS: in 14 MS (majority of regions in BE, DE, IT and the UK) FAS advisory activities tend to focus strictly on the statutory management requirements (SMR) and the GAECs included in the scope of cross compliance, while in 12 MS, and some regions within four MS, FAS advisory activities are broadened to issues going beyond the scope of cross compliance (Kania et al., 2014).

EU Water Framework and Nitrates Directives are delivered though regulatory (e.g. cross compliance) and voluntary mechanisms which foster best management practices to prevent nitrates and sediments reaching waterways through leaching and erosion. In some countries there has been a shift towards initiatives based on partnerships with the farming industry favouring voluntary approaches to support compliance and complement regulation (e.g. catchment partnerships in UK). This involves a combination of awareness raising, technical

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[14]Internationally polices such as United Nations Framework Convention on Climate Change (UNFCCC) and SDGs[14] also have relevance at European level.

[15] The 2012 EC Communication on The implementation of the Soil Thematic Strategy and ongoing activities is a policy document with no mandatory authority.

[16] the Regulation on Farm Advisory Systems (FAS, Regulation (EC) N◦73/2009) makes it compulsory for every Member State to guarantee that farmers have access to information and knowledge about how to comply with EU standards about health and the environment.

advice, capital grants and advice emphasising the win-win messages of good soil management which prevent erosion into and diffuse pollution in water courses.

A specific measure under RDPs provides support for the set-up of voluntary "operational groups" (OG) linked to the work of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). The EIP-AGRI seeks to promote the uptake of innovations in agriculture by bridging research and practice. Its implementation is based on local/regional innovative projects developed by OGs in which a group of farmers, advisers and researchers and other actors work together to develop a particular innovation, technique or practice (some concern soil management).

4.3.2 Soil management advice and support linked to national policy measures

A number of countries have developed their own policies, legislation and strategies to protect soil (England, Netherlands, Germany, Austria) (Bouma and Droogers, 2007). The extent to which they offer specific agricultural advice for soil management (i.e. relevant to SICS) varies and will be described in detail in the country summaries. For example, both the Czech Republic and Germany have national soil protection arable legislation while in England there is a Soil Strategy that pulls together a wide range of existing activities, regulations and policies. A key advisory device to support such policies and strategies is a national Code of Good Agricultural Practice (e.g. Germany, England) which is the accepted standard and required reading for all land managers, but the extent to which this is used as a basis for advice is unknown. Governments and regional authorities take and adjust different approaches such as adjusting GAEC conditions to address specific soil issues (e.g. soil erosion in Flanders) or integrate them (e.g. regional programme in Austria) (Vrebos et al., 2017). Governments and regional authorities also deliver programmes supporting agronomic research, extension, and practice for yield enhancement (linked to resource efficiency) either separately or in partnership with industry or FBOs. These follow national and regional policies (agricultural and natural capital) which are oriented towards different concepts or interpretations of sustainable agriculture and different approaches and farming systems (agro-ecological farming, sustainable intensification, ecological intensification, multifunctional agriculture, climate smart agriculture, carbon farming, smart farming), e.g. in UK sustainable intensification (Defra ref), in France agro-ecological farming (Compagnone and Hellec, 2015).

Vrebos et al. (2017) points out the diversity of policies and the complex interactions present between different spatial and temporal scales means that the impact of most policies (and correspondingly associated advice), positive or negative, on a soil function is usually not established, but depends on how the policy is implemented by local authorities and the farmers.

4.3.3 Soil management advice and support linked to productivity and efficiency

Advice concerning soil and crop productivity support can come from public research and innovation institutes, private commercial organisations (and their advisers), public-private initiatives and partnerships, supply chain actors (suppliers, processors, retailers), farmer-based organisations (e.g. levy boards) for different sectors, NGOs, independent advisers (Table 1). Here the emphasis is on soil productivity to support yield enhancement (managing inputs and techniques) but often with a focus on efficient nutrient management and promoting soil health (SOM, structure) in line with sustainability considerations. Typically advice is delivered via agreed standards: decision support guidance (tools, manuals, technical sheets) for fertilizer application, nutrient management, crop establishment guidance etc.

Box 1 CAP Soil related instruments receiving advice support

CAP Cross-compliance Good Agricultural and Environmental Conditions

As a baseline standard all farmers must adhere to EU requirements to meet Statutory Management Requirements and maintaining Good Agricultural and Environmental Conditions. Requirements are related to payments under the Common Agricultural Policy (as well as those in certain agri-environment schemes). Member states decide the exact specification of GAEC parameters, including minimum requirements. For example they can include measures to control erosion in permanent crops (Spain) and Measures to control erosion in arable crops (Greece) (Louwagie et al., 2009). Cross compliance requirements are often inked to legislation on water quality, Nitrates and water framework directive.

The rules require a basic level of protection for soils through management techniques that: maintain minimum soil cover, particularly in the wetter winter months; prevent and ameliorate erosion; and retain levels of organic matter, through a ban on burning arable stubble, and carrying out improvements on uncultivated land. Three GAEC requirements address soil protection: GAEC 4 requires minimum soil cover unless there is an agronomic reason for not doing so, GAEC 5 requires limiting of erosion through land management reflecting site specific conditions (eg minimum soil management - minimum tillage, cultivation of rootcrops), and GAEC 6 requires maintenance of soil organic matter level through appropriate practices (eg straw/stubble burning). GAEC 7 which aims to maintain features (ditches, hedges etc) is also relevant.

Typical advice: information about rules and recommended practices - Codes of Good Agricultural Practice

CAP Greening Payment Requirements

It is mandatory to comply with Greening requirements. These cover: permanent grassland; crop diversification and Ecological Focus Areas (EFAs). Indirectly these all affect soil. Countries have to choose EFA elements, some of these can protect soils e.g.: fallow, buffer strips, catch crops/green cover, agroforestry and short rotation coppice SRC), nitrogen-fixing crops.

CAP Rural Development Programme 2014-20, National Programme

Within the RDP voluntary agri-environment measures can indirectly address soil conservation, although to a variable degree e.g. those with measures to convert arable land to grassland, to install cover crops and buffer strips, to encourage lower stocking densities and to adopt organic farming. Measures aimed primarily at soil management are much less common and do not always achieve a high take-up rate (Louwagie et al., 2009). Depending on the soil threat RDP can put land under contract to improve soil management using AES. Soil erosion and loss of soil organic carbon can be explicitly mentioned in some RDPs; for example: 4C (preventing soil erosion and improving soil management) through demonstration projects, agro-environmental-climate measures (managements agreements for erosion prevention), support for organic farming and EIP Operational Groups and 5E (fostering carbon conservation and sequestration in agriculture and forestry) through afforestation and agro-forestry. Agri-environment schemes have great potential partly because they can be tailored to local conditions, which is particularly pertinent given the specificity of the contributing factors and the soil degradation processes themselves.

Typical advice: information, workshops, face to face visits, leaflets

EU WFD and Nitrates Directives

Advice supporting national regulations associated with EU WFD and Nitrates Directives is concerned with farm practices to prevent or reduce diffuse pollution from agricultural land. It is integrated with cross compliance SMR and GAEC and supported with the same levels of support often with additional technical information about nutrient management and sediment pollution using DSTs.

5 Advisory systems and services: how farmers currently obtain information about soil management

5.1 Advisory systems and services for soil

The advice landscape for soil is determined at the farm level by **farm advisory services** which sit within the wider **agricultural advisory system** (see box for definitions)

Describing the advisory systems and services for soils is increasingly complex as they are no longer organised centrally by a government agency but characterised by a diversity of individual and collective actors, organisational forms, methods and institutional structures (Knierim et al., 2015; OECD, 2015). To date there has been no review or evaluation of advice with respect to soil management, as typically evaluations or assessments are available at a programme or project level (Faure et al., 2011), or for larger (public or private) organisations, not for individual topics. Such evaluations are also constrained by fragmented governance and multi spatial and temporal character of soil (Juerges and Hansjürgens, 2018, Prager et al., 2017).

5.1.1 Background – diversity in approaches

The organisation and structure of advisory systems and services in each MS is distinctive. A variety of strategies and mechanisms operating within the AKS will be active at a number of scales and governance levels (local, regional, national and international). These will be concerned with delivering policy on public goods (sustainable land management, water quality issues and climate change) and ensuring that a competitive and innovative farming industry is both supported and regulated. As discussed already, **advisory systems and services are dynamic, reacting to policy and market changes**. The nature and extent of these will reflect the varying agricultural contexts and needs of the farmers, market opportunities, institutional resource settings, policy objectives and priorities, and state, capacity and functionality of extension services. Furthermore all MS have experienced some form of transformation of advisory systems and services and have become decentralised, privatised and fragmented to different extents with a result that they are a mix of public, private, non-governmental (NGO) or farmer-based organisation (FBO) (Kania et al., 2014). Within a farming community, multiple advisory systems and approaches are typically present and strongly influence each other, making it very difficult to describe or to evaluate the effectiveness of individual approaches or individual topics like soil management in delivering on expected outcomes (Bourne et al., 2017). **As such advisory systems in each MS are unique, so each MS will have a different soil knowledge system and advisory landscape that concerns soil management and therefore SICS.**

Box 2 Definitions

With respect to information, advice and knowledge, they are qualitatively different, although any specific service may have elements of both information and advice. Information comprises facts, interpretations and projections which reduce the uncertainty faced by decision makers. It enables land managers to identify alternative strategies and decisions and assess the likely outcomes of each. Advice implies the recommendation of a particular course of action, or the presentation of a range of alternatives. This can be blanket advice (akin to information) or tailored (Garforth et al., 2003). It is how people understand information and attribute meaning (and value) to it that turns this information into knowledge.

The advice landscape for soil is determined at the farm level by farm advisory services defined by (Labarthe et al., 2013) as an activity that enables farmers to co-produce farm-level solutions by establishing service relationships with advisers so as to produce knowledge and enhance skills. These sit within the wider agricultural advisory system components which includes: the institutional environment and the structures necessary for the operation of agricultural advisory services; the actors providing advisory services and the skills deployed in advisory activities; and the approaches, methods, tools and content of advisory activities (Faure et al., 2012). Birner et al. (2009 p342) state that advisory systems include "the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being". These include governance structures and mechanisms; methods for generating advice; and the capacities and competence of advisers.

Privatised systems are those comprising public, private and semi-public 'systems' that make up a multi-institutional, multi-sectoral 'pluralistic' system (Rivera and Sulaiman, 2009). Private advice provision is therefore not a single entity but a range of private-public arrangements and funding strategies, which include new actors such as farmer-organised businesses, private businesses and NGOs (Chapman and Tripp, 2003).

Commercial and private advice need clarification. Commercial refers to the activities carried out by organisations who offer advisory services for a fee. Originally, commercialisation referred to private consultancies selling their advisory services to farmers. Today a range of organisations (including public organisations) are involved in commercial advisory activities. As such commercialisation should be seen as a gradient that refers to the extent to which advisory activities carried out by the organisations are charged for, i.e. are offered to the client on a 'fee-for-service' basis (Rivera and Sulaiman, 2009). Private refers to the status of an organisation. 'Private advisory organisation' refers to independent private consultants providing unbiased advice that is not coupled with selling agricultural commodities (Labarthe and Laurent, 2013, Prager et al., 2016) . Other commercial advice at the farm level is often provided by supply chain upstream and downstream industries who offer advisory services coupled with selling inputs or buying outputs (e.g. fertiliser, machinery, pesticides), for example through agronomists.

Different advice delivery systems, with varying roles for private and NGO providers, government, and semi-government entities, operate simultaneously. In view of this, it is argued that it is not useful, or necessary, to introduce a uniform national approach where the farming clientele is heterogeneous, with different farming systems and socioeconomic groups (Feder et al., 2011) This is supported by others who argue that it is difficult to determine the 'best fit' for advice provision – scholars have noted that **emerging configurations serve different types of farmers**, that is, private advisers serve different clients in different ways; **these could be considered subsystems within the overall advisory system** (Klerkx et al., 2017). These subsystems are further divided if considering a single topic such a soil management.

5.1.2 Advice for soil management –diversity in approaches

An example of the diversity of advice provision for soil was provided by the SoCo project in 2009 which described advice on soil in European case studies. In Denmark, for example, advice was highly centralised, dominated by the Danish Agricultural Advisory Service (now SEGES), a farmer-controlled extension service characterised by high levels of technical expertise. In Greece, the Directorate General of Extension and Research of the Ministry of Agriculture supervised an intermediary organisation responsible for training and certifying the farm advisers. The content of the advice received also varied; some was predominantly agronomic as in the Czech Republic, whereas some covered a whole range of agronomic and environmental issues, and was delivered through a whole farm plan approach, as in England. Private advisory companies (CZ), private consultants (IT) and commercial companies have become important and influential in advisory systems, however in some countries, there are only a few private advisory companies, but with a large number of advisers (e.g. Sweden) (see country summaries) (Louwagie et al., 2009). More recently in the SmartSOIL project, a review across six European counties of farmer awareness and adviser delivery of soil management also illustrated this diversity in advisory priorities and approaches (Ingram et al., 2014a, Ingram et al., 2014b).

5.1.3 Changing role of advisers

Advisers have always been important in supporting farmers' decisions, this is particularly the case for soil management advice which needs to be tailored to field conditions and is best delivered face to face on-farm. Also Regular adviser-farmer contacts are a potentially powerful way to changing behavior because of frequent contact; familiarity with each other's context, personal characteristics, preferences, beliefs, aspirations and competencies; and a relationship of trust that develops (Klerkx and Jansen, 2010).

However, the farm advisers' role is diverse and changing. One of the key changes in advice concerns the role of the private sector. Over the past twenty-plus years, the profitability of farming advice has spurred expansion of the role of private sector advisers in supporting decisions about increasing yields, lowering production costs, improving crop quality, and managing certain types of risk (Prokopy et al., 2013). As the need and worth of specialised information has increased, market demands have become sufficient to support advisers and information brokers in the private sector alongside the public sector (Lemos et al., 2014). In some countries (e.g. England) many arable farmers now rely heavily on independent private or supply chain agronomists when making decisions about cropping systems and agronomic techniques. Klerkx and Jansen (2010) distinguish 'specialized' independent advisers, such as agronomists, and 'embedded advisers' that embed advice within a broader palette of goods or services, for example, agricultural input providers (selling feed, pesticides and fertilizers) and veterinarians (providing general animal health advice alongside disease treatment).

The role of the adviser is being re-assessed given the contextual changes. The new public-private partnership arrangements mean that some advisers/agronomists can simultaneously provide public and private good advice (Vrain and Lovett, 2016, Klerkx and Jansen, 2010). However, while called upon by some to represent and deliver public good messages, they can face tensions with their clients (Ingram, 2008a). More generally the influential role of advisers have also been explored, and they have been described variously as change agents, intermediaries, knowledge brokers (Rogers, 1995). In addition other intermediaries or innovation brokers have emerged in response to diverse needs, including lead or innovator farmers (champion farmers). In parallel with this, multiple informal networks between farmers (and farmers and advisers, innovation brokers, researchers, other actors) have emerged as a means for sharing information, often supported by intermediaries, these are described later.

Furthermore, although face to face advice is important and effective, access to IT and digital technologies such as decision support tools is increasing (Eastwood et al., 2017). In some countries formalised extension services are being replaced by online facilities, for example in the Czech Republic, as Slavik (2003) explains "Recent and rapid changes have occurred in the structure of agriculture in the Czech Republic. …The information resource for agriculture has been developed by encouraging sources and centres from which information and advice can be obtained by farmers, rather than by the introduction of a formalised national Extension Service. Hence, the emerging system is based on farmers constructing their own information systems as responses to what they perceive to be their needs and what they find most useful".

5.2 Implication of changes in advisory systems for soil – gaps and limitations

Overall, although a number of gaps and deficiencies can be found in the delivery of soil advice, there are also opportunities that the transformation in advisory systems and services offer.

5.2.1 Lack of integration and emphasis on compliance with regulation

Studies suggest that a focus on complying with EU regulation neglects other soil issues and prevents an integrated approach. According to some sources reliance on cross compliance means that certain aspects of soil protection are not given adequate attention. In UK a recent House of Commons Environmental Audit Committee on Soil Health argued that the GAEC requirements fail to address important aspects of soil health such as soil biota and soil structure (House of Commons, 2016). It also noted that "There is reason to doubt that the current cross compliance regime is achieving its goal of preventing soil damage. In 2015 only two breaches of the soil rules were detected. Moreover, the Good Agricultural and Environmental Condition standards are not ambitious enough to support Defra's goal that all soils are managed sustainably by 2030, since they focus only on preventing damaging practices and not on restoration or improvement of soil quality" (Paragraph 68), although there is differing evidence (Borrelli et al., 2016)[17]. A further criticism is that GAEC only applies to land subject to direct payments. These criticisms could imply that advice and support by FAS (which are primarily required to support GAEC) is limited not only in scope but in effectiveness.

Similarly another study in UK (in the south west) in 2010 found that main focus of current policy initiatives and accompanying measures tended to be on the control of diffuse water pollution rather than protecting or conserving soil in situ, and gaps remain in the implementation of effective targeted measures. A more integrated approach to land and water management, consisting of voluntary and regulatory measures, involving farmers and other stakeholders, tailored to local circumstances and supported by economic incentives and advisory services, was recommended (Posthumus et al., 2011).

In line with this, the IEEP (2016) identified the lack of a strategic policy framework both at EU level, and in many MS, which makes it difficult to tackle the multiple challenges related to soil. They suggest that this hinders the integration of soil considerations into sectoral and environmental policies; clarity and direction in structuring regional and local action is also compromised. Arguably the consequences for advice are that there is an absence of strategic overview or steer. However, they also identified some opportunities for change with emerging signals from the European Commission around the need to improve the coherence of the Common Agricultural Policy (CAP), prioritising the efficient use of soil resources.

Similarly the need for integrated sets of metrics, understanding of how different aspects of agricultural systems and different environmental services interact, and tools that allow the results of management decisions to be easily communicated was noted by a review of knowledge needs for sustainable agriculture (Dicks et al., 2013).

5.2.2 Implications of privatisation and commercialisation for soil advice

A body of research has examined and critiqued the ability of advisory services to meet current demands from farmers, given the complex challenges they face and in many cases the loss of public extension services. Although not explicitly about soil, the issues raised are relevant.

A key issue is the quality and orientation of the advice. Countries where farm advice was commercialised in the 1980s and 90s (UK, Netherlands, some German Länder) experienced a lack of support for networks, and a lack of investment in updating knowledge for advisers and farmers, especially knowledge of how to integrate environmental issues into their production systems and farming practices (Leeuwis 2000; Laurent et al., 2006; Labarthe, 2009). Another concern about commercialised advice is the bias towards productivity oriented advice possibly to the detriment or neglect of public good advice. Productivist tendencies and client oriented motivations of commercial advisers are thought to affect their provision of sound and impartial environmental advice, and this client orientation may have implications for achieving sustainable soil management. With a move towards demand driven advice,

[17] There is some evidence that GAEC leads to carbon storage

advisers from private businesses working on a fee for service basis become more 'reactive' and more accountable to their clients as they respond to pressures to maximise their 'market share' among farmers (Ingram, 2008b). Furthermore, some argue that private advisory organisations might have difficulties to renew their knowledge as they do not have the resources to invest in training or R and D (Labarthe and Laurent, 2013) This is partly due to the fragmentation of service delivery and to a lack of coordination and interaction between private advice and public research.

In addition, as a consequence of privatisation, public extension services that remain are often poorly resourced, with insufficient investment/training, and providing advice of low quality, as described in Poland and Hungary in the SmartSOIL project[18]. Reduced funding has led to a decrease in expertise and numbers of staff in some countries' often extension staff do not have the capacity or resources available to allow all landholders to receive the attention they require. This was also noted by (Lobry de Bruyn et al., 2017). In summary reduced adviser competencies, and limited room for addressing sustainable soil management in a commercial, demand-driven, farmer-adviser relationship are flagged up as a concern (Ingram and Morris, 2007). These studies indicate that policy measures such as adviser capacity-building support and awareness building among farmers to stimulate demand for sustainable soil management advice are needed. Advisers are expected to take on a facilitative role for co-production of knowledge with farmers, they also need to develop social skills, the right attitude and competencies if they are to become facilitators rather than technical experts.

However, others argue that the diversity of actors, and networks among farm consultants and between farm consultants and other actors, facilitated by intermediaries and knowledge brokers could ensure that consultants' knowledge is continuously updated, and that networks can facilitate knowledge exchange for private advice (Klerkx and Proctor, 2013). Prager et al. (2016) recently demonstrated how private advisers offer a more personalised service (albeit favouring larger profitable farmers) and tended to use horizontal peer-to-peer cooperation links to update their knowledge, as their private organsisations spent less time in back office investment in R and D. Others point to the benefit of greater adviser diversity and increased client orientation (Klerkx and Proctor, 2013) and advice being demand driven and therefore subject to markets and competition, which arguably should increase standards, accountability, and therefore quality control (and provide better services) (Dwyer et al., 2002).

Lemos et al. (2014) argue that in the USA, although public and private information brokers are often seen as competitors, in practice, their roles are complementary and synergistic. **Different types of advisers respond to different information needs among their clients,** who vary in both their ability to use and process data and their needs for information. In addition, public and private advisers may have developed interdependence, relying on one another to varying degrees to collect, analyse, and repackage information (Wolf et al., 2001). It is therefore important to examine the potential of advisers in both the public and private domains to understand fully the current and potential future support for farmers managing

[18] This studied advice provision for managing carbon in soil in 6 case studies Hungary, Italy, Spain, Denmark, Scotland, Poland www.smartsoil.eu

soil. This is in line with the view that **emerging configurations serve different types of farmers.**

Furthermore the evolution of advisory services has led to creative partnership initiatives and farmer-farmer/farmer-advisers-researcher groups producing and sharing their own information and knowledge in the absence of an effective advisory service. Networking observed amongst the advisory community provides evidence that the involvement of many agencies and actors, including an active NGO sector, can provide the flexibility and space for creativity, and for networking and alliances which were denied under a more rigid closed system (Garforth et al., 2003).

These observations come from studies of advisory systems and services in general, there are very few studies of these services with respect to soil management. The implications of a shift towards pluralistic systems on delivery of advice on soil were examined some 10 years ago in UK revealing a cohort of advisers with mixed awareness and skills sets with respect to sustainable soil management (Ingram, 2008b, Ingram and Morris, 2007). Conclusions from this and similar work generally are that private advice provision on sustainable farm management is 'suboptimal' (Klerkx and Jansen, 2010, Prager and Thomson, 2014) . In support of this, a report from the SoCo project (Louwagie et al., 2009) concluded that, for the most part, independent advice to farmers on the mitigation of soil degradation processes, particularly from the public sector, is perceived to be inadequate. This appeared to be a significant reason behind a lack of uptake of schemes that are beneficial for soil conservation. The SoCo project, which worked with a number of case studies across Europe, identified poor exposure to soil topics stating "the lack of routine advice and encouragement for farmers to practice soil conservation was referred to in nearly all case study regions and at the stakeholder workshops. On the one hand, this indicated the apparently limited effort devoted to soil conservation by the formal farm advisory and extension services. On the other, it pointed to the low profile of soil issues in the public debate and in organisations engaging with farmers like input suppliers, or food processors and retailers. The latter is in contrast with the higher public profile given to water and biodiversity concerns in recent years. The tailoring of solutions to diverse farm conditions requires a depth of support and advice that, although evident in some case studies, is not generally available". Notably this was published in 2009 and attention to soil has increased significantly since then, however these comments are still pertinent in some countries, particularly some Eastern European, as consultation with stakeholders in the SmartSOIL project (2011-2015) demonstrated (Ingram et al., 2016, Ingram et al., 2014b).

A further issue highlighted is access. Some authors have pointed out that privatisation linked to commercialisation (fee paying) may lead to greater exclusion of some categories of farmers, e.g. small-scale farmers (Labarthe and Laurent, 2013) and disproportionately serve those who can afford them (Kidd et al., 2000). Those providing public good advice consistently identify difficulties in influencing the 'hard to reach' who operate outside advisory, media or farmer-farmer networks.

5.2.3 Lack of specialist soil technical support and expertise

One particular concern raised in the SmartSOIL project (Ingram et al., 2016, Ingram et al., 2014b) and in other studies is the lack of specialist soil technical support and expertise in the advisory and research community. This was a feature of poorly resourced public advisory systems and services, particularly in some eastern European countries. The SoCo project also identified barriers to uptake of soil conservation practices as: lack of access to technical know-how and equipment, lack of knowledge regarding the best practices in a given situation, and lack of access to specialist advice (Louwagie et al., 2009). Indeed in the UK the NFU emphasised the importance of educating farmers in how to manage soil sustainably, according to the NFU remarked with respect to an audit of soil health that farmers repeatedly ask how to manage cover crops at farmer events and need more advice and support in such topics (House of Commons, 2016).

This is seen to be part of a wider problem for the soil knowledge system. In UK, a gap analysis for soil research (and links to advice) revealed poor transfer/exchange due to changing (loss of public sector KT) knowledge systems in arable and horticultural sectors (Kibblewhite et al., 2010) (Rickson and Deeks, 2013). This point was picked up in another UK report into the status of soil and water management which recommended that “Future emphasis, therefore, needs to be given to applied research and development, conducted by personnel with a good understanding of agricultural and environmental needs who can “design” innovative solutions to practical problems. These professionals need also to be encouraged to provide extension advice and practical training for farmers and agronomists” (Godwin et al., 2008). This loss of soil specialists is a consequence of fragmentation in the advisory systems and AKS, such that previously effective demonstration or experimental farms which linked soil management research and practice are no longer operating in some countries (Curry et al., 2012). This observation is not limited to Europe (Lobry de Bruyn et al., 2017).

The implications of changes in advice services for SCIS, where the objective is a durable increased ability of the soil to fulfil its functions, are complex, but in summary the following gaps can be identified:

- Free face to face advice at the farm level from public extension services is often no longer available, as a result not all farmers have access to tailor made advice to suit local soil conditions
- Public extension services can be poorly resourced, low capacity, with poorly trained advisers
- Face to face advice at the farm level is provided by agronomists/crop consultants (independent or supply chain) on a fee paying basis and has become influential in some countries - with potentially negative consequences for SICS.

- Access to advice on a fee paying basis can be unequal - smaller farmers cannot always afford to pay for agronomic /technical advice, private advisers tend to focus on larger and more profitable farmers.

- Public good messages supporting regulating ecosystems services (SSM) are delivered by broad dissemination activities with blanket advice/information, web sites, workshops, larger events. This tends to reach the already well informed and misses the 'hard to reach'. With increasing reliance on internet/social media – access and motivation become important - less well educated or older farmers will miss out or will not have access to good quality advice/support

- Standards and quality of soil advice from private sources might not be monitored/evaluated, nor supported with sufficient 'back office' investment in training, R and D, although in some countries CBD ensures good standards (e.g. BASIS in UK)

- Emphasis on complying with regulations with respect to soil and lack of integration at a policy level often means that there is no systemic joined-up approach to advice on soil management. Formal public advisory/extension services supported by governments tend to support regulatory requirements or RDP, e.g. the FAS in most countries. This focus on helping farmers comply with minimum legislative requirements, which Botha et al. (2008) have called operating in 'catch-up mode', limits their potential for other duties.

5.3 Examples of effective advice/best practice for soil management

IEEP (2016) summarises what works well to protect soils, these are relevant at a higher level of developing and coordinating advisory systems:

- Collective effort from well-grounded and operational relationships between key actors in a region or supply chain makes a difference.
- Public, private actor interactions produce positive outcomes by, for example, organising actors around a supply chain or creating a certification or labelling scheme.
- Governance and institutions are critical to securing durability and success of collective initiatives especially when market signals are weaker.
- Increasing public awareness and appreciation of environmental and social goods help increase their provision.
- More robust, spatially explicit and accessible data is essential to establish causal links between management actions and the provision of environmental goods/services.

A number of initiatives and programmes that deliver crop and soil management advice are active across Europe and internationally which provide useful insights into, both how the current soil/crop advice landscape is operating, and the most effective ways of disseminating advice. It should be noted that there is a general lack of systematic evaluation of advisory services at the national level in general, and no thorough assessment of what constitutes good practice with respect to advice on soil and cropping or SICS. This stems from the complexity of the systems, the difficulty in measuring an 'intangible service activity' (Gadrey, 2000), where the entity transformed by the services are the skills, knowledge and attitudes of the people involved in farming activities (Prager et al., 2017), as well as an absence of studies on soil-oriented advice. This is in line with a shift towards facilitating farmer learning, working with stakeholders and integrating different knowledges, and a bigger emphasis in research circles to use transdisciplinary approaches (Bouma, 2014). These new collaborative research and innovation approaches are becoming popular (e.g. multi actor approaches, transdisciplinary research) and can potentially lead to more relevant and outcomes. Approaches can include supporting/facilitation joint learning between researchers, advisers and farmers, for example, in identifying problems to be solved and co-designing solutions, as well as tools to support these. Furthermore new understandings of how to effectively engage farmers and nurture peer to peer learning are opening up new opportunities (Mills et al., 2017, Pike, 2013, KOUTSOURIS et al., 2018). Table 2 lists examples of effective advisory approaches in UK.

In summary, some key points can be drawn out with respect to characteristics of effective approaches:

- Farmer groups and networks interested in soil are emerging to fill the gaps in delivery and topics (although these tend to be the more innovative farmers). These are face to face or virtual aided by social media. Tapping into these existing farmer groups and networks using innovator farmers as champions for further diffusion, and advisers as intermediaries can be effective (Defoer, 2002).

- This is most pronounced where win-win gains can be made as with systems and practices such as reduced tillage where economic gains can be demonstrated, or where value can be added (e.g. organic producer groups).

- Groups of farmers, advisers and researchers working together can be facilitated and supported to explore ways of enhancing soil productivity and sustainability, e.g. study clubs in the Netherlands, or to research and develop innovations e.g. Farmer Field Labs in UK, Operational Groups (an RDP programme) in all MS. Previous barriers to communication and professionalisation of farming has blurred the distinctions between soil experts and practitioners.

- The enthusiasm of farmers, the farming community, industry (e.g. Syngenta, Unilever, Valderstad) and society in general for soil health and recognition of its importance with respect to ecosystems services and productivity offers great potential for building new alliances and supporting advice and learning.

- Integrated approaches - Coupling of mandatory measures and incentives together with advice to support voluntary adoption of soil protection measure in priority catchments used in Catchment Sensitive Farming approach in southwest England provides a good example. Approaches that involve farmers and other stakeholders, tailored to local circumstances and supported by economic incentives and advisory services are described as promising (Posthumus et al., 2011). The main emphasis was on information, advice and improved awareness in a series of priority catchments with known problems. Capital costs/investment aid schemes to support the implementation of technical measures that mitigate diffuse pollution have also been successful.

- New digital tools can support both advisers and farmers, for example, the aims of the website tool soilquality.org.uk (planned for 2018) enables tailor made support:
    - Providing improved evidence to underpin recommendations for adoption and local adaptation of more effective soil management
    - Supporting targeted reductions in agricultural inputs (fertilisers, pesticides) by enabling improved understanding and management of soil function supporting crop growth
    - Providing a basic toolkit (with clear description of approaches to sampling and analysis with tools for site-specific interpretation) that can be used to screen proposed management practices in terms of impact on soil function.

Table 2

Provider	Name	Method	Motivation, function/threat
Public	Scotland's Farming for a Better Climate programme	Farmers and experts jointly formulate and assess mitigation options on Climate Change Focus Farms but within context of farm business	The focus is on enhancing the farm business to engage farmers
Charity/NGO	Allerton Trust	Demonstration and farm walks, farmer and adviser CPD training	Emphasis on soil health and productive systems
Partnership (government agencies and NGOs deliver for government)	Catchment Sensitive Farming in England	Face to face advice from catchment officers, events and capital grants on diffuse pollution and soil management Publications: Soil Code, Soil Matters, Think Soils manual Leaflets e.g. Farming for cleaner water and healthier soil	Regulation WFD and Nitrates Directive Cross compliance
Farmer led group	Tamar Organic farmers	Adviser led group of farmers interested in soil health	Solving problems about soil management
Farmer led group	#Rootsnotiron	Virtual twitter network of farmers interested in minimum tillage	Solving problems about soil tillage, increasing yield
Farmer led group	Carbon cutting tool	Farmer led group with virtual networks and events	Soil management for mitigation an general SSM
NGO	LEAF	NGO promoting integrated farming, coordinates a network of farmers Demonstration farm network, events Food assurance scheme/protocol (audit)	Soil management as part of integrated approach
NGO (Soil Association)	Innovative Farmers, Farmer Field Labs	Groups of farmers, meet with researcher and coordinator to carry out on-farm research on soil topics in 'field labs'	Solving problems about soil management, rotations, tillage, cover crops etc

Partnership (gov and industry)	Farming Futures	Web based portal –includes case studies on soil management	Mitigation, nutrient management
Research and marketing (Farmer subscription)	Levy boards (sector based) AHDB	Soil health events, monitor farms	Soil heath and business viability
Partnership (gov and industry)	http://www.innovationforagriculture.org.uk/	Soil health events, guides	Soil heath and business viability
Consortium of English agricultural societies	Innovation for Agriculture	Events, CSF advice, Soil DST	Soil health

6 Key principles for effective advice for SICS

6.1 Introduction

This section reviews the scientific literature identifying the key principles that should be considered when developing advice and a dissemination strategy for SICS within SoilCare.

The significance of the following four features of advice are considered with respect to soil management: attributes of information/advice; connecting to local networks and facilitating learning in groups; the role of advisers/extension officers; effective methods for delivering advice on SCIS. These relate to the **what, how** and **who** of the dissemination strategy. These are summarised below.

6.1.1 Information

When embarking on new practices farmers need information, advice and support. In a survey of rural land holders in Scotland asking about current and future mitigation practices to be implemented, results suggest that farmers do not want to embark on new practices, which they do not know much about. In relation to education and provision of information there were some cases (e.g. precision farming; biological fixation with clover) where farmers pointed to lack of knowledge as the reason they would not implement the practices (Feliciano et al., 2014).

Studies of innovation adoption and diffusion have long recognised information as a key variable, and its availability has been found to correlate with adoption. According to Roger's (1995) innovation-diffusion-adoption model, access to information is the key factor determining adoption. In this model adoption is seen as multi stage process of awareness raising, collecting information, revising opinions and decisions. Recent studies have confirmed this but illustrate the importance of different aspects of information.

With respect to managing soil, investigating variables that influence the adoption of soil conservation practices in agriculture have been the subject of several reviews (Knowler and Bradshaw, 2007, Pannell et al., 2006, De Graaff et al., 2008, Kassam et al., 2014, Prokopy et al., 2008) , as well as other relevant climate smart technologies (Long et al., 2016). Given methodological limitations and relative insignificance of findings from previous reviews, Baumgart-Getz et al. (2012), (p. 17) conducted a meta-analysis of 46 studies on BMP adoption in the United States from 1982 to 2007 and found that the largest impact on adoption was from "… **access to and quality of information, financial capacity, and being connected to agency or local networks of farmers or watershed groups**.""

In support of this, general research on the adoption and diffusion of innovations in agriculture has consistently confirmed that one of farmers' most commonly cited sources of information and ideas is other farmers (Oreszczyn, Lane, and Carr, 2010; Rogers, 1995). They tend to be most influenced by proof of successful farming methods by these other farmers (Hamunen et al., 2015; Kilpatrick and Johns, 2003; Schneider, Ledermann, Rist, and Fry, 2009; Warner, 2007).

6.1.2 Attributes of the message providing credible high quality information and advice

There are number of information and advice (quality) attributes that have been identified as important with respect to soil and crop management.

To be persuasive to encourage behaviour change, the soil and crop management advice needs to recognise that farmers desire information which is directly **relevant** to the farm enterprise (Hallam et al., 2012; Hogan et al., 2011).

Farmers require **evidence** to back up claims about soil and crop management practices and systems. McNAIRN and Mitchell (1992) argue that encouraging the adoption of conservation practices requires **assurance of long-term multiple** (i.e. economic and non-economic) **benefits** from adoption, **unambiguous and accurate information**, and active promotion. Evidence is important in helping farmers make informed decisions about trade-offs or co-benefits. With respect to soil health **synergies and tensions between sustainability and profitability** should be recognised when explaining co-benefits and trade-offs (Bennett and Cattle, 2014). Such evidence and technical information could include: visual evidence of soil health, increases to crop yields, and cost-effectiveness or financial savings (Delgado et al., 2011; Dilling and Failey, 2013). Soil management advice can **emphasise co-benefits or win-wins but honestly and supported with evidence** pointing out different time scales and spatial scale effects (Feliciano et al., 2014) (Moran et al., 2011; Smith and Olesen, 2010). The SmartSOIL project found that evidence was a key factor in communicating effectively about managing soil carbon, but while advisers preferred scientific evidence, farmers preferred field demonstration, visual evidence and stories from other farmers. A toolbox to suit **different preferences** (farmer case studies, technical facts sheets, DST) was developed to suit these multiple needs (Ingram et al., 2016, Naumann et al., 2015).

Language and **indicators** used in information and advice about soil must be relevant to farmers. SOM was found to be one of the two most important soil health factors in some studies (Bennett and Cattle, 2013, Lobry de Bruyn et al., 2017). This was also found in SmartSOIL where farmers referred to soil quality and health with respect to soil productivity but not to soil carbon management with respect to climate change.

Studies in a number of contexts have found that information and advice must be **credible**. This is linked to **credibility, trust in the source and in the messenger** which influences behavioural change (Hallam et al., 2012; Sutherland et al., 2013), as discussed below.

6.1.3 Connecting to local networks and facilitating learning in groups

Other farmers and family members have long been considered as valued sources of advice, often more highly valued than information from commercial, government or other organisations, which might be viewed as having vested interests (Dwyer et al., 2007). Following their meta analysis, Baumgart-Getz et al. (2012) argued that effective BMP adoption efforts should combine complementary social factors to increase their impact overall. For example, using networks to implement extension efforts and disseminating information presents a logical way to combine and extend the reach of factors found to have a significant effect on BMP. Prokopy et al. (2008) had also concluded that any local effort to increase the adoption of conservation practices should consider trying to plan interventions that increase farmers' access to networks and information, change farmers' attitudes towards the environment, and increase farmers' factual knowledge about the environment. A large scale study by Hijbeek (2017) also identified the importance of social referents in farmers' decisions about adopting practices that enhance SOM.

In a study of soil conservation policy for farm land in New Zealand, Reid (2013) identified the significant role of an informal network of soil conservation advocates strategically positioned in central and regional government. They supported farmers in using whole farm plans, the principal mechanism for shaping farmers' on-farm management. These are supported by incentives for farmers and regular support and interaction from regional council staff.

The **facilitation of collective or group learning** has been applied in many contexts, examples include longstanding specialist Farmer-Field Schools, study groups in Netherlands, and monitor farm discussion groups which can provide a collective learning environment (New Zealand Scotland). These programmes appeal to farmers' agronomic and business motivations, as well as soil management interests. Soil lends itself to this sort of dissemination as **farmers enjoy being in the field** and talking practically about soil management. Baird et al. (2016) and Isaac (2012) highlight the importance of maintaining both farmer–organisation ties and farmer–farmer ties for successful and sustainable agricultural practices. It is proposed that informal (peer-based) entry points into farmer advice networks may be used by government agencies to effectively disseminate information, influence BMP adoption.

6.1.4 Understanding and working with advisers and extension officers

Due to the complexity and variety of information and skills involved in decision making, farmers often rely on significant input from agricultural specialists. Bennett and Cattle (2014) talking about soil health suggest that the role of extension officers and agronomists will be increasing, because of complexities of management associated with the increasing scientific nature of farming (and the consequent loss of connectivity between farmers and their land). This point has been reiterated by other commentators.

Working with advisers and improving the understanding of the information they use is essential to delivering effective dissemination strategies (Prokopy et al., 2013). The advisers' influential role as broker, change agents or intermediary is well known and there are calls to exploit this to disseminate policy messages (e.g. Agricultural Industries Confederation, 2013). This is based on the fact that farmers value trusted relationships with professional advisers, including agronomists, feed advisers, land agents and vets, who focus on improving farm business performance and resource efficiency to deliver economic as well as environmental outcomes. In UK according to a report by ADAS (2012) arable farmers trust specialist advice from the private sector the most, and are willing to pay for this. **Credibility and trust in the source and in the**

messenger depends on experiences with different actors in the advisory services. In contrasts to advisers, advice connected to perceived government agendas or regulation is rarely trusted (Palmer et al., 2009). However Bennett and Cattle (2014) in their study of adoption of soil health improvement strategies by Australian farmers found some scepticism amongst landholders concerning agronomists and government. This is linked to reduced capacity and resources as mentioned above.

A study in Australia looked at who influenced adoption of soil health management plans. A survey of landholders (mixed farming enterprises in New South Wales (141 respondents) found that 3 most influential factors for adoption of Soil Health Management plan were: **agronomists, neighbours and friends, and extension agency efforts**. Agencies and extension organisations are regarded as influential but this is positive and negative, sometimes cost of soil analysis was too high to warrant using soil health agencies and this was a major concern (48%), as was lack of freely available support (46%) (Bennett and Cattle (2014), (Bennett and Cattle, 2013). These results (agronomists and extension agencies featuring in the three most influential factors) are in contrast to previous research which found adoption of farming methods to be influenced, in order, by: ‘seeing the method working on a local property’ (78%), ‘talking to a local producer using the method’ (63.5%) and ‘having the method explained at a local field day’ (60.7%) (Lees and Reeve 1994).

Although advisers have been identified as important messengers and influencers for SCIS advice, this places more responsibility on them. Furthermore whether advisers are equipped to provide soil management advice has been questioned, as discussed above (Ingram and Morris, 2007). Palmer et al. (2008) reviewed the KT activities required to implement the cross compliance soil regulations in UK and found some limitations. Some argue that on-going training is essential with education programmes for personnel to develop a more efficient workforce which is abreast of research. In part this will involve the training and education of advisers to improve understanding. Advisers, if trained, can provide a forum for exchange between farmers, scientists, conservation practitioners and the public to discuss advantages and disadvantages of recent developments (Delgado et al., 2011).

Advisers use a variety of DSTs, manuals and need to stay up to date with technical and scientific developments. They are also being expected to host and coordinate discussion groups, farmer networks and facilitate operational groups. The need to upskill to meet these new demands has been widely recognised. In Victoria, Australia, there has been increased capacity by training soil champions[19].

It is common practice now in research projects to consult and involve advisers as active researchers and as gatekeepers to access farmers. In developing DST to support cropping and

[19] Cann and Mitchell no date http://www.nzsssconference.co.nz/images/Melissa_Cann_-_Increasing_the_capability_of_Agriculture_Victoria_staff.pdf

agronomic decisions, researchers have consulted and targeted advisers as potential users and interpreters for farmers (Carberry et al. 2002; McCown et al. 2012; Naumann et al., 2015).

Ideally farmers and advisers or specialists work together to co construct knowledge in dialogue in which information is exchanged between farmer and adviser with the purpose of joint knowledge creation, rather than a transfer of information based on the adviser's problem diagnosis.

6.1.5 Effective methods for delivering advice on soil and crop management

In provision of knowledge, **tailored, place-specific advice** is more appropriate than a ‘one size fits all’ approach. Some have found that a blanket approach to encouraging and promoting Soil Health indicators is not desirable or effective (Bennet and Cattle 2014; Lobry de Bruyn and Abbey, 2003). Palmer et al. (2006) for UK argue that due to the complex and inherently variable nature of soils and their management, it is unlikely that a simple prescriptive message can be developed with wide applicability. Delgado et al. (2011), reviewing soil and water management in conservation tillage context in USA, propose that soil management advice needs be **targeted to the farm**, farmers’ knowledge and context. Raymond and Robinson (2013) suggest that advisers can develop a ‘portfolio of adaptation options’ to acknowledge a continuum of individual positions to sustainable practices the adviser can support movement along.

Researchers have pointed out that **timing** of advice and support is important and that it is essential to work with lead times and when decisions are made, to target advice and points in time where they may be more useful. For example, in promoting sustainable use of fertiliser in USA the concept of the “4R’s” (right rate, right type, right timing, right placement) emerged (Lal et al., 2011). Prokopy et al. (2012), in their study of advisers’ role in climate change, identified three categories of decisions: operational (lead time of days to weeks), tactical (lead time of months), and strategic (lead time of a year or more). Also according to Roger’s (1995) innovation-diffusion-adoption model, different types of advice and information are more effective at different stages of the adoption process.

Soil management advice needs to consider how the initiative and the information will sit in the landscape of advice, and which advisory service is to deliver the message. It should **complement other advice**, not confuse or contradict. For example it is suggested that a message can demonstrate utility and increase awareness of the problem through connecting up with cross-compliance and relevant guidance and fit with current agri-environment schemes (Failey and Dilling, 2010, Dilling and Failey, 2013).

6.2 Understanding the audience

6.2.1 Farmer utilisation of knowledge

Simply providing information is not enough, understanding of how farmers use it is essential. Farmers’ utilisation of knowledge is influenced by a number of factors including their beliefs and values, quality and perceived relevance and credibility of the information; while their ability to access and use knowledge depends on the personal and farm factors, as well as on the institutional and market context. Dilling and Failey (2013) examined the role of information in supporting decision making for carbon management in Colorado (where there were opportunities for farmers and ranchers to enrol their acres in a voluntary carbon market). Lack of information does emerge as a potential barrier, but results suggest some differences in what is lacking for public and private land managers. Many public land managers said that they do not have adequate information on how various management options that they have at their disposal affect carbon sequestration, they stressed the importance of reliable scientific information. Private land owners tend to get their information from a range of sources, including trade magazines, neighbours, agricultural consultants, and agency employees and most of the farmer and rancher interviewees did not mention lack of information as a particular issue.

Also importantly, farmers have individual learning styles, they learn about innovations in different ways and therefore need different levels of engagement. Long (2004) recognises there is no such thing as a 'stereotypical' adult learner. Taking account of the variation in learning capacities and learning styles of individual farmers and their diversity of knowledge and skills (Millar and Curtis, 1997; La Grange et al., 2010) is an important part of enabling learning. The process of adoption although it can follow similar pathways: the adoption of new technology or knowledge is seen as a learning process that involves 1) the collection, integration and evaluation of new information and 2) the adaptation of the innovation to the user's situation (Rogers 1995; Pannell et al. 2006). However this process will vary with different farmers dependent on their motivation, level of support and adaptive capacity which is linked to learning (Darnhofer et al., 2010). Providing farmers with both the information/knowledge and the capacity to change are important, particularly as "an individual's decision about an innovation is not an instantaneous act. Rather, it is a process that occurs over time and consists of a series of different actions" (Rogers, 2003, p. 169). Others confirm that farmers' trajectories are mostly a series of changes that are the result of a mix of various technical practices, and of ongoing adjustments to the political, social, and economic context, more successive adaptations of farming practices than one off adoption of a technical package (Chantre and Cardona, 2014).

Farmer personal factors influence ability to access and engage with knowledge and information. Individual's ability to engage with knowledge and information is a function of their access to resources. There are always some costs associated with acquiring knowledge, and as such it is argued that larger well-resourced farms will most likely be the first to utilise knowledge. This is relevant to European countries where privatisation of advisory services has meant some farmers cannot afford agronomic advice. Given this arguably strengthening extension alone is insufficient to ensure uptake. With increasing amount of advice delivered through the private sector, access to good quality advice at the farm scale becomes an important issue.

6.2.2 Heterogeneity of human decision-making

Although it is possible to identify factors that influence farmer behaviour, and therefore possibly identify target audiences with information and advice (typologies, market segments) (e.g. Pike, 2013; Arbuckle, 2012), numerous studies have demonstrated the complexity and heterogeneity of human decision-making that make this approach difficult. Studies of farmer behaviour, and by inference use of advice, in many contexts have demonstrated the influence of different motivations, cultural norms, habits, identity, farming styles, values, goals and worldviews on farmers' environmental behaviour (Blackstock et al., 2010, Slee et al., 2006, Siebert et al., 2006). Knowler and Bradshaw (2007) in a review of 31 separate analyses of conservation tillage adoption found that 171 significant variables affect adoption, however few of these influences apply universally. In recognition that farmers need nurturing and persuading to change behaviours scholars have identified the importance of engagement activities (Mills et al., 2016, Pike, 2013).

6.3 Key principles for advice and dissemination on SCIS:

Drawing on this full review, the key principles relevant to SCIS are summarised below, structured around the three main elements of the dissemination strategy: the message (the what), the methods (the how) and the audience (the who).

6.3.1 The Message (what)

- **Demonstrate the utility and relevance** of the information for the farmer
- **Be aware of the inherent tensions** between existing advice supporting productivity and sustainability but also of the **opportunities for synergies**
- Advice on SCIS needs to **agree with compliance and standards** in current AEM contracts and other measures but also needs to be aware that the **emphasis on meeting cross compliance regulations** limits scope
- **Advice on single SCIS is not always very helpful** -SCIS are conducted in combination and often carried out simultaneously, single issue advice does not reflect what is happening on the farm and the way the land managers makes decisions or manages cropping
- **SCIS advice should complement other advice**, not confuse or contradict. Find **synergies** with existing advice messages and programmes is essential **-**land managers receive multiple messages
- **Advice needs to communicate principles** rather than prescriptions for SCIS (integrated and smart systems and practices) –complex SCIS and spatial heterogeneity means that it is **unlikely that a simple prescriptive message** can be developed with wide applicability
- **Adoption vs adaptation** Advice has different requirements **depending on the extent of change involved** - systemic changes requires adaptation and long term support, agronomic techniques require shorter technical input.
- **Advice should provide unambiguous and accurate information -** convincing evidence relevant to particular farmer contexts about the effect of SCIS on crop yield and soil is important

- **Advice should emphasise co-benefits or win-wins but be honest about trade-offs and support with evidence** pointing out different time scales and spatial scale effects
- **Advice should provide assurance of long-term, multiple** (i.e. economic and non-economic) **benefits** from SCIS implementation
- **Short term penalties** should be explained - these may have to be weathered before longer term benefits become apparent. This has implications for financial management.
- **Language** and **indicators** used in information and advice about soil must be relevant and familiar to land managers. **Find a common message** and vocabulary that relates to land managers, be aware that there are different concepts/language re soil (soil health, soil fertility, soil quality etc)

6.3.2 The Methods (how)

- **Be aware of variable capacity** of advisory system and competence of staff to deliver good quality advice on SCIS
- **SCIS can be demanding** on adviser skills and knowledge - recognise that some may need upskilling (technical and facilitation skills)
- **Be aware of orientation and structure of advisory systems** (attitudes, culture) and consider how the advice and the information will sit in the landscape of advice
- **Be aware that credibility, trust in the source** and in the messenger is critical if it is to influence change- recognise that some providers are not trusted
- **Make use of different methods** of delivery to suit different audiences. Where possible tailored, place-specific advice is more appropriate than a 'one size fits all' approach, in other cases provide a menu of options
- **SCIS advice needs be targeted** to the farm, land managers' knowledge and context and target advice and points in time when it is most appropriate
- **Exploit existing sources and channels-** tap into existing trusted sources, networks, use farmer champions and advisers as brokers where appropriate

6.3.3 The audience (who)

- **Understand that SCIS may be unfamiliar** to land managers and require a new skills set, more observation and monitoring and some understanding of soil and crop processes
- **Lack of specialist knowledge/information on SCIS** (not available) can be a barrier to uptake
- **Access** to good quality advice on SCIS is crucial and cannot be assumed to be universal
- There are always **some costs associated with acquiring knowledge** –try to account for individual's ability to engage and access knowledge and information
- **Land managers are variable**- include producers, smallholders, large commercial farm managers, contractors with varying tenure arrangements, decision making autonomy and stewardship ethic/commitment to the land

- **Land managers use a range of information sources** and have different knowledge needs, priorities and preferences, for some reliable scientific information is important, for others field demonstration is key
- **Dissemination and advice needs to account for the different capacity** and ability to use advice (economic status etc) of land managers
- **Land managers have different motivations** for seeking and acting on advice
- The **same message is received differently** by different land managers
- It is **difficult to segment the audience** for advice at a large scale, although this may be possible for local management at a local scale
- Advice needs to **engage land managers at the level of the farm business** however it is also interpreted in the context of a wider set of influences (innovation systems).

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