Are advisory services 'fit for purpose' to support sustainable soil management? An assessment of advice in Europe

J. A. INGRAM * and J. MILLS

Countryside & Community Research Institute, University of Gloucestershire, UK

***Corresponding Author:** Julie Ingram; jingram@glos.ac.uk

Running Title: [Advice to support sustainable soil management]

Summary

This assessment examines the extent to which advisory services are able to address practitioners (primarily farmers) current and emerging knowledge needs about sustainable soil management (SSM) in Europe. The assessment is structured around the following components: the context of advice (policy, market, socio economic conditions, privatisation of advisory systems); the challenges that SSM presents for advice; the current and emerging practitioner knowledge needs and the existing structure and function of advisory services for SSM. The analysis reveals fragmented policy and advisory services, paralleled by the multi-scale character of SSM and a diverse audience for advice. The challenges and opportunities this complex arena presents are analysed and suggestions made for achieving more effective advisory services for SSM, together with examples of existing approaches.

Keywords: advice, advisory services, advisers, policy, sustainable soil management, farmers, knowledge, Agricultural Knowledge and Innovation Systems

Introduction

There is increasing attention given by research and policy organisations to the role of soil management in meeting the global change pressures of food security, climate change, land use change and resource degradation (McBratney *et al.*, 2014; Weigelt *et al.*, 2015; Montanarella *et al.*, 2016; Turpin *et al.*, 2017). At the same time there has been a resurgence of interest within the farming community in a number of countries worldwide in protecting soil and, in particular,

in, the notion of soil health (Wood & Litterick, 2017; Derner *et al.*, 2018). As part of this interest, the need to provide appropriate information, advice and support to farmers[1] about sustainable soil management (SSM) has been identified at the international, European and national levels (McIntire *et al.*, 2009; Frelih-Larsen, 2016; Campbell *et al.*, 2017; FAO, 2017), where SSM is 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).*

The importance of effective advice[2], information and dissemination at the farm level in supporting adoption of soil conservation is well known (Pannell *et al.*, 2006; Prokopy *et al.*, 2008; Baumgart-Getz *et al.*, 2012; Carlisle, 2016). However, the changing context of agriculture has brought new demands on advisory services. Specifically for soil, the increasing complexities of managing multiple soil functions and a range of specialised, 'smarter' yet sustainable systems, all call for qualitatively different sorts of advice which, not only provide technical support, but also build farmer capacity for SSM (Briggs & Eclair-Heath, 2017). The knowledge needs of practitioners (farming, advisory and supply chain actors) and researchers in relation to soil and its resilience to agricultural and environmental change have been widely expressed, as have the demands for more guidance in implementing soil management practices and interpreting soil analysis (e.g. Dicks *et al.*, 2013; Barbero-Sierra *et al.*, 2016).

Concurrent with these changes, there has been a shift from supply-led to demand-led advisory services, which has blurred traditional roles (researchers, advisers, farmers, educators) and

[1] The term 'farmers' is used here to represent the full range of land managers who all make management decisions effecting soil.

[2] '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. Information comprises facts, interpretations and projections that reduce the uncertainty faced by decision makers (Garforth et al., 2003).

introduced new players creating a more complex system of innovation support services. Thus, advisory services can be defined as *sets of organisations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills, and technologies, by enabling farmers to co-produce farm-level solutions by establishing service relationships with advisers* (Birner *et al.*, 2009; Labarthe *et al.*, 2013; Prager *et al.*, 2017). Actors and structures involved in advisory services represent a subsystem of the wider Agricultural Knowledge and Innovation System (AKIS), a system of diverse actors from the private, public and non-profit sectors that links people and organisations to generate, share, and utilise agriculture-related technology, knowledge, and information (Birner *et al*., 2009).

Against this background it is timely to ask: "*Are advisory services 'fit for purpose' to support sustainable soil management?"* Although we know about the importance of advice in supporting soil management decisions, to date there has been little academic analysis of how advisory services are performing with respect to SSM at regional, national or European scales.

In addressing this question, an assessment of advisory services for SSM in Europe was carried out. In accordance with AKIS, and related frameworks used to analyse both advisory services (Birner et al., 2009), and soil governance (Juerges & Hansjürgens, 2018), this assessment is structured around the following components: the context of advice (policy, market, socio-economic conditions); the challenges that SSM presents for advice; current and emerging practitioner knowledge needs; and the existing advisory services for SSM. The implications of this analysis are discussed with respect to the paper's key question, and suggestions (and examples) for achieving effective SSM advice are presented. Countries in Europe are highly

diversified in terms of the structure of their agriculture[3], farming systems, soils, productivity, advisory services and AKIS (Eurostat, 2013). Therefore, although country examples are presented, inevitably, this question can only be addressed at a general level.

The assessment draws on papers and reports published since 2000. As there is very little literature available that specifically addresses advisory services for SSM in Europe, the analysis considers a) the role of advisory services in farmers' adoption of broader best management practices (BMP)[4]; b) governance and policy measures relevant to soil management; c) the structure and function of advisory systems and services. Insights from research based on stakeholder engagement and reviews (unpublished) conducted within three European Union (EU) funded projects complement the analysis: SmartSOIL, RECARE and SoilCare (see acknowledgements for details). The focus is mainly on advisory services rather than the mechanisms and tools of delivery (websites, leaflets, face to face, workshops), and largely on evidence from arable farming systems.

Context of advice for sustainable soil management

Four main contextual factors that influence advisory services for SSM are considered here. Firstly, the agricultural sector is increasingly organised along demand-driven production chains (Richards *et al.*, 2013). In response to a volatile, competitive marketplace, increasing costs of production, and falling farm gate prices, there is a trend of increasing intensification and specialisation (Assefa *et al.*, 2016; Smith *et al.*, 2016; Techen & Helming, 2017). This has resulted in farm restructuring, with an overall decline in the number of holdings, amalgamation

[3] For example, in 2013 more than two-thirds of all holdings were < 5 ha, occupying 6% of the total land area used for farming in the EU-28, while more than half of this area belonged to farms > 100 hectares (Eurostat, 2013).

[4] BMP is used here in its widest sense to include a range of systems and management practices that counter soil threats and potentially improve soil functions. Baumgart-Getz et al. (2012) provide an extensive list of BMP types.

into larger holdings, and a shift towards larger fields (notably in N.W. Europe) and simplified tillage systems, such as reduced tillage (Louwagie *et al.*, 2009; Townsend *et al.*, 2016; Struik & Kuyper, 2017; Techen & Helming, 2017). In this context, soil-provisioning functions are prioritised and the incentives are set to manage soils within a short-term time perspective, although risking negative effects for soil quality in the long-term (Van den Putte *et al.*, 2010; Posthumus *et al.*, 2011; Juerges & Hansjürgens, 2018). Secondly, there has been a coincident change in the farming population, the audience for advice, with new decision makers and different tenure arrangements (owners, tenants, contractors, partnerships, cooperatives, large commercial farm companies). This, together with farm size and farm demographic change, creates land managers with differentiated innovation pathways, motivations, competences, capacities, and access to advice, with respect to SSM (Kania *et al.*, 2014; Renske, 2017). Thirdly, soil is subject to a range of cross-sectoral policy priorities and instruments at EU, national and regional levels, which together create a highly fragmented policy landscape. These are largely aimed at protecting soil regulating functions (filtering of nutrients, carbon storage, flood mitigation) (Calatrava *et al.*, 2011; Turpin, 2015; Vrebos *et al.*, 2017). Fourthly, there has been a transformation in advisory services in countries across Europe with a trend towards privatisation, decentralisation and more demand-led systems. This change has resulted in pluralistic advisory systems comprising a diverse mix of public, private (supply chain, consultants) Non-Governmental Organisation (NGOs) and Farmer-Based Organisations (FBOs) (chambers of agriculture, farmer unions, farmer associations, farmer co-operatives), with differing objectives, priorities and delivery approaches, and employing advisers with variable skill sets, with respect to SSM (Garforth *et al.*, 2003; Faure *et al.*, 2012; OECD, 2015). This shift has been accompanied by an increase in digital communication and technology enabling greater access to soil information and data for all practitioners (Piikki *et al.*, 2017). The traditional role of the farm adviser, linking research and practice, has largely been replaced

by a range of new roles (specialist/generalist agronomist, crop consultant, facilitator, research project partner), and expanded with new intermediaries and knowledge brokers, (Kania et al., 2014)., for example, the consultants in the Netherlands who support farmers to gain funding for study clubs (Klerkx and Leeuwis, 2009). Notably there has been an expansion in the number of private advisers reported in a number of countries, either linked to the agro-industrial industry (e.g. Portugal, Italy) or active in supporting farmers' applications for national and European funds (Table 1) (Kania et al., 2014).

These many interacting contextual factors illustrate how farmers and advisory services are embedded in, and influenced by, a wider dynamic AKIS. According to this framework innovation (utilising information and knowledge) is no longer seen as a linear process in which technological knowledge is generated by science and subsequently transferred by advisory services to end-users (Leeuwis & Aarts, 2011). Instead, advice is part of a complex, interactive and learning based systems, and advisers are just one of the many stakeholders within a networked innovation system.

The challenges that sustainable soil management present for advice

SSM can present some particular challenges for those coordinating, formulating and delivering advice, primarily because it is interpreted and operationalised differently according to context (policy priorities, research institutions, farming community). SSM is framed by several concepts (e.g. natural capital, soil functions, ecosystems services, multifunctionality); associated with different farming approaches (e.g. agro-ecological farming, sustainable intensification, ecological intensification, climate smart agriculture, carbon farming, smart and precision farming); operationalised according to generic sets of practices (e.g. BMP, soil

Table 1 Contextual characteristics, adviser effectiveness and farmer knowledge needs in three contrasting countries

Example country	DENMARK	HUNGARY	ITALY
Farm characteristics[5]	55% farms are >20ha Average size of a holding increased from 35 ha to 66 ha (1990-2012).	Agricultural holdings dominated by two size classes: small holdings < 2 ha (3% of land), and farms with <50 ha (75% of agricultural land)	The average farm size is 7.9 hectares Farms>30ha cover >53% of agricultural area Diverse farmers.
Advisory service characteristics**	**Predominantly private** (not for profit). Organised as a two-layered partnership: SEGES national institute, trains advisers and provides guidelines, and offers contact with experts. At the local level 30 Danish Agricultural Advisery Service (DAAS) centres are independent advisory units (farmer-based organizations) across the country, where the advisers have a direct contact to the farmers. This system is financed and owned by the farmers (SEGES is also supported by public support and research funds etc).	**Predominantly public** with: (a) free advisory services at the national level, funded by the EU and public sectors (village extension services and the Hungarian Chamber of Agriculture); (b) the FAS, subsidised advice (c) commercial consultancy; and (d) consultancy by input providers. FAS services farms 30-200 ha but demand is low. Very big farms have their own advisers, very small farms do not seek technical advice. There are very few genuinely independent commercial advisers because farmers do not like to pay for, cannot see the benefits of, advice.	**Predominantly public organisations (with FBO)** have jurisdiction over agricultural extension services, operating through 21 regional agencies/ authorities. **FBO deliver at province level.** Increasing privatisation and plurality, new supply chain advisers; increase in private advisers. In 2008 5000 advisors were working in agricultural upstream and 734 in the downstream industries. Public organisations/FBOs mainly service medium-small farms/producer groups. Private organisations service large-medium farms.
General characteristics that affect SSM	Active communication about soil/crop management practices between research, advisory service and the farmers through SEGES/DAAS. Being farmer owned, the main focus is farm economic profitability. SEGES/DAAS are reluctant to support regulation targeting soil. Some tension between advice for regulations and advice for SSM. Regulations for application of slurry (Nitrate Directive) results in farmer operations when soil is vulnerable to compaction.	The quality and consistency of advice is a problem, leading to lack of trust. There is difficulty in locating the right person to give advice on technical subjects such as soil management, also the best advisers prefer not to be part of the public services. In Hungary advice on soil management practices focuses primarily on regulated areas- degradation and nitrate pollution issues.	Nationally - a growing demand for highly specialized experts in soil, animal health. Regional variation in support. Tuscany -farmers' poor awareness of the soil management practices attributed to the unsatisfactory advisory system in this region. In contrast Veneto region promotes training courses for agronomists and farmers, innovation transfer, participates in several research projects, supports farmers to solve specific problems in the field.
Adviser effectiveness	There is generally a high awareness amongst advisers of soil management practices in Demark, however there are differences among advisers. Organic farming advisers have a higher awareness.	Some advisory services on nutrient management are out of date; there are contradictions between specialists interested in nutrient management/reduced tillage and those interested in soil protection. Commercial advice linked to	Tuscany - inadequate regional agricultural services and technical skills to provide information/train farmers on min/no-tillage, crop rotation, residue management, and their cost effectiveness.

*[5] Figures from Eurostat (2013); Other details from Country reports for the AKIS of the PRO AKIS project (2014) http://proakis.webarchive.hutton.ac.uk/inventory and SmartSOIl, RECARE and SoilCare project reviews.

		product sales conflicts with advice on soil management concerned with public goods.	Level of adviser awareness depends on the interests of the regions and the professional associations who train them. They need to broaden services from simply advising on cross-compliance measures.
Farmer knowledge needs	Generally, soil is considered an important resource and farmers are aware of SOM benefits to soil strcuture and crop productivity. Many farmers are more focused on the regulations than on what is actually best for the soil. In Zealand region lack of scientific knowledge and communication to farmers about cover crops.	In Central Hungary - lack of appropriate knowledge about soils in general and a strong attachment to "traditional" methods. Uptake of reduced tillage, residue management and cover crops is limited due to lack of up-to-date knowledge and conflicting technical advice. Farmers request more "practice" oriented advisory services.	Tuscany (62% holdings <5ha)- increase in contract farming has resulted in reduced farmer soil stewardship. Older farmers do not take up advice on 'non-traditional' practices, but young farmers are more disposed to follow advice on new measures, e.g. minimum tillage. Veneto Region – there is low uptake up of measures introduced to address loss of SOM (e.g. crop rotations, organic inputs).

health practices, soil conservation, soil protection), principles, and functions (Baird *et al.*, 2016; Gunton *et al.*, 2016); assessed with reference to a number of concepts (e.g. soil health, soil quality, soil fertility, productivity, resilience) and indicators (Sherwood & Uphoff, 2000; Buckwell *et al.*, 2014); and subject to multiple synergies and trade-offs at the farm level (Powlson *et al.*, 2011; Struik & Kuyper, 2017). Translating these ideas into meaningful information and evidence for use as a basis for advice is challenging, particularly given the inherently variable nature of soils, and the fact that soil management problems need to be addressed at multiple spatial and temporal scales (Juerges & Hansjürgens, 2018). Tailoring SSM advice to the farm level, and meeting the fine resolution of soil information and data that farmers require (Campbell et al., 2017) is therefore demanding, both for advisers and for those translating research outputs.

This analysis serves to illustrate that there are multiple understandings of what constitutes SSM and consequently, there is no single message or set of advice that is relevant to all contexts, beyond setting out high level principles (FAO, 2017).

Current and emerging practitioner knowledge needs

Collectively the contextual changes outlined above and the multi-faceted demands of implementing SSM result in a new set of knowledge needs for the multiple actors engaged in the soil AKIS (Dicks et al., 2013). Furthermore, the overarching dual imperatives from markets (private goods) and policy (primarily public goods) bring a competing set of soil management demands (provisioning and regulating functions) both for farmers and those supporting them.

Researchers note that the role of advice and advisers is more important than ever because of the increasingly scientific nature of managing soil quality (Bennett & Cattle, 2014). As such, advisers for SSM need: clarity from policy makers, good links to research to access evidence to be able to deliver credible and balanced advice at the farm level; a good level of specialist

soil knowledge; as well as the ability to accommodate different styles of farmer learning. Furthermore, advisers formulating advice to support farmers need the understanding to be able to take account of trades-off and synergies between soil functions, particularly with respect to cost of production and impact on yield, and variable scales (spatial and temporal). For example, while interpretation of soil nutrient data can support one-off field operations (e.g fertilizer recommendations), longer term facilitation of farmer experimentation and learning is needed for those transitioning to new systems, such as organic systems or zero tillage (Coughenour & Chamala, 2007; Ingram, 2010).

For farmers in particular, the increasingly complex nature of managing soil within the context of competitive and efficient farming systems and multiple policy measures brings new demands. Europe-wide evidence of farmer SSM knowledge needs is not available, however there is indicative research to draw on. For example, Renske (2017) found in a large scale survey of farmers across Europe that, although they regarded SOM as important, farmers in general considered it hard to understand and manage; they were concerned about trade-offs and needed more specific guidance on applying cultivation practices for SOM to avoid weeds and pest. In line with this, a farm practice survey in UK (Defra, 2018) found that one of the main reasons (31% farmers surveyed) for farmers not testing soils for SOM was that they found the results difficult to interpret. Other researchers have identified needs in relation to soil analysis. A review and survey in UK found that farmers and agronomists/suppliers lack meaningful guidance to help maximise the value and impact of soil testing for soil health, specifically concerning what they should be testing and how they should interpret soil test results in light of their farm's soil type, topography, weather, crops, rotation, and cultivations (Briggs & Eclair-Heath, 2017). Lack of awareness, knowledge and skills have been widely cited as barriers to farmer uptake of practices, such as minimum tillage, cover crops and residue management (Ingram *et al.*, 2014; Pronk, 2015; Renske, 2017). A survey of 119 farmers in a

semi-arid district of Madrid, Spain found that farmers were aware of their own knowledge limitations with respect to soil improvement and conservation and suggested awareness raising, capacity building, technical and policy support to address this (Barbero-Sierra et al., 2016). However, in other contexts farmers are well informed and supported, in Denmark, for example, (Table 1), and in Scotland, where a small number of farmers interviewed reported accessing and interpreting sufficient field scale soil data (nutrient and structure) through a range of soil testing and interpretation techniques, including sampling and laboratory-based analysis, GPS soil mapping and soil structure scanning, provided by commercial companies (Prager & McKee, 2014). It is also acknowledged that many individuals and farmer groups are active in experimenting with, and implementing, cover crops, reduced tillage, organic amendments, residue management (Schneider *et al.*, 2009; Compagnone & Hellec, 2015), however, evidence of the declining quality of agricultural soils would suggest that these are not represented across Europe. Table 1 sets out further examples in three countries with contrasting contexts.

Advisory services relating to sustainable soil management

Advisory services are reactive, responding to the policy, market and farming community changes (Birner et al., 2009; Prager et al., 2017). As such, the nature of advisory services relating to soil reflects the varying agricultural contexts and needs of the farmers, market opportunities, institutional resource settings, policy objectives and priorities. In most EU countries advisory services which relate to soil are characterised by a diversity of actors, private-public arrangements and funding strategies (Louwagie *et al.*, 2011; OECD, 2015) (illustrated for three countries in Table 1). As noted earlier there are different market and policy priorities which determine the advice agenda for soil with a broad distinction between advice supporting soil regulating and provisioning functions (Coulter *et al.*, 2008). For the former, regulatory, industry and voluntary instruments are delivered by a mix of public, private, NGOs

or FBOs. Chief among these is advice associated with EU's Common Agricultural Policy (CAP) Pillar 1 cross compliance which regulates soil management practices at the farm level through Good Agricultural and Environmental Conditions (GAEC), and Greening measures, delivered in each country by a dedicated national Farm Advisory System (FAS) (Frelih-Larsen, 2016). Advice is also provided as part of country Rural Development Programmes (RDP), supported under Pillar 2, which can identify priority areas, for example, soil erosion in Belgium and Portugal, and support regional soil management initiatives, as well as Operational Groups on soils (see Table 2). Advice supporting provisioning functions to enhance soil productivity and minimise inputs, e.g. through tillage and nutrient management, is predominantly the remit of private organisations, FBOs and public-private partnerships in each country.

Implications for sustainable soil management advice

From the foregoing analysis it would appear that the fragmented policy and advisory services are paralleled by the multi-scale character of SSM, as well as the diverse farming population, creating a complex arena in which to provide advice to the farming community. This section examines the implications of this for delivering SSM advice.

Poor integration within policy and advisory services

Montanarella and Alva (2015) argue that national and regional governance systems have widely failed to achieve SSM in Europe. This is attributed to a highly fragmented policy field and a tendency to focus on single soil functions (Calatrava et al., 2011). This has repercussions for advisory approaches and services at field level, and can create tensions between providers due to competing priorities. For example, Vrebos et al. (2017) report that, for the implementation of the RDP in Emilia-Romagna, Italy, a range of soil management options

available to farmers can impact the different soil functions both positively and negatively. This tension is also observed in Denmark with respect to regulations (Table 1).

Low priority given to SSM in advisory services

Formal public advisory services (including FAS) tend to focus advisory support to help farmers comply with minimum legislative requirements, which has been called operating in 'catch-up mode' (Klerkx & Jansen, 2010). This preoccupation with regulatory compliance, often to the detriment of wider soil conservation efforts, has been widely reported, for example in Poland, Hungary, Czech Republic and Romania in the SoilCare, RECARE and SmartSOIL[6] projects, (reported in interviews and workshops with experts, advisers and representative farmers) (Ingram et al., 2014) (Table 1). This situation also described in two English catchments, where the emphasis on preventing diffuse pollution led to gaps in the implementation of measures for conserving soil in situ (Posthumus et al., 2011). The SoCo project, which worked with a number of soil conservation case studies across Europe, concluded that public sector advice to farmers on the mitigation of soil degradation processes, was inadequate (Louwagie et al., 2009).

This gap is not necessarily filled by the private sector or FBO services. Although these organisations engage in SSM advice, their priority is supporting their clients' or members' interests, as illustrated for DAAS in Denmark, a farmer owned organisation, with respect to regulation (Table 1). In addition, privatisation can mean that smaller farms cannot afford, or

[6] SmartSOIL worked with advisers and representative farmers in 6 case study regions in Hungary, Italy, Spain, Denmark, Scotland and Poland to understand their awareness of, and advice provision for, practices that enhance soil carbon (e.g. residue management, reduced tillage, cover crops, rotations), and to develop a decision support toolbox (Table 2) .

see the benefit of, advice (Labarthe & Laurent, 2013). This distinction is significant given the number of small farms across Europe (see Hungary, Table 1).

There is also concern that the influence of productivity-oriented advisers, who work on a fee for service basis or whose advice is linked to product sales, can promote practices (e.g. multiple field operations with heavy machinery, a reliance on inorganic fertiliser and poor budgeting of organic inputs) detrimental to SSM (see Hungary, Table 1). In Scotland a consultation of farmers also revealed concerns about the potential for bias or misinterpretation from those who provide soil data interpretation, as well as the focus on single issues (Prager & McKee, 2014). However, as markets introduce new forms of so called 'private regulation' (e.g. retailers' food assurance schemes) (Richards et al., 2013), which require farmers to follow protocol (e.g Unilever's Guidelines for Integrated Production), this is creating a cohort of experienced agronomists with a wider focus on sustainable agriculture. Equally NGOs, notably within the organic sector, specifically address SSM and have built a community of advisers with specialist interest in soil.

SSM advice in pluralistic services

A common observation is that privatisation leads to vertical fragmentation, such that previously effective advice mechanisms (specialist advisory service, demonstration or experimental farms), which directly connected research and practice, are no longer available (Curry *et al.*, 2012). A gap analysis for soil research (and links to advice) in the UK, for example, revealed poor transfer and exchange due to changing knowledge systems (and loss of public sector knowledge transfer) in arable and horticultural sectors (Kibblewhite *et al.*, 2010; Rickson & Deeks, 2013). Furthermore, it has been observed that horizontal fragmentation of previously public services has created a plethora of disconnected actors delivering either duplicate or

conflicting advice to farmers with potential tensions between public and private goods advice, even from the same adviser (Ingram, 2008; Klerkx & Jansen, 2010; Vrain & Lovett, 2016).

However, others suggest that these changes have allowed a multiplicity of communities of practice and network types to emerge, and that such 'bottom up' participation of farmers and other actors (e.g. NGOs) is beneficial (Feder *et al.*, 2011). For soil this is evidenced in the growing number of networks and programmes where advisers facilitate farmer-to-farmer learning/experimentation, and broker researcher-practitioner interaction (Schneider et al., 2009; MacMillan & Benton, 2014; Compagnone & Hellec, 2015; Baird et al., 2016) (see also Table 2).

Adviser capacity and expertise in SSM advice

The quality of advice and adviser competence is a key characteristic of the advisory services' capacity to support SSM. A lack of investment in updating environmental knowledge for advisers has been noted in private advisory organisations (Labarthe & Laurent, 2013). Although, others observe that greater adviser diversity and client orientation has increased competition, and therefore standards of advice (Klerkx & Proctor, 2013).

More specifically for SSM, Ingram and Morris (2007) described a cohort of advisers in the UK with mixed awareness and skill sets with respect to SSM, while numerous other studies have identified barriers to farmer uptake of soil conservation practices as: lack of access to technical 'know-how' and specialist advice (e.g. Louwagie et al., 2009; Renske, 2017). A recent audit on Soil Health in the UK (House of Commons, 2016) reported farmers unmet need for specialist soil advice. Conclusions from such studies, supported by additional analysis, are that private advice provision on sustainable farm management is 'suboptimal' (Klerkx & Jansen, 2010). A lack of specialist soil knowledge in advisory communities was reported in the

SmartSOIL project for case study regions in Poland and Hungary and attributed to poorly resourced public extension services (Table 1)(Ingram et al., 2014). Similarly there is a growing and often unmet demand for highly specialised experts in soil reported in other countries (e.g. Italy, Denmark, Cyprus) (Kania et al., 2014). However, there is also evidence of advisers providing specialist support required by farmers, for example, figures from UK farm practice survey (Defra 2017) show the that 76% of farmers completed a nutrient management plan with the support of, or solely by, an adviser. Advisers in Scotland interpret a range of soil information and data for farmers that require it (Prager & McKee, 2014); furthermore, Renske (2017) found, in a large scale survey across Europe, that farmers' ranked advisers above other farmers as their main social referents for learning about how to manage SOM.

The loss of soil specialists has been linked to fragmentation in the advisory services and AKIS (Kibblewhite et al., 2010). To bridge this gap, a report into the status of soil and water management in the UK recommended that agricultural professionals need to be encouraged to provide extension advice and practical training for farmers and agronomists about soil (Godwin *et al.*, 2008).

Conclusions: building capacity in advisory services for sustainable soil management

It is clear that in posing the question *"Are advisory services 'fit for purpose' to support sustainable soil management?"* there are some inherent challenges in identifying a 'purpose'. The fragmented governance, multiple functions, different conceptions of, and priorities for, SSM, the complex and variable nature of soil, and the many needs for locally specific advice all prevent a single purpose for advice on SSM being determined. The diversity between European countries and regions compounds this further. Equally, it is now widely agreed that it is not necessary, to introduce a uniform national approach to advice where the farming

clientele is heterogeneous, nor is it useful to determine the 'best fit' for advice provision, since emerging configurations serve different types of farmers (Feder et al., 2011). Nevertheless, this assessment would suggest that advisory services are not currently meeting all of the farmer and adviser knowledge needs for SSM. With the continued trends of farm restructuring, intensification, privatisation of advisory services, and degradation of soil functions, the need to build capacity at all levels of advisory services is arguably greater than ever. Suggestions of how this might be done are set out below, together with examples of existing effective approaches listed in Table 2.

Table 2 Examples of effective advisory activities and services

Suggested support:	**Example of effective advisory services**
Provide advisers with evidence and tools from research for formulating credible advice	• SmartSOIL toolbox (developed with practitioners): evidence based tool for advisers and farmers across Europe to identify practices for optimising profitability and carbon storage • Carbon Cutting Toolbox - farmer-led group in UK, promoting a decision support tool, and disseminating info. about soil health and mitigation • In Denmark the decision support system Terranimo has potential to improve communication among farmers and their advisers on how to avoid compaction damage
Generate and utilise local data for advice–indicators and targets for farmers Monitoring soil with farmers for benchmarking to support advice	• In the Netherlands, a large Public Private Partnership 'Sustainable Soil' is developing a soil quality assessment system in which a set of soil indicators is related to target values and ranges for integral advice on soil management • Study groups in Netherlands (private consultancies); Monitor farms in England (Levy boards)
Build capacity in advisory services: developing technical expertise in advisers	• The UK's BASIS (an independent standards setting and auditing organisation for the pesticide, fertiliser and allied industries) offers courses in soil and water management • The Veneto region in Italy offers technical/refresher courses and promotion of professional learning communities • SEGES Denmark trains farm level (DAAS) advisers as specialists in reduced till and other soil topics
Link advisers with research, training and updating with research outcomes Enhancing trainer skills Recognise and support of Communities of Practice (COP)	• SEGES/DAAS in Denmark integrated national and local services • Advanced Training Partnership set up by Biotechnology and Biological Science Research Council (BBSRC) in UK trains experts in soil science • H2020 Thematic networks formalise COP across Europe on specific themes and topics • COP around conservation agriculture in Europe (informal networks as well as an active European Conservation Agriculture Federation with industry, research, advisers and farmers involved)
Build capacity in advisory services: training in facilitation/ brokering of farmer networks	• NGOs (Soil Association, Farming and Wildlife Advisory Group) in UK train their advisers in facilitation skills to run workshop, field labs, demonstration farms

Support peer to peer and, farmer-centred learning networks and adviser, scientist, supply chain and farmer initiatives with advice and research expertise	• In Denmark "ERFA groups" a small group of farmers join forces with local advisers for sharing experience on topics such as min till/soil quality. SEGES has played a major role in technically supporting these • Innovative Farmers (coordinated by the Soil Association an NGO for organic farmers) in England runs Farmer Field Labs in which farmers, advisers and researcher select and conduct field experiments together on topics such as co-composting phosphate and FYM, biochar effectiveness
Identify pathways and mechanisms for scaling up groups, networks and COP	• Operational groups (OGs) funded by CAP RDP funds. Multiple examples of farmer groups, facilitated by advisers, supported by researchers, across Europe problem solving on soil topics. For example, four OGs in Emilia-Romagna, Italy currently, such as "Agroecological cover - Cover crops for the increase of the soil organic matter and the containment of weeds"
Build farmer capacity, enabling individual and peer-peer learning, awareness, education	• UK's Nuffield Scholarship programme supports farmers to travel and learn from other farmers about soil management in UK and internationally • BASIS courses in UK for farmers and advisers
Raise adviser and farmer awareness about SSM	• Dissemination campaigns • Champion farmers

Firstly, advisers need access to evidence and tools from research to formulate credible and tailored advice for farmers (e.g. on nutrient and SOM management), particularly with respect to the co-benefits and trade-offs (cost effectiveness) of different, or combinations of, soil management options under varying scenarios. Involving advisers and farmers in research, assessing their requirements, validating such evidence and co-designing decision support tools are all effective ways of ensuring outputs and advice is useful. In relation to this, providing advisers with the means for monitoring and interpreting soil conditions at field level, together with farmers, can support benchmarking and best practice (Table 2).

Secondly, building technical capacity in advisory services is key for SSM, particularly in advisers' field assessment, soil data and soil analysis interpretation skills in the context of nutrient management and soil health indicators. This could be achieved by encouraging investment in training and continuous professional development in all advisory communities (public, private, FBOs). In doing this there is a need to differentially target the diverse adviser community, identifying sectors (e.g. the increasing number of advisers in commercial and supply chain organisations), which might benefit most from, or contribute to (e.g. Unilever), such training. Examples of existing training are provided in Table 2.

Thirdly, as part of this capacity building, links between research and advice should be enhanced to encourage integration of scientific and practitioner knowledge, the arrangement between SEGES and DAAS in Denmark provides an example of expert support to advisers (Table 2). Such links need to be supported by training experts in agronomy and soil science, for example through the Advanced Training Partnerships in UK (Table 2). Fostering and formalising informal communities of practice, which link researchers, practitioners and industry, already active in exchanging knowledge about SSM, is also important, for example, through the thematic networks of EU's H2020, or recognising the role of tillage-interest groups and organisations (Table 2).

Fourthly, it is important to recognise the new facilitating role of advisers and offer them training in initiating, fostering and brokering farmer-centred networks interested in SSM, and in facilitating group problem-solving (Table 2).

Fifthly, examples of best practice, where adviser, scientist and farmer SSM knowledge are effectively integrated, need to be characterised, and pathways and mechanisms for scaling these up identified, using, for example, EU CAP measures (RDP Operational Groups), incentives, facilitation funds, public-industry alliances (Table 2).

Sixthly, these should all be backed up with capacity building in the farming community. Supporting individual experimental and peer to peer learning (as illustrated in Table 2), should be complemented with education and training among farmers to strengthen technical understanding, so as to optimise the use of advice.

Finally, these should be complemented with raising adviser awareness about the value of soil and its multiple functions, to shift the focus away from meeting EU CAP regulatory and grant

requirements, or single functions. Given that many advisory services are demand-led, such awareness raising is equally important for farmers to stimulate demand for SSM support. This is in line with Pillar Two of the European Soil Partnership (FAO).

Acknowledgements

The work was part of the following projects:

SoilCare (Soil care for profitable and sustainable crop production in Europe). Grant Agreement 677407 funded by the European Union's Horizon 2020 research and innovation programme. www.Soilcare-project.eu. 2016-2021.

RECARE (Preventing and remediating degradation of soils in Europe through Land Care. Grant Agreement 603498 funded by the European Commission, within the 7th Framework Programme of RTD. www.recare-project.eu. 2013-2018

SmartSOIL (Grant Agreement 289694) funded by the European Commission, within the 7th Framework Programme of RTD. www.smartsoil.eu. 2011-2014

References

Assefa, T. T., Meuwissen, M. P. & Lansink, A. G. O. 2016. Price volatility perceptions, management strategies, and policy options in EU food supply chains. *Agricultural Markets Instability: Revisiting the Recent Food Crises***,** 178.

Baird, J., Jollineau, M., Plummer, R. & Valenti, J. 2016. Exploring agricultural advice networks, beneficial management practices and water quality on the landscape: A geospatial social-ecological systems analysis. *Land Use Policy,* **51,** 236-243.

Barbero-Sierra, C., Marques, M., Ruíz-Pérez, M., Bienes, R. & Cruz-Maceín, J. 2016. Farmer knowledge, perception and management of soils in the Las Vegas agricultural district, Madrid, Spain. *Soil Use and Management,* **32,** 446-454.

Baumgart-Getz, A., Prokopy, L. S. & Floress, K. 2012. Why farmers adopt best management practice in the United States: a meta-analysis of the adoption literature. *Journal of environmental management,* **96,** 17-25.

Bennett, J. M. & Cattle, S. R. 2014. Adoption of Soil Health Improvement Strategies by Australian Farmers: II. Impediments and Incentives. *The Journal of Agricultural Education and Extension,* **20,** 107-131.

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D. J., Horna, D. & Benin, S. 2009. From best practice to best fit: a framework for designing and analyzing pluralistic agricultural advisory services worldwide. *Journal of Agricultural Education and Extension,* **15,** 341-355.

Briggs, S. & Eclair-Heath, G. 2017. Helping UK farmers to choose, use, and interpret soil test results to inform soil management decisions for soil health. *Aspects of Applied Biology, Crop Production in Southern Britain,* **134,** 161-168.

Buckwell, A., Heissenhuber, A. & Blum, W. 2014. The sustainable intensification of European agriculture. *A review sponsored by the*.

Calatrava, J., Barberá, G. & Castillo, V. 2011. Farming practices and policy measures for agricultural soil conservation in semi-arid Mediterranean areas: The case of the Guadalentín basin in southeast Spain. *Land degradation & development,* **22,** 58-69.

Campbell, G. A., Lilly, A., Corstanje, R., Mayr, T. R. & Black, H. I. J. 2017. Are existing soils data meeting the needs of stakeholders in Europe? An analysis of practical use from policy to field. *Land Use Policy,* **69,** 211-223.

Carlisle, L. 2016. Factors influencing farmer adoption of soil health practices in the United States: A narrative review. *Agroecology and Sustainable Food Systems,* **40,** 583-613.

Compagnone, C. & Hellec, F. 2015. Farmers' Professional Dialogue Networks and Dynamics of Change: The Case of ICP and No-Tillage Adoption in Burgundy (France). *Rural Sociology,* **80,** 248-273.

Coughenour, C. M. & Chamala, S. 2007. *Conservation tillage and cropping innovation: constructing the new culture of agriculture,* John Wiley & Sons.

Coulter, S., Lalor, S., Alex, C. S., Black, A., Bol, A., Burke, J., Carton, O. T., Coulter, B. S., Culleton, N. & Dillon, P. 2008. Major and micro nutrient advice for productive agricultural crops.

Curry, N., Ingram, J., Kirwan, J. & Maye, D. 2012. Knowledge networks for sustainable agriculture in England. *Outlook on AGRICULTURE,* **41,** 243-248.

Derner, J. D., Smart, A. J., Toombs, T. P., Larsen, D., McCulley, R. L., Goodwin, J., Sims, S. & Roche, L. M. 2018. Soil Health as a Transformational Change Agent for US Grazing Lands Management. *Rangeland Ecology & Management,* **71,** 403-408.

Dicks, L. V., Bardgett, R. D., Bell, J., Benton, T. G., Booth, A., Bouwman, J., Brown, C., Bruce, A., Burgess, P. J. & Butler, S. J. 2013. What do we need to know to enhance the environmental sustainability of agricultural production? A prioritisation of knowledge needs for the UK food system. *Sustainability,* **5,** 3095-3115.

Eurostat 2013. Farm Structure Survey.

FAO European Soil Partnership.

FAO 2017. Voluntary Guidelines for Sustainable Soil Management. In.

Faure, G., Desjeux, Y. & Gasselin, P. 2012. New challenges in agricultural advisory services from a research perspective: a literature review, synthesis and research agenda. *The Journal of Agricultural Education and Extension,* **18,** 461-492.

Feder, G., Birner, R. & Anderson, J. R. 2011. The private sector's role in agricultural extension systems: potential and limitations. *Journal of Agribusiness in Developing and Emerging Economies,* **1,** 31-54.

Frelih-Larsen, A., et al 2016. Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States'. In: *Final Report to DG Environment. Berlin: Ecologic Institute.*

Garforth, C., Angell, B., Archer, J. & Green, K. 2003. Fragmentation or creative diversity? Options in the provision of land management advisory services. *Land Use Policy,* **20,** 323-333.

Godwin, R., Spoor, G., Finney, B., Hann, M. & Davies, B. 2008. The current status of soil and water management in England. *Warwickshire, UK: Royal Agricultural Society of England*.

Gunton, R. M., Firbank, L. G., Inman, A. & Winter, D. M. 2016. How scalable is sustainable intensification. *Nat. Plants,* **2,** 10.1038.

House of Commons 2016. Environmental Audit Committee on Soil Health. In.

Ingram, J. 2008. Agronomist–farmer knowledge encounters: an analysis of knowledge exchange in the context of best management practices in England. *Agriculture and Human Values,* **25,** 405-418.

Ingram, J. 2010. Technical and social dimensions of farmer learning: an analysis of the emergence of reduced tillage systems in England. *Journal of Sustainable Agriculture,* **34,** 183-201.

Ingram, J., Mills, J., Frelih-Larsen, A., Davis, M., Merante, P., Ringrose, S., Molnar, A., Sánchez, B., Ghaley, B. B. & Karaczun, Z. 2014. Managing soil organic carbon: a farm perspective. *EuroChoices,* **13,** 12-19.

Ingram, J. & Morris, C. 2007. The knowledge challenge within the transition towards sustainable soil management: an analysis of agricultural advisors in England. *Land Use Policy,* **24,** 100-117.

Juerges, N. & Hansjürgens, B. 2018. Soil governance in the transition towards a sustainable bioeconomy–A review. *Journal of Cleaner Production,* **170,** 1628-1639.

Kania, J., Vinohradnik, K. & Knierim, A. 2014. Agricultural Knowledge and Innovation Systems for an Inclusive Europe. In: *WP3 - AKIS in the EU: The inventory.*

Kibblewhite, M., Deeks, L. & Clarke, M. 2010. A gap analysis on the future requirments of soil and water management in England. *Prepared on behalf of RASE and their project partners*.

Klerkx, L. & Jansen, J. 2010. Building knowledge systems for sustainable agriculture: supporting private advisors to adequately address sustainable farm management in regular service contacts. *International Journal of Agricultural Sustainability,* **8,** 148-163.

Klerkx, L. & Proctor, A. 2013. Beyond fragmentation and disconnect: Networks for knowledge exchange in the English land management advisory system. *Land Use Policy,* **30,** 13-24.

Labarthe, P., Caggiano, M., Laurent, C., Faure, G. & Cerf, M. 2013. Concepts and theories available to describe the functioning and dynamics of agricultural advisory services. Learning for the inventory (PRO AKIS WP3): Deliverable WP2-1 (Pro AKIS: Prospect for Farmers' Support: Advisory Services in European AKIS; WP2: Advisory services within AKIS: International debates).

Labarthe, P. & Laurent, C. 2013. Privatization of agricultural extension services in the EU: Towards a lack of adequate knowledge for small-scale farms? *Food policy,* **38,** 240-252.

Leeuwis, C. & Aarts, N. 2011. Rethinking communication in innovation processes: creating space for change in complex systems. *Journal of Agricultural Education and Extension,* **17,** 21-36.

Lobry de Bruyn, L., Jenkins, A. & Samson-Liebig, S. 2017. Lessons Learnt: Sharing Soil Knowledge to Improve Land Management and Sustainable Soil Use. *Soil Science Society of America Journal*.

Louwagie, G., Gay, S. & Burrell, A. 2009. Sustainable agriculture and soil conservation (SoCo). *Final report. EUR,* **23820**.

Louwagie, G., Gay, S. H., Sammeth, F. & Ratinger, T. 2011. The potential of European Union policies to address soil degradation in agriculture. *Land degradation & development,* **22,** 5-17.

MacMillan, T. & Benton, T. G. 2014. Engage farmers in research. *Nature,* **509,** 25.

McBratney, A., Field, D. J. & Koch, A. 2014. The dimensions of soil security. *Geoderma,* **213,** 203-213.

McIntire, B., Herren, H., Wakhungu, J. & Watson, R. 2009. Agriculture at a crossroads: International assessment of agricultural knowledge, science and technology for development. *Synthesis*.

Montanarella, L. & Alva, I. L. 2015. Putting soils on the agenda: the three Rio Conventions and the post-2015 development agenda. *Current Opinion in Environmental Sustainability,* **15,** 41-48.

Montanarella, L., Pennock, D. J., McKenzie, N., Badraoui, M., Chude, V., Baptista, I., Mamo, T., Yemefack, M., Singh Aulakh, M. & Yagi, K. 2016. World's soils are under threat. *Soil,* **2,** 79-82.

OECD 2015. *Fostering Green Growth in Agriculture,* OECD Publishing.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F. & Wilkinson, R. 2006. Understanding and promoting adoption of conservation practices by rural landholders. *Animal Production Science,* **46,** 1407-1424.

Piikki, K., Söderström, M. & Stadig, H. 2017. Local adaptation of a national digital soil map for use in precision agriculture. *Advances in Animal Biosciences,* **8,** 430-432.

Posthumus, H., Deeks, L., Fenn, I. & Rickson, R. 2011. Soil conservation in two English catchments: linking soil management with policies. *Land degradation & development,* **22,** 97-110.

Powlson, D. S., Gregory, P. J., Whalley, W. R., Quinton, J. N., Hopkins, D. W., Whitmore, A. P., Hirsch, P. R. & Goulding, K. W. T. 2011. Soil management in relation to sustainable agriculture and ecosystem services. *Food policy,* **36,** S72-S87.

Prager, K., Creaney, R. & Lorenzo-Arribas, A. 2017. Criteria for a system level evaluation of farm advisory services. *Land Use Policy,* **61,** 86-98.

Prager, K. & McKee, A. 2014. Use and awareness of soil data and information among local authorities, farmers and estate managers.

Prokopy, L. S., Floress, K., Klotthor-Weinkauf, D. & Baumgart-Getz, A. 2008. Determinants of agricultural best management practice adoption: evidence from the literature. *Journal of Soil and Water Conservation,* **63,** 300-311.

Pronk, A. 2015. List of Drivers and Barriers governing Soil Management by Farmers, including Cost Aspects. In: *Catch C Project Deliverable 4.434.*

Renske, H. 2017. On the role of soil organic matter for crop production in European arable farming. In: *Wageningen University.* Wageningen University, Wageningen University.

Richards, C., Bjørkhaug, H., Lawrence, G. & Hickman, E. 2013. Retailer-driven agricultural restructuring—Australia, the UK and Norway in comparison. *Agriculture and Human Values,* **30,** 235-245.

Rickson, R. & Deeks, L. 2013. A gap analysis of soil management research and knowledge transfer in horticulture to inform future research programmes. *CP107 Final Report to the HDC. National Soils Resources Institute, Cranfield University*.

Schneider, F., Fry, P., Ledermann, T. & Rist, S. 2009. Social learning processes in Swiss soil protection—the 'from farmer-to farmer'project. *Human ecology,* **37,** 475-489.

Sherwood, S. & Uphoff, N. 2000. Soil health: research, practice and policy for a more regenerative agriculture. *Applied Soil Ecology,* **15,** 85-97.

Smith, P., House, J. I., Bustamante, M., Sobocká, J., Harper, R., Pan, G., West, P. C., Clark, J. M., Adhya, T. & Rumpel, C. 2016. Global change pressures on soils from land use and management. *Global Change Biology,* **22,** 1008-1028.

Struik, P. C. & Kuyper, T. W. 2017. Sustainable intensification in agriculture: the richer shade of green. A review. *Agronomy for Sustainable Development,* **37,** 39.

Techen, A.-K. & Helming, K. 2017. Pressures on soil functions from soil management in Germany. A foresight review. *Agronomy for Sustainable Development,* **37,** 64.

Townsend, T. J., Ramsden, S. J. & Wilson, P. 2016. How do we cultivate in England? Tillage practices in crop production systems. *Soil use and management,* **32,** 106-117.

Turpin, N. 2015. Interactions between BMPs and policies at EU and national levels, "Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health", . Policy bundles framing agricultural soil protection in EU and selected member states. In: *Catch-C project Deliverable 5.524.* pp. 141 p.

Turpin, N., ten Berge, H., Grignani, C., Guzmán, G., Vanderlinden, K., Steinmann, H.-H., Siebielec, G., Spiegel, A., Perret, E. & Ruysschaert, G. 2017. An assessment of policies affecting Sustainable Soil Management in Europe and selected member states. *Land Use Policy,* **66,** 241-249.

Van den Putte, A., Govers, G., Diels, J., Gillijns, K. & Demuzere, M. 2010. Assessing the effect of soil tillage on crop growth: A meta-regression analysis on European crop yields under conservation agriculture. *European journal of agronomy,* **33,** 231-241.

Vrain, E. & Lovett, A. 2016. The roles of farm advisors in the uptake of measures for the mitigation of diffuse water pollution. *Land Use Policy,* **54,** 413-422.

Vrebos, D., Bampa, F., Creamer, R. E., Gardi, C., Ghaley, B. B., Jones, A., Rutgers, M., Sandén, T., Staes, J. & Meire, P. 2017. The impact of policy instruments on soil multifunctionality in the European Union. *Sustainability,* **9,** 407.

Weigelt, J., Müller, A., Janetschek, H. & Töpfer, K. 2015. Land and soil governance towards a transformational post-2015 Development Agenda: an overview. *Current Opinion in Environmental Sustainability,* **15,** 57-65.

Wood, M. & Litterick, A. 2017. Soil health–What should the doctor order? *Soil Use and Management,* **33,** 339-345.