SoilCare
SOILCARE FOR PROFITABLE AND SUSTAINABLE CROP PRODUCTION IN EUROPE

Social factors influencing adoption

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ACRONYMS

AES	Agri-Environment Schemes
AKIS	Agricultural Knowledge and Information Systems
AIC	Alternative intermediate cover
DEFRA	The Department for Environment, Food and Rural Affairs
EA	Environment Agency
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
ITPS	The Intergovernmental Technical Panel on Soils
IYS	International Year of Soils
PCA	Principle Component Analysis
SDGs	Sustainable Development Goals
SICS	Soil Improving Cropping Systems
SOM	Soil Organic Matter
UNCCD	United Nations Convention to Combat Desertification
UK	United Kingdom
USA	United States of America

EXECUTIVE SUMMARY

This report presents the evidence on the social factors influencing the adoption of soil-improving cropping innovations. The report comprises of both published and unpublished articles and analysis using a range of methodologies such as Q-methodology, online survey and content analysis to discuss different aspects of the social such as the role of trust, norms, connectedness, power, social capital and gender in influencing the decision of farmers to change the management of their soils towards more sustainable soil practices across and within select project sites. Through the different articles and analysis the report reiterates the value of social learning from different peers and networks and the kind of likely dynamics of trust and social acceptability it can engender. The report is divided into following subsections with respect to understanding the uptake of soil improving cropping innovations a) Literature review on social capital factors influencing uptake of sustainable soil practices; b) stakeholders perception of causal problems and accepted solutions of declining soil quality; c) the role of trust in affecting the uptake of soil improving cropping systems; and finally, understanding the representation of women, generally and more particularly with respect to sustainable soil practices in one of the leading farmer's magazine called 'Farmer's Weekly'. The report provides an increased insight into the economic, social and political barriers for adoption, and in ways that can help to overcome such barriers.

1. INTRODUCTION

The United Nations (2019) warned that the world's soils face exhaustion and depletion and that business-as-usual approach is untenable when thinking from both sustainability and productivity point of view. And that, if adequate and timely measures are not taken, then by 2050 in all likelihood it may reduce up to 10 per cent of crop yields, which is equivalent to removing millions of hectares of land from crop production. The declaration of 2015 as the International Year of Soils (IYS 2015) by the Sixty-eighth session of the United Nations is a stark reminder of the common global challenge.

Sustainable management of soils is crucial to enable the long-term use of the various soil functions. Although soil degradation caused by agriculture is a process defined by technical, climatic, and biophysical factors, there is a growing recognition that the underlying causes are to be found in the socio-economic, political, and cultural context in which farmers exist and operate (Boardman, Posen, and Evans. 2003). Studies have shown the critical role and engagement of farmers, land managers, researchers and policy makers in determining behavioural change in agriculture in general and sustainable farming practices in particular (Davies and Hodge, 2006; Defrancesco, Gatto, Runge and Trestini, 2008; Prager and Posthumus, 2010).

One of the main aims of Work Package 3 was to understand how policies and socio-economic factors affect adoption process. In addition, identify major barriers to adoption of soil improving cropping techniques and possible ways to overcome these. Based on qualitative and mixed methodology approach data was collected from different sites and sources and the different research findings presented in this report empirically and theoretically demonstrate: a) how dynamics of trust, social norms and power (across space, time, social groups and culture) can explain adoption process of innovations, and how trust and active engagement between different stakeholders can enable social learning through individual and collaborative processes at different levels; and b) that social acceptability and adoption of new soil improving cropping systems (SICS) are also dependent on shared values, beliefs and personal preferences of different social groups (including members of the research, policy and practitioner communities). The report is structured as follows. Chapter 2 discusses the role of social capital in enabling the uptake of SICS. This is followed by Chapter 3 which explores as to what the different agricultural stakeholders think are the problems and accepted solutions to declining soil quality. Chapter 4 examines the role of Trust in affecting uptake of soil improving cropping systems. Finally, Chapter 5 presents the Gender Analysis of farmer representation and sustainable farming practices in the largest circulated newsmagazine in the UK "Farmers Weekly" .

2. LITERATURE REVIEW ON SOCIAL CAPITAL FACTORS INFLUENCING UPTAKE OF SOIL IMPROVING CROPPING SYSTEMS

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Abstract

Soil quality is in decline in many parts of the world, in part due to the intensification of agricultural practices. Whilst economic instruments and regulations can help incentivise uptake of more sustainable soil management practices, they rarely motivate long-term behaviour change when used alone. We are now beginning to pay attention to the complex social factors that affect uptake of sustainable soil management practices. To understand why some communities try these practices whilst others do not, we undertook a narrative review to understand how social capital influences adoption. We found that the four components of social capital – trust, norms, connectedness and power – can all influence the decision of farmers to change their soil management. Specifically, information flows more effectively across trusted, diverse networks where social norms exist to encourage innovation. Uptake is more limited in homogenous, close-knit farming communities that do not have many links with non-farmers and where there is a strong social norm to adhere to the status quo. Power can enhance or inhibit uptake depending on how it is managed. Future research, policy and practice should consider whether a lack of effective social capital could hinder uptake of new practices and, if so, which aspects of social capital could be developed to increase adoption of sustainable soil management practices. Enabling diverse, collaborative groups (including farmers, advisers and government officials) to work constructively together could help build effective social capital, where they can co-define, -develop and -enact measures to sustainably manage soils.

Introduction

There has arguably never been a more important time in history to improve the sustainability of agriculture (Willett et al. 2019). Climate change, a growing human population, an increased demand for (cheap) food, rapid biodiversity loss and a decline in soil and water quality make it increasingly likely that more planetary boundaries will be crossed, triggering abrupt environmental change with potentially catastrophic effects (Steffen et al. 2015). Dynamic interactions between these drivers require new approaches that consider ecological and social processes (Ostrom 2009). These approaches must consider the sustainability of agricultural production and consumption to secure enough food, feed, fuel and fibre in the coming decades, whilst concurrently ensuring that the environment is protected, as is recognised in the UN Sustainable Development Goals (SDGs) (Griggs et al. 2013).

Soil is the black gold upon which almost all terrestrial life depends, making it the foundation for all crop and livestock agriculture. However, soil quality across the world is in decline, which has repercussions for rural livelihoods and the economy. For example, soil erosion has been estimated to cost $8 billion a year globally (Sartori et al. 2019). Whilst farm management directly impacts soils, underlying drivers of soil degradation are socio-economic, political and cultural (Prager and Posthumus 2010). Successful agri-environmental policies that incentivise more sustainable soil management must therefore consider the drivers of human decision-making (Carlisle 2016).

To understand what, besides policies, contributes to farmer decision-making, researchers have studied the economic, financial, educational, technical, psychological, environmental and demographic factors that influence uptake of sustainable agricultural practices (e.g. Siebert, Toogood, & Knierim, 2006). However, farmer decision-making is often influenced just as much by socio-cultural factors as it is by ecological and economic factors (Burton 2004; Mills et al. 2016; Rust et al. 2016). Much of the above research has focused on the behavior of land managers, where a range of factors explaining (non)-adoption of tillage, best management practices and agri-environmental schemes (AES) are evaluated (e.g. Baumgart-Getz, Prokopy, & Floress, 2012; Knowler & Bradshaw, 2007; Siebert et al., 2006). Many earlier studies from the 1980s-1990s have their roots in theories on adoption of soil conservation practices from North America, where the effect of numerous individual socio-economic farm and farmer factors (e.g. Demographic and attitudinal) have been widely studied (Ervin and Ervin 1982; Napier 1990; Smit and Smithers 1992). More recent work from the USA provides further examples showing that a range of factors combine to influence farmer behaviour change. Carlisle (2016), for example, found that uptake of practices to improve soil health were influenced by market forces, psychology, agronomy, environmental, educational and financial

constraints. Grover & Gruver (2017) found that barriers to uptake of sustainable agricultural practices on smallholder farms included markets, labour restrictions, environmental factors, regulations, access to information and networks. However, meta-analyses of previous agricultural adoption studies found no universal patterns or determining factors that explain uptake of more sustainable soil management practices, in part due to the range of methods used and also due to the complexity and context dependence of the studies (Knowler and Bradshaw 2007; Prokopy et al. 2008; Wauters and Mathijs 2014). The importance of context and complex interactions among various factors can also be found when studying the influence of social capital on the uptake of sustainable agricultural practices. Due to the diverse set of dynamics affecting interactions taking place within farming communities, generalizable findings are difficult to discern.

Underpinning all of the above-mentioned factors is the learning process through which a farmer gains knowledge of the practice and decides to act upon it (Kilpatrick and Johns 2003; Leeuwis 2004). This process ranges from uni-directional "knowledge transfer" or acquisition from any number of sources (e.g. Media or other farmers) to more multi-directional "knowledge exchange", co-production and social learning, involving interactions with other farmers, advisers and/or other actors (Brunori et al. 2013). Although some of these learning processes are more social than others, a farmer who learns about a new cropping system by reading a magazine will do so in a specific social context with norms that influence how information is interpreted and how knowledge is learned (Bandura 1977). It is therefore clear that uptake of sustainable soil management practices is inherently a social and a learning process (Schneider et al. 2009; Wynne 2016). It is, however, less clear how factors related to social capital influence how farmers make decisions about soil management.

Knowledge acquisition largely depends on receiving information from another person, be that another farmer, a family member, an agronomist, or someone else (Rose et al. 2018). When presented with a fact, we often look to find out who communicated it and where they got that information from (Carolan 2006) to assess the validity of the claim. The source of information is important, as we more easily accept the knowledge that comes from the social networks that we trust (Carolan 2006; Sutherland et al., 2013). Uptake of new agricultural technologies and practices are thus partly dependent on the social capital of the system (Putnam 1993; Butler et al. 2006). This chapter thereby focuses on evaluating how social relations influences farmers' willingness to act on new agricultural knowledge by adopting sustainable soil management practices.

Social capital has numerous definitions in the literature but has two dominant conceptualisations: firstly, the ability for an individual to do well in social situations or, secondly, the group-level attributes, like a social network (Glaeser et al. 2002). We base our social capital conceptual model on the seminal, somewhat contrasting, contributions to the

subject by Putnam (1993) and Bourdieu (1986). Putnam purported that social capital is composed of elements of trust, norms and connections, which are reinforced over time through successive rounds of collaboration that become self-perpetuating (Putnam 1993). Bourdieu noted that these elements are relational and influenced by the presence and dynamics of power within the network (1986). When it comes to diffusion of ideas between individuals, social capital research has tended to focus on the roles of trust, norms, connectedness and power, especially as they function on a micro-level. These four elements will form the basis of our review.

Proponents of social capital have argued its importance for the proper functioning of effective societies (Grootaert 1998; Paldam and Svendsen 2000). Communities with large stocks of social capital have been shown to exhibit better health, less crime, quicker economic growth, and higher support for the government than those with lower stocks of social capital (World Bank (2006) cited in Larsson (2012)). Yet, it is important to note that social capital stands as a contested term, due to the wide variance in its definition and utility within several academic fields. Critiques of social capital tend to focus on the conceptual understanding that has been adopted (Harriss and De Renzio 1997; Ishihara and Pascual 2009; Poder 2011). Since social capital is not a generalizable concept, how best to implement a social capital approach depends on contextual factors such as cultural, socio-political, economic, and historical factors that shape power relations within a community. The context may also vary considerably based on spatial and temporal considerations. The confluence of such factors can predispose communities in their willingness to engage with stakeholders and the capacity to build social capital (Lasinska 2013).

In agriculture, social capital has been well studied (e.g. Butler et al., 2006; Chloupkova, Svendsen, & Svendsen, 2003; Putnam, 1993), yet it is less clear how trust, norms, connectedness and power each feed into this concept and how these four aspects of social capital affect a farmer's uptake of soil management practices. Evidence is scattered across a wide range of disciplines and literatures and there has been no attempt to synthesise lessons that could be used to promote higher uptake of sustainable soil practices. This is important because without understanding the social capital factors that underpin farmer behaviour change, it may not be possible to fully scale up sustainable intensification of agriculture across national and international contexts to the extent necessary to meet the sdgs (Pretty et al. 2018).

In this review, we examine how social capital and its components of trust, connectedness, norms and power affect uptake of sustainable soil management practices. We define "sustainable soil management practices" as those that improve soil quality (and hence its

functions) and that have positive impacts on the profitability and sustainability of cropping systems. We understand adoption/uptake to be a process of adaptation and learning rather than one-off uptake of a technology. We start by looking at studies that have studied social capital as a whole, and then go on to cover studies that focus on the four elements of social capital.

Method

We undertook a narrative review of peer-reviewed and grey literature to understand the social capital factors that influence uptake of sustainable soil management practices. A narrative literature review is an expert-based "best-evidence synthesis" of key literature; it does not seek to capture all literature. Narrative reviews are well-suited to providing critiques or interpretations of issues, especially where it is difficult to identify specific outcome measures for comparison across studies, or where it is based on expert interpretation of key literature. Narrative reviews differ from systematic reviews and meta-analyses that attempt to holistically synthesise literature around more narrowly framed questions and outcomes, often aided by statistics (Greenhalgh et al. 2018). Given the broad scope of the review and wide range of potential outcomes, a narrative approach was selected here. Our focus was specifically on agricultural soil management practices in developed nations. However, where literature in the developed world context was scarce but studies from a developing world context were found, these were included. To undertake the narrative review, we searched for articles on Google Scholar and Web of Science using the following Boolean search terms:

- For trust: trust AND ("soil conservation" OR "soil improving" OR "sustainable agriculture" OR "conservation agriculture") AND farm*
- For norms: ("social norm" OR norms OR culture OR tradition) AND ("soil conservation" OR "soil improving" OR "sustainable agriculture" OR "conservation agriculture") AND farm*
- For power and connectedness: ("social capital" OR (social AND (power OR connectedness)) AND ("soil conservation" OR "soil improving" OR "sustainable agriculture" OR "conservation agriculture") AND farm*

The scope of the study and criteria for filtering papers are defined below:

- Sustainable soil management: this is a diffuse concept and here we use the terms soil improving, sustainable agriculture, and conservation agriculture to capture the suite of practices that potentially benefit soil quality.
- Language: English

- Date range of publication: 1970-2018
- Date of search: June 2018 - August 2018
- Type of articles: journal articles, book chapters, books, dissertations, policy briefings, monographs, technical reports
- Topic: as defined above with the Boolean search terms

The process for searching for relevant articles and analysing texts began with reading the title of the document to check if it was within scope and, if so, to read the abstract and, if still in scope, the entire paper. If, when reading the article, other articles relevant to the research questions were cited in the document, these were also sought and analysed. Additional papers were included where co-authors had knowledge of further relevant research not found within the above search. This process continued until theoretical saturation had been reached and no new themes were emerging from the literature (Glaser 1965). Results were written by summarising these common themes that emerged from the articles (Denzin et al. 2018).

Results

Studies on social capital have sought to understand how it affects agricultural management, though less attention has specifically been directed at soil management. We therefore start with a broad overview of studies that have looked at sustainable land management practices (sought through the narrative review search term "sustainable agriculture") and then focus on studies that covered soil management specifically.

In terms of broader land management, social capital has been found to be an important ingredient for effective environmental governance (Pretty and Ward 2001) and for influencing adoption of more environmentally friendly practices (Pretty and Smith 2004). In relation to agricultural management, Sobels et al. (2001) noted that government support for social capital was a factor that helped lead to considerable success for the Landcare Australia initiative (Koutsou et al. 2014).

When it comes to soil management practices specifically, similar patterns have been found to those above. One study noted that where American farmers were embedded within larger farmer networks (where other farmers were already using practices to improve soil health on the fields), these farmers were more likely to try these practices too (Carlisle 2016). However, Carlisle 's 2016 study also found that whilst the farmer networks promoted soil health practices, this mostly influenced early and middle adopters, meaning that late adopters were harder to reach even in networks with apparently high social capital. Similarly, an Italian study showed that non-adopters of agri-environmental measures were reluctant to seek information

from neighbouring farmers, preferring instead to get their agricultural information from input producers and farming magazines, whereas adopters were more willing to seek agricultural information from other farmers (Defrancesco et al. 2008). This suggests that how farmers use their connections can influence who they trust about where to get agricultural information from. Furthermore, learning in social networks and peer support is particularly important when farmers undertake longer-term systemic changes towards more sustainable systems such as organic, agro-ecological, and conservation agriculture (where soil improvement is a core element) (Schneider et al. 2009; J. Ingram 2010).

Some of the proposed processes through which social capital can facilitate increased uptake of agricultural practices include:

- The idea that trust reduces the transaction costs of learning about new information,
- Social norms, which are created and maintained that promote adoption behavior,
- Certain network characteristics and power dynamics that promote the wider diffusion of innovations (Pretty and Smith 2004; de Krom 2017).

We continue this narrative review by looking at these different dimensions of social capital, starting with trust.

TRUST

Trust between individuals can help an individual believe information and turn it into usable knowledge, so this section focuses on how trust functions within a social network and how this can influence uptake of new agricultural practices, especially sustainable soil management. Trust is a key attribute of social capital, as high social capital can promote trust between people, which in turn promotes collective action (Porta et al. 1996; Tsai and Ghoshal 1998). People tend to exhibit a higher willingness to accept knowledge that comes from the social networks they trust, especially in instances where risks and uncertainty are high (Carolan 2006; Taylor and Van Grieken 2015; de Vries et al. 2015). To understand how trust might influence adoption of more sustainable soil management practices, we first reflect on what trust is and how it develops and operates between individuals and institutions.

Interpersonal trust is the trust developed between individuals, including a willingness to accept risk or be vulnerable in the relationship (Mayer et al. 1995; Sundaramurthy 2008; Stern and Coleman 2015). A distinction is usually made between the trustor (the one trusting) and the trustee (the one being trusted). Trusting someone is not only about being confident that another person has your own interests and welfare in mind, but also relates to whether you

will act on the other person's actions and words (Möllering 2001). Trusting someone tends to mean you believe they are competent, reciprocal, fair, reliable, responsible and dependable (mcallister 1995). The roles of trustor and trustee are not fixed but can be reversed. I.e. In one situation farmer A is the trustor and farmer B the trustee and the next time it can be the other way round. Indeed, an important aspect of social capital is reciprocity, a norm which is closely linked with trustworthiness, and reciprocating builds trust and cements relationships. Trust is based on the success of past interactions as well as social similarity, such as ethnicity or religious background. Trust is not limited to the interaction between two people but also between a person and an institution, such as a government (Luhmann 1979; Zucker 1986).

Trust may be formed, maintained and broken in different ways, at different social, spatial and temporal scales (de Vries et al. 2015). When trust is violated, the trustor may be less likely to cooperate with the trustee in the future, which can inhibit business productivity (Lewicki and Tomlinson 2003). Depending on how badly the trust has been violated, the reaction from the victim could range from forgiveness to retribution, or even ending the relationship forever. Trust is specific: someone can trust a person on one specific issue, while distrusting on another issue (Lewicki et al. 1998). A breakdown of trust could result in a farmer choosing different sources to get agricultural advice from and the social memory of a community can either enhance or inhibit future uptake of sustainable agricultural practices depending on past experiences (Wilson 2013).

In participatory processes, trust is vital in influencing the process both positively and negatively (devente et al. 2016; Kelliher et al. 2018). Trust has shown to aide individuals to cope with uncertainty (O'Brien 2001), reduce complexity (Luhmann 1979) and improve credibility (J. Ingram et al. 2016). Relationships with a high degree of trust can result in a greater degree of exchange between participants, with people being more willing both to share and receive information with others in the group, as well as to absorb other's knowledge (Lyon 2000; Levin and Cross 2004; Stobard 2004). In a farming context, this could mean that, in networks that exhibit a high degree of trust, learning about new practices takes place easier and faster (Schneider et al. 2009) and could encourage either quicker and/or more frequent uptake of innovations, such as more sustainable soil management practices.

Potential detrimental effects from excessive or insufficient levels of trust are often overlooked (Lacey et al. 2017). Such effects can be a tendency of 'blind faith' between parties, which can lead to complacency (Gargiulo and Ertug 2003), a lack of objectivism or favouritism (Stevens et al. 2015) or even a halt to pursuing new innovative ideas (Stern and Baird 2015). For instance, farmers may trust their agronomists, and the advice they share, because of the long-term relationship they have built up over time (Sutherland et al. 2013), which could result in over-use of chemicals if this is what their agronomist recommends. In countries without government

agricultural extension officers, agronomists can be independent or work for an agricultural distribution company; if the latter, they could push the company's agenda, which may lower trust in the information shared. Independent agronomists are in a better position to build trust with farmers due to being seen as impartial, which can build agronomists' credibility, reliability, respect, competence and empathy. Thus, trust in both the information itself and the information bearer affect farmer decisions to act on that information (o'connor et al. 2005; Knowler and Bradshaw 2007).

Trust in institutions is different to trust in people. Low trust in institutions, such as governments, can reduce uptake of more sustainable farming practices (Hall 2008; Prager and Posthumus 2010). One study showed that historical mistrust of regulators contributed to farmers being unwilling to use more sustainable practices but also found that this distrust could be overcome by using third-party knowledge brokers that could build trust more quickly (Breetz et al. 2005). Institutional trust is affected by past and ongoing relationships. For instance, a UK study found that distrust of information on bovine tuberculosis provided by the government to farmers was due to the government's past irregular, inconsistent contact with farmers (Fisher 2013). Higher degrees of trust and confidence in institutions like the government have been associated with increased uptake of sustainable agricultural practices that benefit the soil like no-till (Swan 2012; Turpin et al. 2017). Trust works both ways between governments and farmers: for instance, governments that trust farmers to undertake actions as being part of agri-environmental schemes spend less money on monitoring farmers' actions for compliance (Falconer et al. 2001).

The degree to which a farmer puts trust in others can by influenced by what type of land manager they are. In a study on Australian landowners to understand who they most trusted, all landowners put most trust in their neighbours (Pannell et al. 2006). However, this study also found that landowners who farmed predominantly for production reasons had the least trust in the government, whereas hobbyist farmers and landowners who were most interested in conservation put least trust in productionist groups. Similarly, an American study showed that some organic farmers were averse to trusting information from universities as they were suspicious of this type of knowledge generation (possibly due to phenomenological differences), which affected their uptake of integrated pest management practices (Park and Lohr 2005). Like other social variables, it is important not to assume all farmers act in the same way, making generalisations only possible for situations with the same context.

Given the influence of globalisation and digitalisation, many trust building interactions will need to be developed and maintained over long distances. Insights from social network analysis and diffusion of innovation theory can shed light into the underlying mechanism of developing long-distance trust. The concept of homophily (the degree to which actors associate themselves with similar people; akin to "in-groups" discussed below) plays an

important role for trust building over long distances. Homophily is influential if people attribute trustworthiness to others based on the other person's network position or organisational/institutional affiliations, or having the same culture or ethnicity (Rogers 2003). Based on stereotypes, trust can even be assigned to roles and public figures that one trustee has never met in person (Henry and Dietz 2011). Whilst long-distance trust building is important, personal face-to-face trust building between all stakeholders (government, land managers, business, and researchers) is the basis for large-scale, long-distance trust building.

Organisational reputation influences trust building, just as trust between individuals can affect organisational reputations (Lacey et al. 2017). For instance, a farmer may already trust a farming association that has a good reputation with the farming industry and therefore would be more likely to trust the advice from that organisations' employee. If one individual (or institution) is seen as trustworthy, the people they trust will likely be trusted as well: this is known as transitivity (Henry and Dietz 2011). For example, if a national farmers union is trusted by farmers, the policy makers that the union trusts are more likely to be trusted by the farmer too, just as uptake of policies goes faster when policy administrators are trusted by farmers (Prazan and Dumbrovsky 2011).

It is therefore apparent that trust is a crucial aspect of social capital and especially as it relates to accepting information when deciding whether to start the transition towards more sustainable soil management practices. We shall now consider the next element of social capital: connectedness.

CONNECTEDNESS

Connectedness is the configuration of social interactions on a community scale or between networks and is an important part of social capital (Pretty and Ward 2001; Pretty 2003). Connectedness relates to both real and perceived connections within a network, as well as their strength. There are three types of structural social capital connections:

- *Bonding* refers to the close, horizontal ties between similar individuals within a network, such as between other farmers
- *Bridging* refers to horizontal ties between two different networks, such as between farmers and conservationists;
- *Linking/bracing* refers to vertical ties between different hierarchical levels, such as between policymakers and farmers.

Connections between individuals within a network are dynamic and contextual, with the type of social capital linkages within a network being important for how effective knowledge exchange is. For instance, new practices and information are more likely to be shared between

people who have weak social ties, going beyond the close ties of their normal network (Granovetter 1977). This new knowledge is then transferred to people they trust within their closer network, spreading tacit knowledge (Butler et al. 2006). For more efficient knowledge transfer of new agricultural practices such as those that promote sustainable soil management, bridging and linking ties could be important forms of connectedness (Adler and Kwon 2002; J. Hall and Pretty 2008).

Bonding social capital is equally important to farmers. Sociologist James Coleman explains the benefit of bonding social capital to traditional farming in the following way:

> "*In a farming community…where one farmer got his hay baled by another and where farm tools are extensively borrowed and lent, the social capital allows each farmer to get his work done with less physical capital in the form of tools and equipment*" (Coleman, 1990: 307).

However, given that industrial-scale farming is moving away from the above situation, bonding social capital could be waning in these agricultural contexts. Bonding social capital can affect how trust operates in a system. Trust in "out-groups" (i.e. People different to you so bonding social capital is limited) tends to be lower than for "in-group" members (Brewer 1979). For instance, information providers that are considered as part of the "in-group" (i.e. Similar to farmers) are more likely to result in farmers believing what the information provider says and acting on this (Blackstock et al. 2010); indeed, a study of Australian livestock farmers found that "trust in the messenger is more important than the message" (Palmer, Fozdar, & Sully, 2009: 371). This suggests the importance of who the messenger is in relation to how their message will be received. The level of trust decreases as people move further away from their own group (Gallo et al. 2018), with institutional actors and public administration often being perceived as the furthest away (Harring 2018). In a UK farming context, this has been deemed "rings of confidence" and farmers tend to go to similar people within their network that they trust more than unfamiliar out-groups such as policymakers (AIC 2018).

Being connected to a network is important for transfusion of ideas and practices, but it is not clear what type of network creates the biggest utility. Some successful networks consist of lots of farmers living geographically close to each other, whereas others include looser affiliations in a diverse network. For instance, one study showed that using social networks to gather information was associated with more interest by farmers in wanting to use more sustainable agricultural practices (Jussaume and Glenna 2009). Strong bonding social capital can influence others within a farmer's network to follow their lead. For instance, in a study of British farmers, a high level of bridging social capital between farmers and vets meant that farmers trusted information from vets, which led to knowledge transfer and was encouraged by regular, long term, consistent contact (Fisher 2013). This study concluded that bonding social capital between different farmers helped to spread knowledge but also led to tight-knit exclusive groups that led to distrust between groups. The study also found that low levels of linking social

capital between farmers and the government caused mistrust and a lack of confidence in the information given by government outreach officers, demonstrating the relationship between connectedness and trust. However, too much bonding social capital within a network can have negative consequences if the group is very insular (Browning et al. 2000), which can inhibit knowledge transfer.

Besides bonding social capital, bridging social capital can enhance uptake of more sustainable soil management practices. A meta-analysis of American studies that looked at adoption of best management practices, including aspects related to soil improvement, showed that bridging connections between farmers and other groups (such as government agency personnel and watershed groups) was one of the biggest influencers on adoption (Baumgart-Getz et al. 2012). Diverse networks involving bridging and linking social capital, whilst encouraging networks with strong bonding linkages, could therefore be useful when it comes to spreading uptake of more sustainable soil management practices. Sometimes 'farmer champions' or 'early adopters' can contribute in the uptake of best soil management practices through their bridging connections and bonding connections respectively.

If an individual is more attached to their community, they may be more likely to be socially responsible, as well as have better access to information. A study of Georgian farmers found those who were more involved with their community were also more likely to adopt environmentally friendly practices (Breetz et al. 2005). Furthermore, an Australian study which looked at uptake of climate adaptation strategies by farmers showed that connectedness, as it related to feeling a sense of community, affected uptake (Brown et al. 2016). Equally, being open to making new connections can influence willingness to adopt new practices. In a UK study, farmers who were more open to professional and non-professional contacts were more likely to take part in an agri-environment scheme (Mathijs 2003). This suggests that farmers with strong bonding ties but a lack of bridging or linking ties could reduce adoption of more sustainable soil management practices, unless they receive the information about management practices from their peers.
Connected, diverse farming networks can enable better exchange of knowledge, but this is also influenced by the social norms around whether farmers prefer to adhere to the status quo (Inman et al. 2018). This leads us on to the next aspect of social capital that we will discuss as it relates to uptake of sustainable agricultural practices: norms.

NORMS

Norms establish behavioural standards that set expectations and guarantee predictability of social relations within a network (or community). A norm is a degree of consensus within a community and is an element of social capital. Norms can give people the confidence to take

part in group action if there is the expectation that others will too (Gómez-Limón et al. 2014). Social norms, traditions and peer pressure can help to shape environmentally sustainable behaviour (Reimer et al. 2014). As mentioned above, the norm of reciprocity, where favours done now will be returned in the future, has been argued as one of the most important social norms for building social capital as it allows people to gauge trustworthiness over time and creates a memory of collaborative work (Ashby et al. 1998). Norms and trust are closely linked because norms can be thought of as the basis for developing and maintaining trust (Lyon 2000). Norms are often imposed by powerful actors from the top down, which can increase trust among subordinates (Gelderblom 2018). To further show the links between norms and trust, Fukuyama (1995: 26) has described trust as:

> *"the expectation that arises within a community of regular, honest and cooperative behaviour, based on commonly shared norms on the part of other members of that community. Those norms can be about deep 'value' questions like the nature of God or justice, but they also encompass secular norms like professional standards and codes of behaviour."*

Norms have been shown in numerous agricultural studies to be important drivers of behaviour. Research from the US Corn Belt found that norms and social networks both played key roles in influencing farmers' decisions to adopt conservation practices (Atwell et al. 2009). Similarly, wine growers in France were more willing to change their agricultural management if they thought their peers would do too (Kuhfuss et al. 2016) and, in Greece, farmers were more likely to participate in environmentally-friendly farming measures if their neighbours or relatives did (Damianos and Giannakopoulos 2002). Furthermore, active adopters of agri-environmental practices in an Italian study were more sensitive to what they thought society thinks about farming (i.e. A social norm) than non-adopters (Defrancesco et al. 2008).

Farmers can face social barriers that hinder uptake of certain practices, which can cause a "lock in" within the community, with community members resisting change due to past negative experiences (Marshall and Stokes 2014). For instance, conventional farmers can be highly critical and judgemental of practices that go against the norms of that group (R. J. Burton and Paragahawewa 2011), such as organic farming (Morgan and Murdoch 2000) and reduced tillage (J. Ingram 2010). In a Swiss study to understand what affected a farmer's decision to turn organic, a significant barrier was the social norm to be productive as it was assumed that organic farming is less productive (Home et al. 2015). Like other aspects of social capital, it is not necessarily true that having a community with strong norms will automatically create the opportunity for change. Rather, it is whether there is a norm that encourages innovative thinking and adaptiveness.

Norms can therefore hinder uptake of more sustainable agricultural practices. For instance, farmers might not adopt a new, beneficial practice if it is thought to go against the status quo;

in some contexts, it can be more important for farmers to change to practices that make their farms look aesthetically pleasing to other farmers, conveying that they are good land stewards, rather than using practices that may be more sustainable (Carlisle 2016). For instance, the social norm of having a farm look neat was a factor inhibiting Spanish farmers from trying methods to reduce soil erosion, and, in Iceland, farmers would not try such methods because of ingrained traditional agricultural practices that were found hard to change (Caspari et al. 2017). Likewise, in a US study, there was a strong cultural norm among farmers to tidy up "weeds" which inhibited some farmers from adopting sustainable agricultural practices that were deemed "untidy" (Carolan 2005). Another American study showed that farmers were not willing to use manure as a natural fertiliser because they were worried about the smell that would dissipate to their neighbours (Battel and Krueger 2004). Similarly, early adopters of conservation tillage practices mentioned the practice of not cultivating when neighbours were cultivating was difficult for the early adopters as this went against the norm within the community (Coughenour and Chamala 2000).

Whilst there may be multiple norms inhibiting a community from changing to more sustainable soil management practices, collective action and the process of developing social capital can work together to help change social norms within a group, thereby fostering more rapid adoption (Cary and Webb 2000). However, in closely-knit networks with strong bonding social capital, change can be hard because there is often the norm to conform to the status quo (Compagnone and Hellec 2015). Whilst setting regulations can itself sometimes change behaviour, it depends on the norm within the community to abide by the new rules and regulations. For instance, in a study looking at how social factors affected uptake of soil conservation practices in the US, social norms were found to be as important as individual motivations to comply with the regulations, which together encouraged farmers to use these practices (Prager and Posthumus 2010).

Norms are therefore crucial aspects of social capital for policymakers and practitioners to consider if they wish to encourage more widespread uptake of soil conservation measures, as norms can either encourage or inhibit farmers to change their agricultural practices. If the norm within a community is to stick to the status quo, it can be very difficult for individual farmers to go against the grain, especially if they have a strong desire to fit in. In this instance, other measures may be useful to help create change, such as financial incentives or regulations.

POWER

Power can be thought of as scalar actor relations and is important to consider with respect to social capital as power plays a role in determining who is able to gain influence. Putnam's

conceptualisation of social capital did not explicitly touch on power, unlike Bourdieu, who was acutely aware of the issues of power within a network. Indeed, Blackshaw and Long (2005: 252) stated that the "value of trust as a form of social capital becomes problematic, because as Bourdieu shows us it will inevitably be exploited for gain, in the practice of symbolic power". Given that most social interactions involve exchanges between people and groups with different power bases, this topic is important to address within an agricultural social capital lens (Chloupkova et al. 2003). Power also influences who is included or excluded from a network therefore relates to trust (Lyon 2000). Trusting someone often means making yourself vulnerable to someone else. If someone puts trust in another person and the trustee uses opportunism to exploit the trustor, this is exploitation of power. For example, trusting an agronomist to provide accurate agricultural advice puts a farmer in a vulnerable position whereby their profits could decline if the agronomist gives incorrect information. Trust in powerful forces becomes important in contexts of high risk and uncertainty. Whether there is a norm to sanction the exploitation of trust depends on the cultural setting including whether the powerful will enforce the sanction. By trusting someone, you are therefore putting yourself in a vulnerable position and the trustee is often acutely aware of this. Social exchange thus includes components of both trust and power (Bachmann 2001). Nunkoo and Ramkissoon (2012: 1000) eloquently summarise this by saying "trust and power complement one another to predict social actors' behaviours across different contexts and situations".

Power struggles occur between individuals and groups daily, which affects who controls and gets access to resources and how these resources are used. In situations of power inequalities, risks can be distributed unequally, such as between landowners and tenants (Boardman et al. 2017) and farmers and buyers (Hall and Pretty 2008). Tenancy contracts tend to be short-term, meaning tenants might not be motivated to think about long-term health of soils. Equally, landlords may stipulate for or against certain land management practices, limiting tenant power to change. One way to redistribute risk between powerful differentials is to create a contract - although this too can be abused. Ways to demonstrate trust in an unequal power relationship include showing transparency, fairness, and procedural justice (Cook 2005).

Power within a network can be abused for personal gain. Szreter (2002) has argued that, when it comes to the connectedness of social networks, it is linking social capital that is the most prone to abuse of power given the nature of the relationship spanning hierarchies. Conversely, associations that already have a certain amount of bridging social capital and are able to build linking social capital tend to be the ones that are more successful at achieving their goals (Szreter 2002) precisely because they tap into and utilise sources of power for their own ends. This could be a farming community that has successfully built a good relationship with local government officials, for example. However, this tends to only works in more egalitarian societies rather than those that privilege the minority in power, including authoritarian states

and those with a strong libertarian market structure. Indeed, Szreter (2002) posits that the tight bonding social capital by the elite in free-market societies could negatively affect natural capital alongside bridging and linking social capital. In agriculture, this has already been seen where companies have formed successful coalitions that fight against regulations to reduce or ban environmentally damaging chemicals.

Power can be used intentionally or unintentionally to control who gets access to information (Brugnach and Ingram 2012). It has been argued that power and knowledge go hand in hand, where power is created via the distribution of knowledge and can be used to control others (Foucault 1980). Therefore, the transfer of knowledge can act as either a process of empowerment or disempowerment depending on how it is enacted (Fazey et al. 2013). For instance, some farmers in Namibia have purposefully limited farm worker access to education as a form of subjugation and control (Rust 2015). Agricultural advisers are in a position of power as they decide what information to share with the farmer and what to withhold. An adviser from a fertiliser company, for example, may share information on the benefits of increased fertiliser usage but refrain from sharing the long-term environmental costs of over-application.

Focusing more on the connectedness of social capital, Blackshaw and Long (2005: 252) state "the poor are geographically constrained and may find it difficult to establish bridging capital through normal day to day contact", meaning that building social capital can be difficult for those with the least power. They conclude that "when [social capital] is good it can be very, very good, but when it is bad it can be horrid" (p 254). It is therefore pertinent to appreciate the role that power in a particular context has in affecting social capital. Regarding uptake of sustainable soil management practices, there is scant literature on power outside developing countries, but it is highly likely that power affects adoption in ways we are only just beginning to understand. For instance, the contracts which some farmers have with supermarket may be an example of this. Often these supermarkets tend to force farmers to produce at specific times and at low cost, neither of which would be good for sustainability.

Discussion

This review set out to examine how social capital and its components of trust, connectedness, norms and power affect the adoption of sustainable soil management practices. We have found that the scientific literature to date has not fully explored how social capital directly affects uptake of sustainable soil management practices, though findings from studies on adoption of broader sustainable agricultural practices have provided several insights. In many instances, higher amounts of social capital facilitated relationship-building and -maintaining between farmers and the external sources they receive agricultural information from.

Knowledge exchange in agricultural contexts may work best in diverse, trusted networks, where the norm of innovation already exists and where less powerful actors can change within the system. Building social capital takes time and the precise way this is done will likely differ depending on context. If a lack of social capital has been established as a source of limited uptake of sustainable soil management practices, strategies to address this would benefit from incorporating measures focused on building bridging and linking social capital, as well as trust between stakeholders.

Whilst we make no claim that understanding the social capital in a farming community can be a silver bullet to entice reluctant land managers to try new practices, we do suggest that social capital is an important factor when it comes to understanding the complex pathway to adoption of sustainable soil management practices. The first – and, some may say, most important – part of social capital is trust, which is a crucial part of this puzzle when it comes to understanding whether someone believes and acts on a piece of information that has been shared. Our review showed how vital it is to develop and maintain trust between the person or institution sharing knowledge on soil management practices and farmers; indeed, farm advisers have long known the significance of relationship building with their clients. It is therefore imperative that trust be nurtured before attempts are made to influence farmer behaviour.

Connectedness can enhance or hinder uptake of new practices depending on the type of connections; a high amount of bonding social capital can hinder uptake if it is not accompanied with linking and bridging capital. Norms also influence farmer behaviour, sometimes encouraging change in practice and sometimes not. The norm of reciprocity, where present within an environment, can help build trust. Power within the system cannot be ignored because it is omnipresent in all social networks. Power is not an easy force to overcome and, even with the best facilitators in the world, must be handled with care or could cause long-lasting damage to relationships. Whilst power differentials between policymakers and farmers is obvious, there are less obvious power differentials that must be addressed. Power may therefore be the most difficult part of social capital to effectively address.

Conclusion

This extensive narrative review has proven the difficulty of drawing general conclusions on how social capital can affect uptake of sustainable soil management. It is important to acknowledge that social capital is highly context specific, which implicates generalizable approaches to critique. This is because of the complex and shifting historical, political, psychological, social, environmental, and economic context in which a farmer is situated that drives them to act in

their own unique ways. In attempting to build social capital, it is important to acknowledge at which level the approach is being implemented and to be highly cognizant of the social dynamics within the particular community. Furthermore, social capital often has positive associations, yet as discussed in the review, there can be unintended negative consequences, which need to be acknowledged and mindful of when implementing a particular strategy.

However, this review has disentangled the dimensions of social capital and their linkages, whilst providing some theoretical insights into the known benefits of farmers' collaborating through discussion, farmer networks and multi-stakeholder networks in the context of farm management decisions. It has also highlighted the importance of influencing social norms to shift farmers' farm management behaviour from the status quo as well as acknowledging the role that power plays in multi-stakeholder networks. Sustainable soil management is a diffuse concept in the literature (Ingram and Mills 2019) and it has not been possible to sufficiently unpack this term in connection to the elements of social capital covered in this review. The heterogeneity of soils, farming systems and management options represented in this study adds a further challenge in terms of determining exactly how social capital impacts uptake of more sustainable soil management practices. However, the review highlights the role of social capital in supporting long-term systemic changes on farm, which require co-learning with the support of trusted peers alongside innovation shared between networks.

With respect to fostering social capital, incentivising cooperation and collaborative approaches in a range of contexts and scales can be effective (Bijman and Iliopoulos 2014) though not explicitly addressing social capital, facilitating interactive groups is now an established component of a number of European Union grants, as well as national programmes and advisory systems that address issues of sustainable agriculture. Some initiatives such as the EU Operational Groups on soil topics provide support to enhance connectedness (particularly bonding and bridging with farmers, advisers and researchers working together) and implicitly foster and rely on trust. However, future support for such multi-actor collaboration in the context of improving soil management would benefit from a more nuanced understanding of how these actors interact in building social capital, particularly in relation to norms and power relationships in their design.

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3. WHAT DO AGRICULTURAL STAKEHOLDERS THINK ARE THE PROBLEMS CAUSING AND ACCEPTED SOLUTIONS TO DECLINING SOIL QUALITY?

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Highlights

- Declining soil quality threatens farmer livelihoods and food security
- We studied perceptions of soil quality causes and solutions
- Agreement that soil erosion and compaction were causes
- Agreement that solutions include training and awareness

Abstract

Soil quality is declining in many parts of the world, with implications for agricultural productivity, resilience and sustainability of agri-food systems. Research suggests multiple causes of soil quality decline with no single solution. To add to the complexity, there is divided stakeholder opinion on how to manage this problem. The creation of socially acceptable and effective policies to halt soil quality decline requires engagement with a diverse range of stakeholders who possess different and complementary knowledges, experiences and perspectives. We undertook a Q-methodology study to better understand Norwegian and UK agricultural stakeholder perceptions of the causes of agricultural soil quality decline and the solutions to address this issue. In Norway, respondents thought soil quality was declining due to soil erosion, monocultures and loss of soil structure and believed the solutions were to reduce compaction, increase rotations and invest in agricultural training. For the UK, respondents thought the causes were loss of soil structure, soil erosion, compaction and loss of organic matter, and the solutions were to develop more collaborative research between scientists and farmers, invest in training, improve trust between farmers and regulatory agencies, and reduce soil compaction. This research highlights potential areas for future Norwegian and UK land use policy development based on agricultural stakeholder-driven proposed solutions to address declining soil quality.

Keywords: Compaction, Deliberative democracy, Erosion, Q-methodology, Soil conservation, Sustainable soil management

Introduction

> *"Countries can withstand coups d'état, wars and conflict, even leaving the EU, but no country can withstand the loss of its soil and fertility."* - Rt Hon Michael Gove, former Secretary of State for the Environment, speaking at the British parliamentary launch of the 'Sustainable Soils Alliance', October 2017.

The ground beneath our feet is not only a substrate upon which we traverse this earth but is also a vital component of our natural capital (Dominati et al. 2010). Soils are the foundation of terrestrial food production, supporting - directly or indirectly - 95% of our food production. With rising human populations and increased individual wealth, it is expected that food demand will grow by as much as 70% by 2050; an estimated 46% of that demand is needing to come from increasing food production (Keating et al. 2014). Along with providing a substrate to grow our food, soils also confer other essential ecosystem services, such as water storage and filtration, nutrient cycling, biodiversity and carbon storage (Moncrieff and Draisey 2018). However, despite its essential function in everyday life, soil quality in many parts of the world is declining due to combination of physical, chemical and biological degradation coupled with socio-economic drivers, reducing the soil's ability to undertake these important ecosystem functions (FAO and ITPS 2015). Globally, 20-30 gigatons of soil are lost each year due to water erosion (FAO and ITPS 2015). There is thus an urgent need to develop and encourage widespread adoption of effective and profitable sustainable soil management practices (Thomas et al. 2018). This is articulated in Sustainable Development Goal 15, which aims to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (UN 2016).

Soils in urban areas are primarily threatened by different drivers than in agricultural areas. In urban areas, the main cause of soil quality degradation is soil sealing, whereas in farmland areas this is primarily related to intensification of agriculture such as increased harvest frequency, overgrazing of livestock, overuse of chemical inputs and irrigation (FAO and ITPS 2015). Indirect drivers of farmland soil degradation differ widely over space and time, such as changes in agricultural policies and food markets, as well as context-specific local environmental conditions of the soil and climate. The relative importance attached to different causes of and solutions to declining soil quality is highly context-dependent; opinions may differ subjectively between different stakeholders depending on their values, beliefs and norms, as well as the costs and benefits they perceive from sustainable soil management. Land use policy and regulation relating to soil therefore is likely to need to be locally targeted and adapted to the constraints and needs of different land uses and land users as they change over space and time.

There are many competing ways to deal with agricultural soil degradation at different governance scales: from multilateral policies such as the United Nations Convention to Combat Desertification (UNCCD) and the proposed EU Soils Directive, to national and sub-national policies and measures designed to incentivise and regulate the management of soils, down to farm- and field-scale interventions, such as soil-improving cropping systems (e.g. WOCAT 2007). The lack of scalable policy options was cited in the UNCCD's (2017) Global Land Outlook as a key barrier to more sustainable land management, but there are no easy solutions given the different social, cultural, economic, environmental and technological contexts in which policies and practices need to operate. Again, the attractiveness and appropriateness of different options for policy and practices differs based on the subjective experience and contrasting knowledge and values of the people the policies are meant to serve.

Policies and practices that can tackle the multiple causes of declining soil quality are urgently needed, but stakeholder engagement in the policy formulation process is crucial for this complex issue, given the subjective and value-laden nature of both the causes and solutions to the challenge. As interest has grown in deliberative democracy, methods have been sought that can represent and integrate the range of perspectives, values and beliefs held by citizens to create more inclusive policy making (Dryzek 2009). The application of Q-methodology to the co-development of inclusive policy options has been used by Durning (1999) and Addams and Proops (2000) as a form of deliberative democracy. These studies had the normative goal of representing more diverse perspectives in the policy-making process. They also had a pragmatic goal of improving the quality of decisions or range of policy options based on more comprehensive information inputs and/or improving the acceptability of policies based on deeper insights into the way publics conceptualise environmental issues. Q-methodology has been used to generate policy options in a range of contexts, for example for national forest management in the USA (Steelman and Maguire 1999), the design of acceptable and effective land use policy options to manage carnivores on livestock farms (Rust 2017) and aviation policy in The Netherlands (van Eeten 2001). Effectively representing diverse stakeholder perspectives in decision-making processes can sometimes lead to better informed, more durable, and flexible outcomes across a wide range of contexts (De Vente et al. 2016). This research shows that policies created through deliberative democracy are sometimes more likely to be appropriate to social and cultural norms and result in increased trust and ownership over problems and solutions, which can lead to decisions that are more likely to be accepted and implemented, helping to achieve environmental goals more effectively.

Definitions of "soil quality" vary and have progressed from focusing solely on agricultural production to a broader focus on the complex and diverse functions that soil confers to humans and our environment (Erkossa et al., 2007; FAO, 2015). Here, we define soil quality as "the capacity of a specific kind of soil to function, within natural or managed ecosystem

boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. In short, the capacity of the soil to function." (Soilcare, 2019).

To identify where contentions and agreements lay between different agricultural stakeholders over causes and solutions to declining soil quality in Norway and the UK, we used Q-methodology to understand the range of perspectives, which could form a basis for the design of socially acceptable options in soil management policy and practice. This approach was undertaken in the UK in late 2018 (when the UK was still part of the EU) and in Norway mid-2019. Study sites were chosen to exemplify how structural changes in European agriculture have affected soil quality across the northern part of continent.

Method

STUDY SITES

UK

Like much of the rest of Europe, the UK has a long history of unsustainable soil management practices, leading to a loss of soil structure and fertility. One estimate has calculated the carbon lost from UK soils due to cultivation equating to £82 million a year (Environment Agency 2007). The cost of soil erosion to the UK is around £45 million a year, including £9 million in lost production (Defra 2009). It has been estimated that UK soil is being lost at a rate ten times that which it is created (Moncrieff and Draisey 2018), with dramatic economic implications. England and Wales alone could be losing 2.9 million tonnes of soil each year, costing £1.2 billion annually (Cranfield University 2011). Soil erosion, compaction and loss of organic matter are thought to cost arable farmers an average of £5,584 per year (Tipper 2017) and English water companies spend £21 million a year on addressing soil erosion (Environment Agency 2007). Improving soil management in the UK is therefore not only an environmental but also an economic imperative.

Soils store carbon at levels far greater than trees: in the UK, if just 1% of the soil's carbon was lost, this would equate to all the fossil fuel emissions from the country for an entire year (Defra 2009). Because agriculture uses approximately 72% of the land in the UK (Defra 2018) and the carbon in the UK's soils stores over 10 billion tonnes of carbon (Defra 2009), UK agricultural soil management makes it a critical component of climate change mitigation. This highlights the need for agricultural policy to reward farmers for land uses that deliver public goods, such as climate change mitigation or protection of drinking water sources (Defra 2018). Soil quality decline in the UK is more pronounced in arable regions due to the highly intensive practices

used, such as monocropping, use of heavy machinery, overuse of chemical inputs and a lack of integration of organic material.

Norway

Only 3.1% of the total land area in Norway is suitable for agriculture; cereals can only be grown on one third of this area due to limiting natural conditions (Hegrenes et al., 2016; Tufte, 2012). Regional agricultural specialization, known as "kanaliseringspolitikken", was introduced in the after-war period. This policy led to increased agricultural production across Norway by incentivizing cereal production in lower-lying areas and animal husbandry in areas not suitable for producing cereals (Arnoldussen, 2014). However, over the last two decades, the total Norwegian cereal yield has declined due to a reduced area used for cropping and genetic breeding for higher yields has flattened (Clark, 2011; Hoel et al., 2013; Tufte, 2012; Vagstad, 2013). Despite the recent decline in cereal production, the Norwegian government has set a target of increasing food production with 20% by 2030 from 2010 levels to meet projected population growth in Norway (Stortinget, 2011).

In southeast Norway, three counties (Akershus, Østfold, and Hedmark) produce 60% of the country's cereal. However, soil organic matter (SOM) content has declined here, with an average loss of 1% of SOM a year from 1991 to 2001 (Hoel et al., 2013; Kolberg, 2016; Riley & Bakkegard, 2006). Riley and Bakkegard (2006) argued that an agriculture system losing SOM on this scale could not be considered sustainable. Reversing SOM decline in this region is considered challenging because of the small areas of perennials and small amounts of available organic fertilizer (Riley, 2012). A combination of more pressure on agricultural productivity in this region and a considerable increase in leased soil has most likely led to less knowledge about the soil, which again could lead to further soil compaction (Olsen & Nyborg, 2014; Seehusen et al., 2019). Soil compaction increases an already high erosion risk in southeast Norway (Stabbetorp, 2014; Unger & Kaspar, 1994; Waalen et al., 2019).

Research Design

Q-methodology is a mixed-methods approach using interviews to understand participant subjectivity of a topic. Q-methodology was chosen due to its capacity to shed light on complex, subjective phenomena where individuals hold differing views (Brown 1996). It allows for exploration of tensions in knowledge and perspectives between stakeholders that may affect the effectiveness and acceptability of a land use policy. The results can show areas of statistical agreement and disagreement, whilst also revealing distinct narratives emerging from groups of respondents (Brown 1996). Davis & Michelle (2011) suggest that Q-methodology provides more structure, scientific rigour and a richer insight into subjectivity than conventional

qualitative methods, such as interviews, focus groups and participant observation. When applied to situations with conflicted stakeholder dynamics, Q-methodology can be useful in identifying common ground among diverse stakeholders in situations where conservation or resource management is contested (Rust 2017). This makes the method particularly useful for this study due to the above benefits.

DATA COLLECTION

It is common to begin a Q-methodology with qualitative approach, where interviews are undertaken with a range of stakeholders on a study's topic to gather the diversity of opinions on the phenomenon in question. This data collection can be enhanced or replaced with a literature review. This qualitative step is used to develop the "concourse", which is the range of views (listed as statements) held on a topic. This is followed by a structured, quantitative step where participants rank the concourse statements, usually based on the extent to which they agree/disagree. Participants are chosen to undertake the survey to cover the range of views, which means random sampling from the wider population is not necessary. Because of non-random sampling and smaller sample sizes, conclusions cannot be generalised but the aim is to understand the range rather than the frequency of the views.

The concourse for this study was developed by interviewing 18 European agricultural stakeholders on causes of declining soil quality and corresponding solutions. Interviewees were purposefully chosen to represent researchers, land managers and other stakeholders from ten European countries participating in the wider project, Soilcare, on which this study is based. Ten researchers and eight other stakeholders (representing agricultural unions, farmers and landowners) were interviewed. An interview guide was used (Appendix 1), which was piloted on a subset of the sample population and amended due to feedback. Interviews were undertaken by telephone or Skype and lasted an average of an hour. Free, prior informed consent was obtained from all interviewees and ethical approval was gained from Newcastle University. Interviews were recorded with permission from the participants and later transcribed. Interviews were conducted in English, apart from one which took place in Italian, which was later translated to English for analysis.

Interviews were supplemented with a literature review on the topic. We searched online scientific publications, grey literature and information sites on the topic of soil quality causes and solutions. This review was to ensure the topic was sufficiently covered by the statements developed from the interview data. Data were then analysed using a thematic analysis focusing on reasons for soil quality decline and solutions for how to fix this. A total of 142 statements were obtained from the interviews and literature review, which included statements both for the problem Q-set and the solution Q-set.

Similar statements for each set were merged, whilst trying to retain as far as possible the original wording of the interviews to capture the intent of the source. For the UK study, this resulted in 41 statements for the "problem" Q-set and 34 statements for the "solution" Q-set, which became the final list of statements. For the Norwegian study, wording was amended subtly to match the country's context e.g. Changing the statement "EU agricultural policy" to "Norwegian agricultural policy", and adding local problems such as drainage, which resulted in 42 problem statements and 36 solution statements.

A "Q-sort" is the ranking of the Q-set by participants. Data collection for the Q-sort was undertaken via an online survey (A.2) using Google Forms. The UK survey was distributed via soil-specific newsgroups, British agricultural union members and by sharing on agricultural social media. The Q-sort survey was first piloted on a subset of the target population and subsequently adapted following feedback to improve question clarity and to include additional statements that were not captured via the interviews or literature review. Participations then ranked the statements on a scale of -2 (strongly disagree) to +2 (strongly agree) using an unforced distribution, which was used in preference to a forced distribution based on feedback from pilot interviews where participants felt the forced distribution was too restrictive. Respondents were asked which country they lived in when completing the survey. A total of 61 UK respondents undertook the survey: 19 scientists, 19 farmers, 16 agricultural advisers, 3 water company employees who work on agriculture, 2 nature conservationists, 1 agricultural union representative and 1 civil servant. For the Norwegian study, a link to the survey was distributed in "Plantenytt", a newsletter from the government extension service Norsk Landbruksrådgivning Øst and to a local "soil education group". Forty-two Norwegian farmers took part in the survey, as well as 6 agricultural advisers and 5 scientists, totalling 53 respondents.

At the end of the survey, participants were asked what they thought was the leading cause of declining soil quality and the most important solution to solve this problem. Participants could choose a statement from the Q-sort or add a new problem/solution. These open-ended questions were firstly used to determine if there were any statements missing from the Q-sort and secondly to find out what, subjectively, they thought were the most important drivers for causing declining soil quality and how to fix this. These answers provided additional information on the participants' reasons for their answers. Data from these open-ended questions were analysed via thematic analysis to understand common themes, patterns and meanings. Quotes in the results section are used to highlight common sentiments as well as responses that stood apart from the rest. Quotes from the Norwegian study were translated into English.

ANALYSIS

Data from the Q-sorts were analysed using kenq (https://shawnbanasick.github.io/ken-q-analysis). First, a principal component analysis (PCA) was used to identify the groups of participants who ranked their Q-sorts similarly; also known as "loaded factors". Flags were automatically added to respondents who significantly loaded onto these factors at $p<0.05$.

For the UK study, the PCA for the problem Q-sort revealed 8 factors with Eigenvalues >1 (which together explained 67% of the variance) but most loaded onto factors 1-4 (which together explained 53% of the variance). Large datasets, such as in this study, run the risk of inflating the Eigenvalues (Coogan and Herrington 2011). Because of this, we focused on the first four factors for the problem set as this explained over half the variance. A Varimax rotation was then applied to the four factors, which calculated the highest variability between factors. A z-score was calculated based on the average ranking participants gave to the statement within each factor group. Respondents that significantly loaded onto more than one factor were excluded from subsequent analysis. Statistical disagreement (and agreement) between participants was set where $p>0.01$, which meant that the groups of participants did (not) rank the statements differently at the 99% confidence level. The PCA for the solutions Q-sort revealed 8 factors with Eigenvalues >1 (which together explained 79% of the variance) but most loaded onto factors 1-3 (which together explained 65% of the variance). The rest of the solutions analysis followed the same process as with the problem Q-sort.

For the Norwegian study, the analysis followed the same procedure as the UK study. For the problem Q-sort, 8 principal components with Eigenvalue above 1 were extracted through the PCA, which explained 69% of the variance. Most of the participants loaded onto the first three problem factors, which together explained 51% of the variation, and these three factors were carried forward for further analysis. For the solution Q-sort, eight factors with Eigenvalues above 1 were extracted, explaining 78% of the variance, though as respondents loaded onto factors 1-3, explaining 63% of the variance, these three factors were used in further analysis.

Results

This section describes results from the problems Q-sort (Table 1: UK; Table 2: Norway) and solutions Q-sorts (Table 3: UK; Table 4: Norway). The number of respondents loading onto each factor (i.e. Ranked statements similarly) is shown in Figs 1. (UK problem Q-sort), 2 (Norway problem Q-sort), 3 (UK solution Q-sort) and 4 (Norway solution Q-sort) Results are grouped under the key defining factors that emerged from each Q-sort, which are summarised in short, narrative phrases based on their main defining traits of each factor. Key areas of consensus and disagreement that emerged across these different groupings are then highlighted.

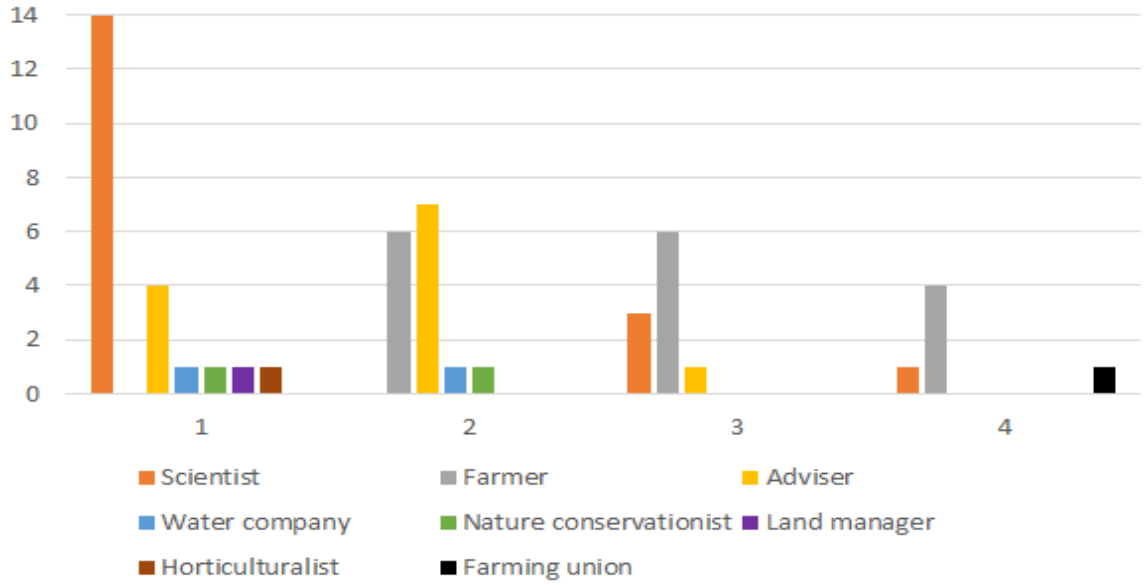
PERCEIVED PROBLEMS CAUSING DECLINING SOIL QUALITY

UK study

Factor 1: "Intensive agriculture to blame"

This factor was defined by respondents being significantly more likely to think the problems causing declining soil quality were due to "intensive use of soil without time to recover" and "overuse of inputs", more strongly agreeing to these statements than other factors. In contrast, they strongly disagreed that the problem was caused by "soil has become too saline", ranking this statement less negatively than other factors.

Fig. 1. Professions of UK respondents loading onto the four problem factor groups



Factor 2: "Farmers need to change"

This factor was defined by respondents more strongly agreeing than other factors that "lack of knowledge of soils amongst farmers" and "some traditions of farmers are damaging" were causing problems in soil quality. Conversely, they more strongly disagreed with statements "declining level of nutrient status", "loss of number of wild species" and "I do not believe there is a problem with soil quality" than other respondents.

Factor 3: "It's the EU, not farmers that are to blame"

Respondents here were defined by more strongly agreeing than other factors that "EU agricultural policy" was the cause of declining soil quality. They also more strongly agreed that "lack of knowledge of soils amongst farmers" and "natural local climate constraints" were problems compared with other factors. Conversely, they strongly disagreed that the problems were "use of contractors" and "loss of numbers of wild species" compared with other respondents.

Factor 4: "Weather and farm management to blame"

Respondents here more strongly agreed than other factors that "pressure on farmers to produce at a low cost", "choice of cropping system" and "flooding or drought" were causing problems with soil. Conversely, they more strongly disagreed with statements "lack of knowledge of soils amongst farmers", "overuse of inputs" and "distrust of scientists by farmers" were causing problems compared with other respondents.

Areas of agreement and disagreement

Respondents in all factors strongly agreed that soil quality was declining due to loss of soil structure, and agreed or strongly agreed that compaction, soil erosion, loss of organic matter and insufficient knowledge exchange were other causes (Table 1). In contrast, they all disagreed or strongly disagreed that the cause was due to farmers having little control over their land and there being a distrust of scientists by farmers. Conversely, the only area of statistical dissensus between each factor was "lack of knowledge of soils amongst farmers" (Table 1).

Table 1. Average Q-sort scores for each of the four factors identified as causing problems by UK respondents.

Statement	*Factor* 1	2	3	4
1. Intensive use of soil without time to recover	**2**	1	0	0
2. Farmers have lost touch with the finer understandings of their land	-2	**1**	**0**	-1
3. Land is being used for other purposes (e.g. Grazing, housing, industry)	0	-1	-1	0
4. Farming has become too quantified, where everything is measured	-2	-1	-1	0
5. Some traditions of farmers are damaging	0	**2**	0	1
6. Loss of organic matter	2	2	2	1
7. Loss of numbers of wild species	1	**-2**	**-2**	**-1**
8. Compaction	1	2	1	2
9. Soil has become too saline	-2	-2	-2	-2
10. Declining level of nutrient status	0	**-2**	1	1
11. Overuse of inputs like fertilisers and pesticides	**2**	0	-1	**-2**
12. Repetition of the same crops, year after year	**1**	0	1	**-1**
13. No crop cover over winter	1	1	0	**-1**
14. Loss of soil structure	2	2	2	2
15. Choice of cropping system	0	0	1	**2**
16. Soil tillage practices	**0**	2	2	2
17. Use of contractors	0	1	**-2**	0
18. Poor management	1	1	1	**-1**
19. Farms have become too big	0	-1	-2	0
20. Soil erosion	2	1	2	1

Statement	*Factor* 1	2	3	4
21. Pressure on farmers to produce at low cost	2	**0**	2	2
22. Product demand from national/international markets	**1**	0	0	0
23. Help towards improvements are not given fairly	-1	0	0	1
24. Too many regulations	-2	-2	**0**	**-1**
25. Too much environmental regulation	-2	-2	**0**	**-1**
26. EU agriculture policy	-2	-1	**2**	-1
27. Farmers have little control over their own land	-1	-2	-1	-2
28. Climate change	1	**-1**	**-1**	1
29. Natural local climate constraints	-1	-1	**1**	0
30. Topography of the land	-1	-1	1	1
31. Flooding or drought	0	**-1**	0	2
32. Disconnection between nature-based land use and modern agriculture	1	0	**-1**	0
33. I do not believe that there is a problem with soil quality	-2	**-2**	-2	**0**
34. Distrust of new technology and innovations by farmers	-1	0	-2	-2
35. Fear of doing something new	0	**1**	0	**-1**
36. Distrust of scientists by farmers	-1	-1	-1	**-2**
37. Not enough knowledge being shared	1	1	1	1
38. Distrust between farmers and advisory agencies	-1	**0**	-1	-2
39. Peer pressure by others	-1	0	-2	0
40. Lack of knowledge of soils amongst farmers	**-1**	**2**	**1**	**-2**
41. Modern machinery is too large	**0**	1	**-1**	1

Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from -2 (strongly disagree) to 2 (strongly agree).

Leading causes of declining soil quality

There were two themes that were frequently mentioned by most UK respondents as the leading causes of declining soil quality when answering this open-ended question. The first group blamed market pressures for pushing farmers into intensifying farming, with a sentiment that an ever-increasing drive to produce more food at cheaper costs was a fundamental driver of unsustainable land management, including soil quality decline. This could relate to the Q-set statement 21, "pressure on farmers to produce at low cost", which respondents in Factors 1, 3 and 4 strongly agreed this was a cause for declining soil quality. This sentiment is captured in an agricultural adviser who said:

> "*There is an increasing demand to produce cheaper food for a larger population using the same/declining land area. Pressure is put on producers by supermarkets and the general public to provide food to contracts, often unknowingly, which results in poor management choices.*"

Conversely, the second group blamed farmers and thought that intensive agricultural practices, such as ploughing and insufficient crop rotations, were the leading causes of soil quality decline. Many respondents felt this was due to a lack of understanding by the farmer of better soil management practices. One nature conservationist summarised this theme by saying the problems causing declining soil quality were due to:

> "*Traditional' farming practices and cropping, which means too many farmers not being innovative/open to new methods. Time to start re-thinking about how we measure what makes a successful farm - it's not all about productivity."*

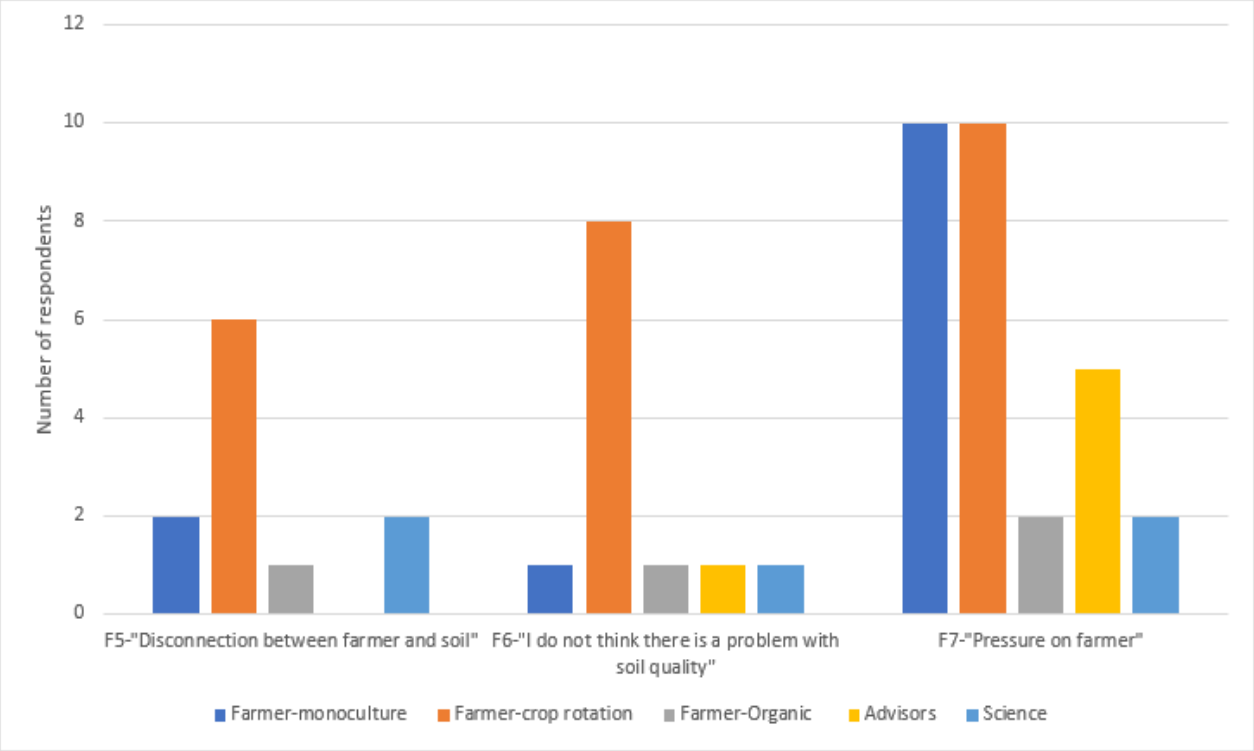
This sentiment was not reflected in the answers to the problem Q-sort. One of the reasons for this could be that it encapsulates many of the problem statements related to farm management as it is a multi-faceted and complex problem.

Norway study

Factor 5: "Disconnection between farmer and soil"

Respondents in this factor were more likely to rank "poor management of the soil" as one of the main reasons for the decline in soil quality. This group disagreed more strongly with the statement "I do not think there is a problem with soil quality". Instead, they ranked statements on agricultural practices and farmers' knowledge as leading causes to decline soil quality such as "farmer has lost the finer touch with his land", "overuse of input like fertilizer and chemicals", and "lack of knowledge on soil amongst farmers".

Fig. 2. Professions of Norwegian respondents loading onto the three problem factor groups



Factor 6: "I do not think there is a problem with the soil quality"

Respondents in this factor disagreed that agricultural practices are reasons leading to a decline in soil quality such as "intensive agriculture to blame" and "overuse of input like fertilizers and chemicals". They also strongly disagreed with the statements "use of contractors", "too much leased land" or "farmers have lost the finer touch with their land". They agreed more strongly than others with the statement "too little advice on soil-improving practices" and "lack of knowledge-sharing between scientists, advisors, and farmers" as problems for soil quality.

Factor 7: "Pressure on the farmer and externalities leading to decline"

Whilst respondents in this factor considered there to be a problem with soil quality, they thought the problems were often outside of the farmer's actions and responsibility compared to factor 5, being significantly more likely to agree on "pressure on the farmer to produce at low cost", and "intensive agriculture" than the other factors. This group also more strongly agreed to structural characteristics like "too large farms" and "high share of leased land" as problems on declining soil quality compared with other factor groups.

Areas of agreement and disagreement:

Respondents in the three factors agreed or strongly agreed that soil quality was declining because of "soil erosion", "repetition of the same crop, year after year; monoculture", and

"loss of soil structure". There were also numerous areas of *statistical disagreement*[1] between the factor groups (Table 2), such as with those related to knowledge/education, environmental conditions and management of the farm.

[1] This suggests values in all factors are different

Table 2. Average Q-sort scores for each of the four factors identified as causing problems by Norwegian respondents.

	Factors loading on to statements		
Problem statements	5	6	7
1. Compaction	2	2	**2**
2. Soil tillage practices	1	0	1
3. Lack of use of new technology and innovation	**-2**	0	-1
4. Use of entrepreneurs/external labor	1	**-1**	1
5. Intensive agriculture	0	**-1**	1
6. Not enough knowledge being shared between scientists, advisors and farmers	0	1	**-1**
7. Loss of organic matter	2	2	2
8. Soil erosion	2	2	2
9. Fear of new practices and methods	0	1	**-1**
10. Local weather and climate	**-1**	1	1
11. Lack of knowledge on soil amongst farmers	2	1	**0**
12. Distrust of scientists among farmers	-1	0	**-2**
13. Soil being used to other types of agriculture (grazing/other plant production)	-2	**-1**	-2
14. Flooding or drought	**-2**	0	1
15. Pressure on farmer to produce at a low cost	0	1	**2**
16. Soil has become too saline	-1	-1	-2
17. Too little advise on soil-improving practices	**1**	**2**	**-1**
18. Peer-pressure	-1	-1	**-2**
19. Choice of crops (cropping system)	1	1	1
20. Too much environmental regulation	**-2**	**0**	**-1**

	Factors loading on to statements		
Problem statements	5	6	7
21. *Too large farms*	**-1**	**-2**	**1**
22. *Topography of the land*	**-2**	0	0
23. *Loss of number of wild species*	**0**	-2	-2
24. *Farmer has lost touch with the finer understandings of his land*	**1**	**-2**	**-1**
25. *Climate change*	**-2**	**0**	**1**
26..*Farmer has little control over his own land*	-1	-2	-1
27. *Loss of soil structure*	2	1	2
28. *Declining level of nutrient status*	0	1	0
29. *Distrust between farmers and advisory agencies*	-1	-1	**-2**
30. *Poor management of the soil/poor soil management*	**2**	1	0
31. *Too many regulations*	-2	**0**	-1
32. *Overuse of input like fertilizers and pesticides*	**1**	**-2**	**-1**
33. *I do not believe that there is a problem with soil quality*	-2	**2**	-2
34. *No cover crop over winter*	1	2	1
35. *Disconnection between nature-based agriculture and the modern agriculture*	**1**	**-1**	**0**
36. *Product demand from the market*	0	**-2**	0
37. *Repetition of same crop year after year; monoculture*	2	1	2
38. *Norwegian agriculture policy*	1	**-1**	0
39. *Agriculture has become too quantified, everything is to be measure*	-1	-1	**0**
40. *High share of leased land*	**0**	**-2**	**1**
41. ***Too little drained land***	**0**	**2**	2

Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from -2 (strongly disagree) to 2 (strongly agree).

Leading causes of declining soil quality

There were two frequently mentioned perceived causes of declining soil quality. The first was thought to be due to an increase in use of large machinery causing soil compaction, captured by the statements;

> *"Larger farms stimulate heavier machinery leading to more compaction"* and *"…modern machinery can drive in unfavourable conditions"*.

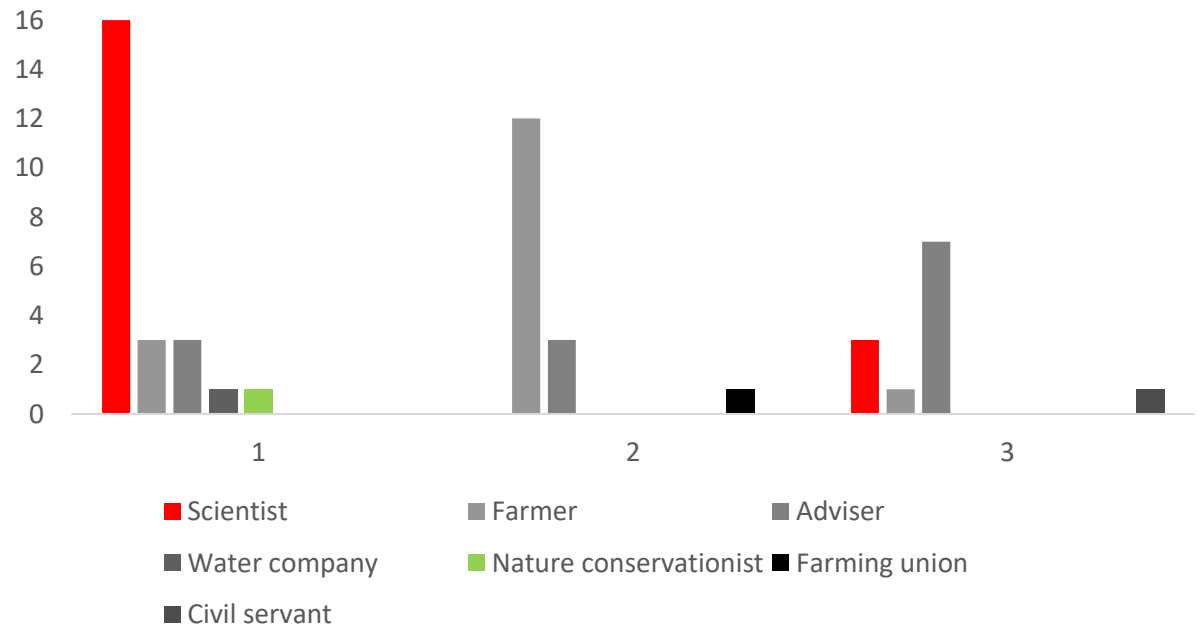
The second aspect considered as a leading cause to declining soil quality was monoculture and lack of crop rotation. Several respondents connected these statements to declining levels of SOM, while some connected monoculture to the regional specialization policy.

PERCEIVED SOLUTIONS TO ADDRESS DECLINING SOIL QUALITY

UK study

Factor A: "Anti-innovation"
This factor was defined by respondents more strongly disagreeing that there is not much we can do to improve soil quality and that the problems were due to natural climatic constraints. They also disagreed with innovations and increasing early adoption of new techniques to solve the issue, ranking these statements more negatively than other factors.

Fig. 3. Professions of UK respondents loading onto the three solution factor groups



Factor B: "Yes to financial incentives but no to more regulation"
Respondents here more strongly agreed that financial incentives could be a solution but more strongly disagreed that restrictive policies - such as more regulation (including for fertilisers and to reduce water usage) and creating a Soil Directive - would improve soil quality.

Factor C: "Early adoption of new techniques"
This factor was defined by respondents more significantly agreeing to increasing early adoption of new techniques as a solution to declining soil quality. They also more strongly disagreed that solutions lie in maintaining small farms, giving more freedom for farmers to manage their land as they would like and that farmers have already tried lots of things.

Areas of agreement and disagreement:
Respondents loading onto the three factors strongly agreed that more research should be done in collaboration with farmers and all either agreed or strongly agreed in investing in education and training (Table 3). All factors agreed that we should work towards improving trust between farmers and regulatory agencies, as well as reduce compaction. Finally, all factors disagreed that we should change the timing of tillage.

A number of statements had statistical disagreement between the factor group's average scoring but a number only differed by 1 point, e.g. Either strongly disagreed or disagreed (Table 3). For statements where the disagreement was two or more points (e.g. One group's average score was -2 and another group's average score was 0) and where there were statistical differences between the groups at $p < 0.01$, factor groups disagreed with each other on solutions being found in maintaining small farms, increasing the early adoption of new techniques and giving more freedom to farmers to manage their land.

Table 3. Average Q-sort scores for each of the four factors identified as solutions to improve soil by UK respondents

Statement	Factor 1	2	3
1. Keep updated with new information	0	0	1
2. Farmers have already tried lots of things to improve soil quality	**-2**	**-1**	**-2**
3. More technical advice	0	1	0
4. Setting examples for others to follow	1	0	2
5. More innovations	**-1**	1	1
6. Maintain small farms	**0**	**-1**	**-2**
7. More resting/recuperating of the soil	1	**-1**	0
8. More organic fertilizer	0	0	0
9. More cover crops	2	0	-1
10. More diverse crop rotations	2	0	1
11. Less use of heavy machinery	0	0	0
12. Change the timing of tillage	-1	-1	-1
13. Reduce compaction	1	2	2
14. More targeted mapping of soil threats	0	0	0
15. More financial incentives	0	**1**	0
16. More financial penalties	-2	-2	**0**
17. More freedom for the farmers to manage their land as they would like	**-1**	**0**	**-2**
18. More regulation	**-2**	**-2**	**-1**
19. More regulations for water usage	-1	**-1**	-1
20. More regulations for fertilisers	**-1**	**-2**	**-1**
21. We cannot do much as the problems are down to natural climatic constraints	**-2**	**-1**	**-2**
22. Creation of a 'Soil Directive'	0	**-2**	0
23. More research done in collaboration with farmers	2	2	2
24. More traditional farming practices	**-1**	-1	-1
25. Improve trust between farmers and regulatory agencies	1	1	1
26. Society needs to change focus on what we want to produce	0	0	**-1**
27. Increase early adoption of new techniques	**-1**	**0**	**1**
28. More farmer demonstration days	**0**	1	1
29. More communication and sharing of knowledge between farmers locally	0	2	1
30. More local knowledge and experience	1	0	0
31. More education on environmental impacts	2	1	0
32. Increase knowledge of difference in soil types	1	2	0
33. Invest in education and training	1	1	2
34. There is not much new we can do in terms of soil management	**-2**	**-2**	-1

Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from -2 (strongly disagree) to 2 (strongly agree)

The most important perceived solutions to addressing soil quality decline:
There were two main themes that came out of this open-ended question, with the first (and most common) requesting improved education/knowledge exchange between agricultural stakeholders. This links to the Q-set statements on "more research should be done in collaboration with farmers" and "investing in education and training", to which all factors agreed. This theme can be best encapsulated by a quote from a scientist who said the solution lay with:

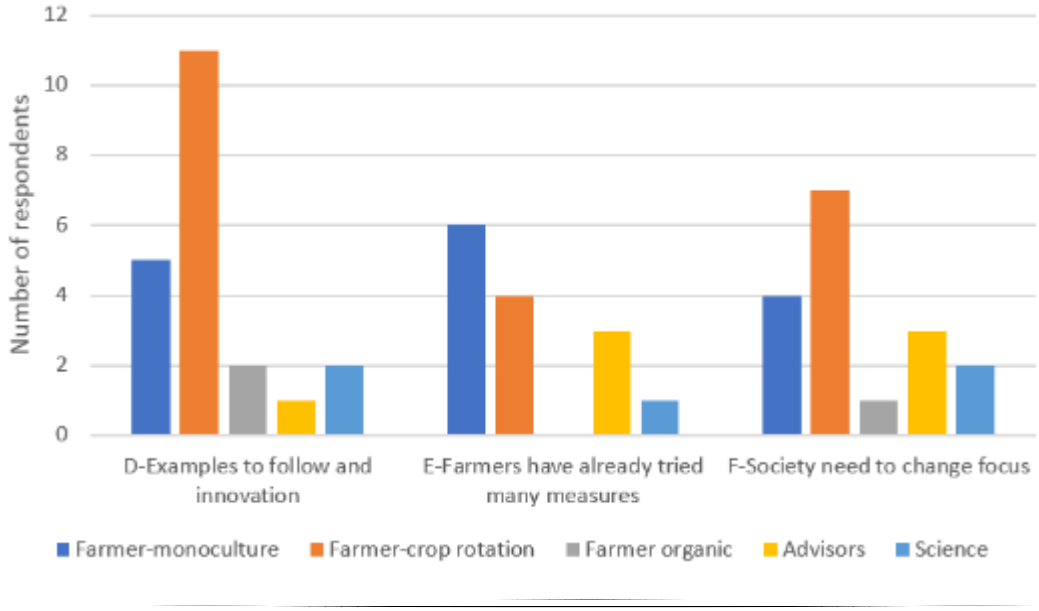
> *"Two-way communication between farmers, researchers and policy makers. Even the best solutions will not work if they can't be shown as favourable or acceptable to the farmer."*

The second theme was around suggestions of using soil-improving cropping systems, or derivatives thereof, such as diverse crop rotations, direct drilling and reduced tillage. This related to many of the solution Q-set statements such as on cover crops, rotations and less use of heavy machinery.

Norway study

Factor D: "Examples to follow and innovation."
Respondents in this factor were more likely to rank "setting examples to follow; if one farmer succeed others will follow", "more innovation" and "more targeted mapping of soil threats" as solutions to declining soil quality than others. This group disagreed more strongly than others on "more small farms" and "reduction of leased land" as solutions to increase soil quality and was the only group that was neutral on the statement "reduce use of heavy machinery".

Fig. 4. Professions of Norwegian respondents loading onto the three solution factor groups



Factor E: "Farmers have already tried many measures."
Respondents in this group agreed more strongly on "farmers have already tried many measures to improve soil quality" compared with other factors. They disagreed on "more use of cover crops", "financial incentives", "creation of a soil directive", "more regulation of fertilizer use", and "more regulation" as solutions. This is not to suggest farmers do not think there is a solution. Perhaps what could help is the nuanced understanding of different soil improving techniques in their respective soils and space for experimentation and failures as well.

Factor F: "Society needs to change focus"
The respondents in this factor distinguished themselves from the others by strongly agreeing on "society needs to change focus on what farmers produce". This group also agreed that the solutions could be to "reduce use of heavy machinery" and "more use of cover crops", though not at the $p < 0.01$ level.

Areas of agreement and disagreement:
All three factors agreed or strongly agreed on "less soil compaction" and "more variation in crop rotation" as measures towards increasing soil quality (Table 4). There was statistical agreement on statements with an educational aspect, such as "investment in education and training" and "more farmer demonstration days".

Respondents disagreed or strongly disagreed on "there is not much we can do with the cropping system to improve soil quality" and "problems are due to natural, climatic variations" (Table 4). All respondents strongly disagreed on "more use of financial penalties" and were neutral or disagreed with "financial incentives" as a solution."

Table 4. Average Q-sort scores for each of the four factors identified as solutions to improve soil by UK respondents.

Discussion

Understanding the range of stakeholder perceptions on the causes and solutions to declining soil quality is useful as it can aide in highlighting potential areas of tensions and agreements that might affect acceptability of soil management policy change. For instance, in both our UK and Norwegian studies, whilst there were disagreements between respondents on the perceived causes of declining soil quality, they agreed on numerous soil-specific factors, e.g. Compaction, soil structure, soil erosion and loss of organic matter. For the UK, there was also agreement on what respondents felt were not causing problems in soil quality, including that soil has become too saline, farmers having little control over their land and distrust of scientists by farmers. For Norwegian respondents, there was agreement that problems were not caused by too saline soil, too large farms, that farmers have lost control over their land, or distrust between farmers and advisory agencies.

The context-specific nature of soil quality was raised by respondents in their responses to the open-ended questions, where UK farmers, in particular, were keen to point out that different soils will require different solutions, whereas this was only mentioned once in the Norway study. Whilst respondents did agree on some causes and solutions, this context-specificity may limit the effectiveness of broad-brush policy approaches to solving declining soil quality and should be considered when developing any regional or national soil policies. Whilst Norway is not part of the EU and the UK has now left, our findings could apply to EU Member States as it suggests that, if an EU Soils Directive were to be created, this should allow country- and district-level tailoring.

Our study purposefully examined perceptions of causes and solutions to soil quality, though perceptions sometimes do not align with reality. By reflecting on how the perceptions of problems causing soil quality relates to published research on the topic, this can help ground truth the suggested causes in the Q-sorts to determine if they mirror scientific understandings of the problem. According to Defra, the main threats to soils in England are soil erosion, compaction and organic matter decline (Defra 2009), which does indeed reflect the main problems respondents in our UK study believed were causing decline in soil quality. Agreement by respondents in the Norwegian study was also found on the problems being perceived to be soil erosion and loss of soil structure, which ties well with previous studies in southeast Norway, where erosion and loss of soil structure are linked to increased soil compaction and a high share of annuals (Seehusen et al., 2019; Waalen et al., 2019). All Norwegian respondents considered lack of crop rotation as a problem causing soil decline, which is a finding not noted in the UK study, perhaps reflecting the promotion of crop rotations in the UK via the EU Common Agricultural Policy. Monoculture is unfavourable for soil quality as it can reduce SOM (Breland, 1992; Chen et al., 2019) With the UK leaving the EU, it remains to be seen whether UK agricultural policy will continue to promote rotations.

Defra's 2009 report on the status of UK soils noted that climate change could reduce soil quality in the future. Respondents in factors 2 and 3 our UK study and 5 and 6 of the Norwegian study did not feel that climate change was a current problem for soils. A repeat of this survey could be conducted in the future to determine whether this sentiment changes over time for respondents, as the effects of climate change are likely to increase during this century, causing increased pressure on agricultural soils. There are registered changes to weather in southeast Norway already, with increasing rain in spring and higher soil temperatures; these changes can cause soil quality to decline through more compaction of soil and loss of SOM (Hegrenes et al., 2016; Riley & Bakkegard, 2006).

Whilst all factors in the UK disagreed that there was not a decline in soil quality, 12 respondents in factor 6 of the Norwegian study agreed to this statement. There can be several reasons to why these Norwegian respondents differed significantly from the other factors and from scientific evidence (Riley & Bakkegard, 2006). One reason could be that respondents in factor 6 had a different definition of soil quality and did not consider there to be a decline. For instance, a crop consultant wrote, "*I do not think that soil quality has gone down, farmers are harvesting higher and higher yields",* perhaps reflecting a historic definition of the term "soil quality" that focused more on productivity rather than wider environmental effects (Erkossa et al., 2007). Also, it can be considered that a decline in soil quality may be hidden by more use of external inputs. If respondents believed that soil is only a medium to grow a crop, they may not have considered there to be soil decline if yields are getting "higher and higher" with continued application of fertiliser and pesticides, as these inputs can cover up underlying soil quality issues (Uhlen et al., 2017).

Factor 7 of the Norwegian study considered regional industrialization as a cause of soil quality decline, particularly the increase in larger farms, leased land, and reduced SOM. This perception reflects the significant structural changes in this region, described by Bjørlo and Rognstad (2019) in their report "*Barely recognizable*" (translated from Norwegian). This sentiment was shared by many UK respondents in their answer to the open-ended question, blaming industrialization and the demand for cheap food as ultimate drivers of soil degradation.

Some UK and Norwegian participants were neutral towards or disagreed with financial incentives as a solution to addressing soil quality decline, which contrasts with previously documented effects of subsidies on environmental measures. Stabbetorp (2014). Previous research to determine stakeholder acceptance of land use polices has also found some stakeholders do not want incentives, as they can be seen as a bribe to get farmers to do what others want them to do (Rust et al., 2016). However, whilst there may be some reluctance to agree to using financial incentives as way to change farmer behaviour, there is widespread

agreement that, when implemented effectively, they can and do create large-scale change in farmer practices (Stabbetorp, 2014).

Many of the problems considered by respondents in the Q-sorts to be important for causing declines in soil quality could be argued to be symptoms rather than causes. For instance, loss of organic matter, compaction and soil erosion are all symptoms related to and exacerbated by poor management of soils (Moncrieff and Draisey 2018). Whilst soil erosion is directly affected by environmental factors such as the weather or slope of the field, it can be partly mitigated by better land management practices (Verheijen et al. 2009). Equally, loss of soil structure and organic matter are affected by on-farm practices such as tillage and choice of cropping systems. It is not clear why respondents did not focus on underlying causes for these issues in the Q-methodology, but it could be that farmers are less likely to blame themselves for the loss in soil quality (possibly due to the complexity of the causes) or they lack awareness of the underlying drivers. Indeed, land management that reduces soil quality is not the sole fault of farmers; instead it is due to lack of incentives to farm in a way that protects the environment (Moncrieff and Draisey 2018).

When analysing the answers to the open-ended question about the main problem causing declining soil quality, both UK and Norway respondents often highlighted the complex nature of this issue being related to external pressures along the food supply chain such as consumers demanding cheap food and agricultural policy dictating farm management. One UK farmer summarised this sentiment succinctly by stating “give a farmer the right tools and he can put things right but remember he is only a puppet in a political system”. Different demands are placed on farmers, pulling them in different directions and this might have a negative effect on the soil. To illustrate this tension, one UK adviser stated that “the machinery industry wants to sell big heavy machinery and the agronomy industry wants to sell more chemistry and soil health is the loser”. The problem Q-sorts could have resulted in oversimplification of the phenomena, resulting in respondents choosing symptoms rather than underlying causes of declining soil quality. More research is needed to fully unpack this issue.

Moving on to the solutions, there was disagreement between factor groups on maintaining small farms, giving more freedom to farmers for them to manage their land and increasing early adoption of new techniques. However, there was strong agreement by UK respondents that more research should be done in collaboration with farmers, as well as investing in education and training, and regulators and reducing compaction. Three of these four agreed solutions deal with the interaction between different stakeholders rather than technical fixes, which suggests respondents in this survey felt that solutions lie at a community, or even societal, level. Norway respondents put more emphasis on education.

Whilst the underlying drivers of soil quality decline are complex, one solution agreed upon by many factors to improve soil quality that can go some ways to addressing different experiences and ideologies was to undertake more research in collaboration with farmers. The EU Horizon 2020 funding stream promotes a "multi-actor approach" for agricultural research projects, encouraging a diverse group of stakeholders to work together rather than research solely (or primarily) being conducted by researchers (EIP-AGRI 2018). This approach has many potential benefits as it can help promote greater understanding of different perspectives, building empathy, making research more robust, allowing quicker uptake of results, grounding research in non-academic stakeholder experiences and knowledge, as well as others (Acquaye-Baddoo et al. 2010). Possible outcomes of this collaborative approach could be that it builds trust between stakeholders so that they can begin to work together more effectively and respect each other's perspectives. Equally, this collaborative approach may go some way to address the epistemological differences between professions noted above. Given that one of the suggested solutions was to build trust between regulators and farmers, future work should encourage participation of regulators in multi-actor projects. In the Norwegian study, "farmer demonstration days" were considered as a consensus solution to improve soil quality. These "demonstration days" is an example of a collaborative approach where scientist, extension service and farmers meet to discuss both theoretical and practical aspects of agriculture.

Many UK and Norwegian farmers interviewed were against EU or national intervention to improve soils, such as creating a Soils Directive, and were also more negative with regards to any form of regulation. This reflects wider UK sentiment on the issue; back in 2012, UK Ministers, together with Germany, France, The Netherlands and Austria played a key role at blocking an EU Soils Directive (Glæsner et al. 2014). This may also reflect the fact that the survey ran during the EU "Brexit" negotiations, where trust in the EU by many UK citizens is at a low. Most UK farmers voted to leave the EU therefore might not have faith that another EU Directive could help in this matter. This may also show lack of faith in the UK's national application of the Common Agricultural Policy. Leaving the EU gives the UK a unique opportunity to revolutionise agricultural policy and the UK's Environment Secretary of State Michael Gove is already promising a new way of doing things by using "public money for public goods" (Defra 2018). It could therefore be that farmers get paid to conserve soils due to the essential ecosystem services they supply. Interestingly, however, financial incentives were not considered by many to be a viable solution to declining soil quality in this study, though those respondents loading onto Factor 2 (including most of the farmers) were more positive of this than those in Factor 1 (mostly scientists) and 3 (mostly advisers).

Investing in education and training was an additional solution that all factor groups agreed on. Research has shown that education and training can be effective at spreading awareness and uptake of more sustainable agricultural practices. This may work best with farmers that are

more open to learning about new topics and trying new ideas and can be integrated into a multi-actor approach. However, conservative farmers that are more risk-averse and less willing to change might be less likely to attend training events or try new practices and it could be these farmers that are undertaking the most soil-damaging practices. Targeting these hard-to-reach farmers has continued to prove challenging. One way of addressing this could be to frame a training course or knowledge exchange event in a way that attracts these farmers by focusing on aspects they are passionate about or else not only the farmers might feel cheated of their time which perhaps could be better utilised. It would be useful for more research to be undertaken on how to attract these farmers to such events.

The final solution agreed by all factor groups was reducing compaction. As compaction was one of the agreed problems causing declining soil quality, it is not surprising that addressing this issue was considered a solution. There has been significant interest in the effects of compaction over the last few years in both Norway and the UK, with numerous research projects, training events, innovations and industry-led technology to help address this problem. This suggests compaction is a salient issue with respondents. However, it was interesting to note that some of the ways for dealing with compaction, such as reducing usage of heavy machinery, were not highly rated by respondents in this survey. More research would be needed to understand why this is.

Conclusion

This research has shown that, in the context of declining soil quality in Norway and the UK, different professions within the agricultural sector focused on different problems and solutions, though there are clear areas of consensus. For policymakers, these areas of consensus are important to understand as they could indicate areas that policy change here might be more acceptable to the range of stakeholders, though more research is needed to see whether these results are found on a wider scale. Areas of disagreement are also essential to understand for policymakers, especially if policymakers are thinking of promoting policy change for the solutions that respondents showed dissensus. The research has also highlighted the complexity of addressing soil quality decline given the deeply embedded causes related to market forces and wider national and international policies. Solutions are unlikely to be effective in the long-term if they focus solely on changing farmer behaviour. To truly ensure a more sustainable land management in Norway and the UK, focus must also be on changing these drivers, which will likely require difficult social, economic and environmental trade-offs.

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Appendix 1: Interview guide to develop the concourse

- What do you see as the main threats to soil quality in Europe?
  - *These may be general or specific to the locality*
- What roles do you see to changes in cropping practices to overcome these threats or to improve soil quality
  - *These may be general or specific to the locality or threat*
- How do you know if these approaches are actually improving the soil?
- Who should have primary responsibility for improving soils in your country or across the EU?
  - *Prompts: individual versus collective*
  - Private versus public etc.?
- In your experience, why do people promote or adopt soil-improving cropping systems?
  - *Why should people promote or adopt these?*
- What factors incentivize or prevent soil improvement from farm to landscape scales?
- Name as many reasons as you can why farmers may choose to adopt soil-improving cropping systems or not

Appendix 2: Q-sort survey

Problems causing and solutions to declining soil quality

Invitation and Brief Summary

You are being invited to take part in a research study. Before you decide whether or not you wish to take part it is important that you understand why the research is being done and what it will involve. Please read this information carefully and discuss it with others if you wish. Take time to decide whether or not you wish to take part. If you do decide to take part, you will be asked to sign a consent form. However, you are free to withdraw at any time, without giving any reason and without any penalty or loss of benefits.

What is the purpose of the research?

This research is part of a study called SOILCARE: Soilcare for profitable and sustainable crop production in Europe. SOILCARE is a European Union-funded research project running from 2016-2021 and aims to identify and evaluate promising soil improving cropping systems and agronomic techniques increasing profitability and sustainability across scales in Europe.

As part of this work, we want to understand what people think are causing problems in declining soil quality and what solutions there are to solve this issue. This information will then be used to help inform and improve our research. We are reaching out to all agricultural stakeholders to study this topic.

The summarised results of this data collection will be shared with other SOILCARE partners and with the European Union. Details of the other SOILCARE partners can be found here: https://www.soilcare-project.eu/project-information2/project-partners2

What does taking part involve?

If you agree to take part, you will be asked to complete a questionnaire, which comprises of 6 questions and should take no more than 20 minutes to finish.

What information will be collected and who will have access to the information collected?

We will not collect any information from you that can be used to identify you. We will, however, ask what industry you work in. The rest of the questionnaire will ask your opinions on what you think is causing declining soil health and what the solutions are.

Anonymised information will be shared with the SOILCARE partners and the European Union. Information collected from this study will be stored in hard copy on the completed questionnaires and will also be inputted into a computer database, which is password protected. The questionnaires will not include any of your personal details which could be used to identify you. The database and questionnaires will then be destroyed once the project ends in April 2021. We have no plans to reuse the data after completion of this study. Anonymised data will be collated into documents such as reports, journal articles, book chapters and presentations.

For more information on SOILCARE please visit www.soilcare-project.eu or contact Dr Niki Rust, Agriculture Building, Newcastle University, Newcastle, NE1 4LU, UK, niki.rust@ncl.ac.uk

This project is financed by the H2020 program.

PLEASE NOTE: the survey works best on a laptop or tablet rather than a phone

1. Which country do you live?
2. What is your profession?

   Tick the one that is the most relevant

   Farmer

Agronomist
Civil servant
Policymaker
Scientist
Environmentalist
Agricultural supply chain employee
Adviser
Other

3. Please rank the statements based on whether you agree or disagree that they are causing problems in soil quality
   Items should be ranked relative to one another rather than independently

   Strongly disagree
   Disagree
   Neutral
   Agree
   Strongly agree

   1. Compaction
   2. Soil tillage practices
   3. Some traditions of farmers are damaging
   4. Distrust of new technology and innovations by farmers
   5. Use of contractors
   6. Intensive use of soil without time to recover
   7. Not enough knowledge being shared
   8. Loss of organic matter
   9. Soil erosion
   10. Fear of doing something new
   11. Natural local climate constraints
   12. Lack of knowledge of soils amongst farmers
   13. Distrust of scientists by farmers
   14. Land is being used for other purposes (e.g. Grazing, housing, industry)
   15. Flooding or drought
   16. Pressure on farmers to produce at low cost
   17. Soil has become too saline
   18. Help towards improvements are not given fairly
   19. Peer pressure by others
   20. Choice of cropping system
   21. Too much environmental regulation
   22. Farms have become too big
   23. Topography of the land
   24. Loss of numbers of wild species
   25. Farmers have lost touch with the finer understandings of their land
   26. Climate change
   27. Farmers have little control over their own land
   28. Loss of soil structure
   29. Declining level of nutrient status
   30. Distrust between farmers and advisory agencies

31. Poor management
32. Too many regulations
33. Overuse of inputs like fertilizers and pesticides
34. I do not believe that there is a problem with soil quality
35. No crop cover over winter
36. Disconnection between nature-based land use and modern agriculture
37. Product demand from national/international markets
38. Repetition of the same crops, year after year
39. EU agriculture policy
40. Farming has become too quantified, where everything is measured

4. What do you think is the leading cause of declining soil quality?
   This can be from the above list or a different cause that is not included above

5. Please rank the statements based on whether you agree or disagree that they are solutions to improve soil quality
   Items should be ranked relative to one another rather than independently

   Strongly disagree
   Disagree
   Neutral
   Agree
   Strongly agree

   1. More regulations for water usage
   2. More communication and sharing of knowledge between farmers on a local scale
   3. Invest in education and training
   4. More local knowledge and experience
   5. More regulations for fertilizers
   6. Less use of heavy machinery
   7. More farmer demonstration days
   8. Change the timing of tillage
   9. More research done in collaboration with farmers
   10. More small farms
   11. Improve trust between farmers and regulatory agencies
   12. More resting/recuperating of the soil
   13. More innovations
   14. There is not much new we can do in terms of cropping systems
   15. More financial incentives
   16. Setting examples to follow - If someone sees a person do well, they will do the same
   17. Creation of a 'Soil Directive'
   18. We cannot do much as the problems are down to natural climatic constraints
   19. Less compaction
   20. More diverse crop rotations
   21. More education on environmental impacts
   22. More organic fertilizer
   23. Society needs to change focus on what we want to produce
   24. More technical advice
   25. More targeted mapping of soil threats

26. More cover crops
27. More traditional farming practices
28. Farmers have already tried lots of things to improve soil quality
29. More regulation
30. Increase early adoption of new techniques
31. More freedom for the farmers to manage their land as they would like
32. More financial penalties
33. Increase knowledge of difference in soil types
34. Keep updated with new information

What do you think is the most important solution to help improve soil health?
Is there anything else you would like to add on this topic?

4. HOW DOES TRUST AFFECT UPTAKE OF SOIL IMPROVING CROPPING SYSTEMS?

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Abstract

The exponential rise of information available means we can now, in theory, access information on almost any question we ask. However, as the amount of unverified information increases, so too does the challenge in deciding which information to trust. Farmers, when learning about agricultural innovations, have historically relied on in-person advice from traditional 'experts', such as agricultural advisers, to inform farm management. As more farmers go online for information, it is not clear whether they are now using digital information to corroborate in-person advice from traditional 'experts', or if they are foregoing 'expert' advice in preference for peer-generated information. To fill this knowledge gap, we sought to understand how farmers in two contrasting European countries (Hungary and the UK) learnt about sustainable soil innovations and who influenced them to innovate. Through interviews with 82 respondents, we found farmers in both countries regularly used online sources to access soil information; some were prompted to change their soil management by farmer social media 'influencers'. Farmers placed most trust in other farmers to learn about new soil practices and were less trusting of traditional 'experts', particularly agricultural researchers from academic and government institutions, who they believed were not empathetic towards farmers' needs. We suggest that some farmers may indeed have had enough of traditional 'experts', instead relying more on their own peer networks to learn and innovate. We discuss ways to improve trustworthy knowledge exchange between agricultural stakeholders to increase uptake of sustainable soil management practices, while acknowledging the value of peer influence in innovation and trust building.

Keywords
Innovation, social learning, social media, sustainable agriculture, technology adoption, trust

Introduction

> "*I think the people in this country have had enough of experts...saying they know what is best and getting it consistently wrong*"
>
> - Rt Hon Michael Gove, then Justice Secretary of the UK Government, Sky News interview, 3 June 2016

We are now living in a world experiencing more information overload than ever before (Bawden and Robinson 2020). Never has there been a time where people can theoretically, with the right technological resources and skills, access much of humanity's collective knowledge in a matter of seconds via the internet. This explosion of digital content has, however, led to numerous challenges. Firstly, there is now such an abundance of content that locating the information needed can be difficult (Holton and Chyi 2012). Secondly, the rise of inaccurate, unchecked, unintentionally or deliberately misleading and pre-filtered content can make it harder to know what is trustworthy, credible and reliable (Hargittai et al. 2010). Together, this can create anxiety, uncertainty, or irrationality in decision-making (Eppler and Mengis 2004), creating a significant cognitive load, which can lead to inefficient and ineffective use of time and resources (Bawden and Robinson 2020). Information seekers are therefore not only challenged with finding information but also assessing, processing and controlling it (Tenopir 1990).

To overcome the problem of making sense of voluminous and conflicting information, we tend to use simple heuristics, or mental short-cuts, to assess information (Hmielowski, Hutchens, and Cicchirillo 2014). Trust is a heuristic used to evaluate information and is based on numerous factors, such as: whether the new information appears compatible with what is already believed, if it comes from a credible source and if it appears to be believed and trusted by peers (Lewandowsky et al. 2012). Traditionally, 'experts', who are thought to contain a high degree of detailed knowledge and expertise on a particular topic (such as scientists and doctors) have been considered trustworthy sources of information. Academic researchers are commonly thought of as 'experts' in their field of study, and studies have found widespread public trust in both science and scientists across 140 countries (Wellcome Trust 2019). In a 2020 analysis across six countries and 80,000 respondents, the Reuters Institute found scientists and doctors were the most trusted source of information on coronavirus – ranking higher than national and global health organisations, and well above governments and the media (Newman et al. 2020). However, these studies focused on *generalised* trust but did not

look at trust towards *specific* scientists. This nuance is important because people may trust science or scientists in general, but not science related to particular topics or scientists who represent them (Nadelson et al. 2014). For instance, though people in the UK generally claim to trust scientists, the level of trust towards government scientists regarding information on GM food has historically been low (Grove White et al. 1997). This suggests the extent to which someone trusts a particular expert on a specific topic is often related to whether that 'expert' appears to hold similar values and interests to them (Siegrist and Cvetkovich 2000).

This begs the question – have farmers had enough of traditional 'experts' like scientists? And if they have, which sources are farmers now using to collect information that they deem more trustworthy? These questions are especially pertinent when understanding uptake of sustainable soil management practices in the farming community (Rust, Ptak, et al. 2020) as soil degradation on farms is a global problem (Lal and Stewart 1990). However, uptake of more sustainable soil management practices has remained low (Alskaf et al. 2020; Lahmar 2010). Farmer motivations to implement more sustainable agricultural practices are complex and include agronomic, economic, environmental, political, psychological and social factors (Baumgart-Getz, Prokopy, and Floress 2012; Prager and Posthumus 2010; Ulrich-Schad et al. 2017). When determining a farmer's likelihood of adopting more sustainable management approaches and technologies, it is crucial that farmers have access to good quality information from sources perceived as trustworthy (Joffre et al. 2020).

Trust in information is also related to risk: it can be risky to change behaviour, especially if outcomes are uncertain, so acting on information where risks are high depends partly on the amount someone trusts the information (Millstone and Van Zwanenberg 2000). For farmers, changing their farm management carries a high risk to their livelihood, especially if the change is substantial or the payoff not instant, as is the case with conversion to no-till farming; here, farmers tend not to trust information that comes from people with limited farming experience (Mauro, mclachlan, and van Acker 2009; Rust, Ptak, et al. 2020).

Knowing which sources of soil information that farmers – and the people who advise them – use and trust, would be of great value for advocates of sustainable agriculture as this information can be used to understand who may be the best messengers for sharing information on sustainable agricultural practices. Historical studies highlighted the agricultural adviser as a valued, trusted and respected source of information and mediator of sustainable

agricultural practice adoption for farmers (Angell et al. 1997; Fearne 1991). However, as it has become more challenging for farmers to navigate through the complex and often messy network of pluralistic advisory services (Klerkx and Proctor 2013), farmers have increasingly turned to their farmer peers rather than traditional 'experts' such as agricultural advisers (Wood et al. 2014). The advent of the internet, coupled with a growth of digital content, presents an information-seeking challenge for farmers who must decide which sources of information on soil to use and trust. Whilst it has been noted that some farmers are now using the internet to learn about farm management in general (Defra 2019), it is not yet known whether they are also using online sources to learn specifically about new soil management practices. Similarly, with the rise in disinformation and fake news (Martens et al. 2018), we do not know how farmers are now validating information nor which sources of information encourage farmers to implement more sustainable soil management practices.

In this study, we address these research gaps using a case study of farmers in Hungary and the UK – two European countries experiencing growing levels of soil degradation (Environment Agency 2019; Szilassi et al. 2006). To better understand the journey that farmers as information seekers take when learning about and implementing new soil management approaches, this study was guided by the following research questions:

1. Which sources of soil information do farmers and those who advise farmers use and trust?
2. How is this information validated?
3. Who influences farmers to implement new soil management practices?

Method

We took an inductive, qualitative approach to this research using a case study design (Merriam 1998), allowing us to gain an in-depth understanding of the topic (O'Leary 2004). We drew upon persuasion theories and diffusion of innovations theory to situate our study conceptually. Persuasion theories posit that someone is more likely to change their behaviour if the beliefs that underpin their attitudes change (Petty et al. 1991). This process is affected by the information shared, its source and characteristics about the information receiver (Blackstock et al. 2010), as well as how this information conveys social norms (Cialdini et al. 2006). Persuasion theories stipulate that trusted sources are thought to be more effective vehicles of

change compared with untrusted sources (Petty et al. 1991). To complement this, the theory on diffusion of innovation posits that external and internal factors influence an individual's decision to innovate; external factors include characteristics about the innovation itself alongside 'change agents' (also known as influencers), plus the social network and communication channels (Rogers 2003).

We undertook semi-structured interviews during 2019 with UK farmers and advisers[2] and at the start of 2020 for Hungarian farmers and advisers. We chose these two case studies as contrasting European examples: the UK being a cooler climate with the country having just voted to leave the European Union (EU) and Hungary being a warm semi-continental climate joining the EU in 2004 having transitioned from communism. Their agricultural knowledge and innovation systems (AKIS) had historically been distinctly different, though have more recently become similarly pluralistic. In Hungary, due in part to the transition from communism to capitalism, state-run farms that had an important role in AKIS were replaced by fragmented public and private organisations (Nemes and High 2013). Hungary now has a complex advisory network, including free, partly subsidised and privatised AKIS institutions. Like Hungary, the AKIS network in the UK has become increasingly pluralistic over the last number of decades (Knierim et al. 2017), with paid-for advice primarily coming from advisors working for large agribusinesses or independent consultants, though some State-funded AKIS through focused programmes such as the Catchment-Based Approach to water management.

An interview guide was developed with input from the authors, informed by the literature and the theoretical concepts described above, and questions were trialled on a subset of the target populations. Following feedback from these pilots, questions were adapted to improve the clarity of question wording. The study obtained ethical approval by the Newcastle University Ethics Committee. All respondents were asked for their free, prior informed consent to take part in the research and accepted verbally. We used a purposeful sampling strategy to source respondents by targeting soil advisers via online agricultural databases, contacting regional farmer groups and attending agricultural meetings, supplemented by snowball sampling. Farmers in our sample included arable and mixed farmers located in south-western Hungary and across the UK. We did not sample livestock-only farmers as soil quality is a more significant issue on arable farms (Environment Agency 2019). A total of 43 farmers and 39 advisers were

[2] Whilst we recognise that, increasingly, there is overlap between these stakeholders (such as where some farmers are also advisers or have advanced degrees). However, due to limited space in this paper, we categorise stakeholders based on the group the respondent primarily categorised themselves

interviewed across the two countries (Table 1). Just over half (45/82) of the interviews took place over the phone, with the remainder taking place in person. All interviews were recorded with consent from the respondents and lasted on average 48 minutes (with a range of 24 – 106 minutes).

Table 5: Characteristics of interview respondents

Country	Profession	Gender
Hungary	Adviser: (11) Agribusiness (6) Farming association (1) Independent (2) University/college (2)	F (1), M (10)
	Farmer: (11) Arable (10) Mixed (1)	F (4), M (7)
UK	Adviser: (28) Agribusiness (6) Agricultural levy board (5) Environmental NGO (3) Farming association (2) Government (2) Independent (5) University/college (5)	F (13), M (15)
	Farmer: (32) Arable (13) Mixed (19)	F (5), M (27)

New respondents were sourced until theoretical saturation had been reached, where no new themes were emerging from the data (o'leary 2004). The recordings were transcribed (and first translated into English if they were conducted in Hungarian) then analysed in QSR nvivo® (QSR International, version 12). Coding was undertaken by the first author inductively using thematic analysis, which involved first reading the transcripts to get an overview of the interviews and then coding each interview based on common themes emerging from the data. The results are presented as summaries of the parent themes that emerged related to our research questions; anonymised quotes have been included where they provide examples of these themes.

Results

Which sources do farmers and advisers use to gather new information on soil management practices and which sources are trusted?

Farmers and advisers in Hungary and the UK used diverse sources to gain new information about soil, ranging from individuals (such as other farmers) to institutions (such as agricultural levy boards). Farmers generally used and placed most trust in other farmers when they wanted to learn about soil management, as one Hungarian arable farmer (HF07) put it:

> "*I discuss our experiences with my fellow farmers. We are in continuous contact; we keep in touch but if some problem occurs then we can just call each other like: "What did you do? How do you deal with it? What are you results? How big is the yield? What is the quality?". We can trust in each other's experiences because we are friends, so we do not want to cause trouble to each other, and we know how the others works; we see the result on each other farms with our eyes.*"

Respondents also frequently used digital technology to find information: for farmers, this was usually via social media and other online sources such as farming forums and the agricultural press; for advisers, this was primarily in online scientific journals. Most respondents thought the internet was a useful way to find out about new information on soil and gauge what other farmers felt about the topic, though advisers (particularly those from colleges/universities) did not find online farmer experiences shared on social media were credible as they believed anecdotal stories were not robust enough to be considered "evidence". Farmers, however, reported that they valued social media to learn directly from and connect with other farmers about agricultural practices and experiences much easier than they could in person. Both Hungarian and British farmers used social media as a source of agricultural information, though this practice tended to be more common in British farmers.

Whilst farmers and advisers regularly used the internet to gather soil information, many were somewhat cautious of fully trusting online sources, as one British mixed farmer (BF04) explained: "*Ultimately the internet is the biggest tool of useless information but also the biggest tool of useful information. It is just knowing what bit of information you are reading at the time*." Therefore, the internet was considered useful to gather information but that this

information needed to be taken "*with a pinch of salt*" - as numerous respondents mentioned - before it could be believed, trusted and acted upon.

Both advisers and farmers used the farming press to gather information on soil, with farmers placing more trust in this source than advisers. However, both farmers and advisers reported a degree of scepticism in the content of the farming press, believing the content to be somewhat swayed by the agribusinesses who pay for adverts in the magazines. National general press sources such as broadsheet newspapers were not trusted as sources of information on soil as these were deemed to have a different agenda to the agricultural sector.

Farmers and advisers alike mentioned that established agricultural levy/membership organisations were trusted sources of information about soil because respondents believed these organisations undertook reliable, robust science that was practical for on-farm use. Here, respondents trusted the research produced from these institutions as the institutions themselves were perceived as trustworthy and being on the side of the farmer. Respondents also felt these institutions were empathetic towards what farmers wanted and communicated in ways farmers understood. Farmers often mentioned partly why they trusted agricultural levy boards was because they were funded by the farming industry.

Whilst farmers trusted the research produced from these agricultural levy boards (though less than they trusted other farmers), they generally only trusted academic research institutions - such as agricultural colleges - that were known for longstanding work on agriculture conducted in collaboration with farmers. Researchers from other institutions, such as governments, non-agriculturally focused colleges and universities (hereafter denoted as "outsider scientists"), were not trusted by farmers, as these researchers were thought to have a conflicting agenda to farmers so did not have farmers' best interests at heart. In Hungary, this was partly due to the changing advisory landscape, as a university adviser explained (HA10):

> "*Unfortunately, the world has changed a lot. State-financing universities are no longer the case. Information is difficult to pass on. Farmers are less and less likely to believe in university research.*"

Therefore, the degree to which farmers trusted scientific outputs was dependent on the institutions producing them. Numerous farmers in Hungary and the UK were suspicious of the funding sources that outsider scientists relied on, assuming that many research projects were

part-funded by (what they deemed) untrustworthy and biased donors such as the agrochemical industry; this was one reason why most farmers placed little trust in advisers who worked for large agribusinesses.

The way in which outsider scientists obtained funding was seen to "*corrupt*" their results, as a British mixed farmer (BF27) proposed. Other farmers mentioned an additional reason for not using information from or trusting outsider scientists was because they could not access academic research, partly as it was often behind paywalls and partly because it was written in a way that farmers found hard to understand. Outsider scientists were also thought to work at different geographic scales to farmers, as the researchers often wanted large-scale generalisable studies whereas farmers wanted locally specific research applicable to their farm. This fed into the suspicion farmers had towards outsider scientists, as the knowledge produced by these researchers was not generally actionable on the farm and was communicated in ways farmers struggled to understand, suggesting a lack of empathy that outsider scientists conveyed towards farmers. The scalar difference was thought to affect the usefulness of scientists' advice, as reflected upon by a British agricultural college adviser (BA23):

> "*Farmers quite rightly trust other farmers and why would they trust the scientists, the scientist who only writes a paper? And why would they trust a scientist who doesn't turn up in their field and talk to them directly? Why would they read a paper and think 'I must try that out'?*"

HOW IS AGRICULTURAL INFORMATION VALIDATED?

Agricultural information on soil was often validated by respondents using a rough triangulation process, including collecting additional evidence (like repeated trials or studies done in different contexts) and getting verification from trusted sources, as this Hungarian agribusiness adviser (HA08) explained:

> *"I do not trust without any doubt, so I do cross analyses and if I find out that more papers state the same then I trust in the information provided."*

However, there was a difference in the sources and methods respondents chose to verify information. Advisers were more likely to look for perceived scientific robustness, as this Hungarian agribusiness adviser (HA01) described: *"I like university research. It is verified back statistically and biologically, confirmed results and a reliable source."* Conversely, farmers often

relied on other farmers to verify information, as a British farmer (BF01) explained: "*Farmers want to see other farmers doing it... It convinced you more when you actually see it and see what the benefits are, that is the crucial thing*". This verification process was used to overcome the challenges with information overload and misleading information, as a British agribusiness adviser (BA15) described:

> *"I built up a network of what I call stakeholders that I will go to and test in terms of their opinion on certain products or certain techniques and what their view is.*"

Scientific advisers rarely needed in-person verification and were content with trusting journal articles, especially those from purported reputable sources deemed to be those that had higher impact factors and written from authors they knew. For farmers, however, they needed tangible proof from a similar farming context, as a Hungarian farmer (HF01) explained:

> "*Show me a fellow farmer who tried that practice and it worked on his field. It is also important that it should be emphasised that it worked in the same kind of natural environment like my farm. It has produced results under similar circumstances than mine.*"

Farmers also tended to rely on sensory verification by seeing, touching, even smelling the soil to determine how a new management practice was affecting the soil. In effect, sensing was believing.

Who influenced farmers to implement innovative soil management practices?

Farmers interviewed in both Hungary and the UK frequently mentioned they were motivated to try new soil management practices for financial reasons, either to save money or due to government subsidies/fines. However, in instances where risks of changing practices and/or the investment costs were high, farmers were influenced to implement more sustainable soil practices by recommendations from trusted peers, primarily other farmers. Whilst farmers interviewed often preferred in-person proof, some did not necessarily need to have met trusted peers in person, as one British farmer (BF32) described when talking about why he decided to try more sustainable soil management practices:

> *"I am quite taken with trust in [two prominent agricultural advisers], what they are saying... Those people, what they are saying is correct and it is not going to cost you a lot to try what they are doing, to compost or to improve your soil, they are not multi-nationals so they are not trying to sell you anything."*

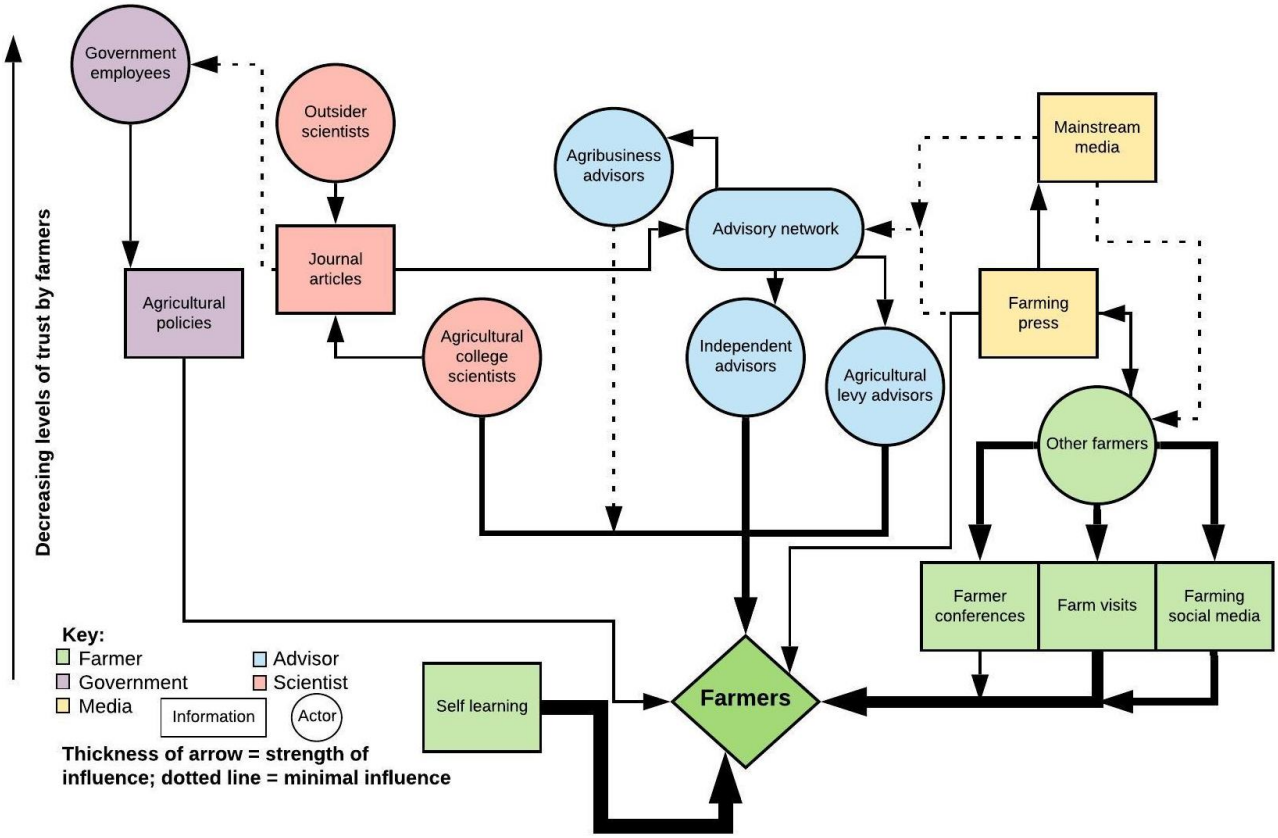
This farmer explained the reason why he trusted these individuals was because he felt they understood farmers and provided useful advice, again conveying the importance of empathy that information providers offered to information receivers. This farmer mentioned he had learnt of these people from the internet and consumed their digital content to find out more about soil. A few other farmers (both in Hungary and the UK) also said they got inspiration to try a new soil management practice by social media posts from farmers they followed online. However, for the majority of farmers, it was not just one person or piece of information that prompted them to change, but a process of building up knowledge from various sources before acting, as a Hungarian farmer (HF04) recalled her reasons for trying composting: "*I have heard about it from my mother-in-law first, then I started to look at it on the internet*".

Whilst the internet was a useful resource for most farmers to learn about soil (including in the verification process), it was not usually the main factor influencing farmers to change their practices. Many farmers interviewed were motivated based on seeing farms be successful with the practice. Whilst some British farmers interviewed did, to some degree, trust the advice from their agricultural advisers, information from other farmers had a stronger influence and tended to be preferred and acted upon more than information from advisers, as one Hungarian agribusiness adviser (HA08) noted:

> "*In Hungary, professional advisers do not count so much for the farmers. In many cases, if the neighbour starts spraying the chemical, so will he.*"

This suggests that, ultimately, social influences affecting uptake were strong, and it was mostly other farmers who prompted farmers to make changes to their soil management. A summary of the sources used and trusted, as well as who influenced farmers to implement new soil management practices is shown in Fig 1.

Fig 5. A conceptual map of the information sources used and trusted by Hungarian and UK farmer respondents, as well as who influenced these farmers to implement a new soil management practice



Discussion

Trust is a critical, but little-understood factor influencing farmer decision-making around the adoption of sustainable farming innovations (Rust, Ptak, et al. 2020). Agricultural information sources are changing over time, and as more and more information is available online, our study has found the farmers we interviewed were frequent consumers of online content, building trust in some information through online social networks. Compared with earlier studies (Chowdhury and Odame 2013; Kaushik et al. 2018), we found farmers and adviser respondents in Hungary and the UK frequently used digital channels to seek information on soil as it was freely accessible and useful, with farmers using agricultural social media sites and advisers using online journals. Whilst most advisers in this study were skeptical of the soil management claims on social media sites, farmers were more willing to consume social media content from respected farmer "influencers" (or what Rogers (2003) deemed "change agents"). Influencers share endorsed opinions on social media platforms, which help spread viral conversations and set norms about behaviours and practices (Kay, Mulcahy, and Parkinson 2020). These farmer influencers also provide tangible evidence of the benefits of new

management practices and technologies on farm, reducing the perceived risks associated with change (mckitterick, Quinn, and Tregear 2019).

For proponents of sustainable soil management practices, it may be useful to determine who farmer influencers are and work with them to showcase soil innovations to their community. Social media users as information seekers perceive influencers as trusted and experienced voices of authority on specific topics, so these influencers are useful messengers to share information (Seo, Primovic, and Jin 2019). Working with known and trusted third parties, such as these online influencers, early on and throughout the knowledge exchange process could help promoters of sustainable soil management practices share information more effectively with farmers (Breetz et al. 2005; Hansen 2002), which we suggest may result in greater uptake. An influencer with a farming background is likely to be more effective at influencing other farmers (Rust, Ptak, et al. 2020), as trust is partly based on the experience and occupation of the person sharing information (Blackstock et al. 2010). Social network analysis can help to identify the important influencers within a network (del Fresno García et al. 2016) and understand why they appear to be a credible source (Lewandowsky et al. 2012); conducting this for online farmer communities of practice would be useful to help pinpoint the most promising influencers who are already trusted in farmer networks.

Recently, some farmers have been rising in popularity - sometimes now being referred to as “rock stars” (Phillipov and Goodman 2017). Whilst Phillipov and Goodman (2017) suggested many of these “rock star” farmers appeal almost exclusively to non-farming public audiences, our study found there has also been a growth in farmer social media influencers appealing to farming audiences. These close-knit social networks may enhance exchange of soil knowledge and uptake of innovations through growth of in-group social capital (Rust, Ptak, et al. 2020). However, there are risks with only interacting with people who share similar views and beliefs through curating your own social media bubble (Colleoni, Rozza, and Arvidsson 2014). These risks include susceptibility to confirmation bias (Nickerson 1998) and content bias (Tian and Chao 2012), through seeking information that matches pre-existing beliefs (Colleoni et al. 2014). Such an approach could exacerbate lack of trust between “insiders” and perceived “outsiders”, even when the information of “outsiders” could provide additional benefits to farmers. Using trusted, perceived similar intermediaries may help to expand knowledge exchange beyond social media bubbles, building more bridging social capital to increase the chance of innovation (Rust, Ptak, et al. 2020).

Unlike findings from some of the more historic agricultural research (e.g. Eldon 1988; Fearne 1991), we found that it was not necessarily the traditional “expert” advisers that farmers preferred to go to when they want to learn about soil – instead, they often chose to learn from other farmers. That farmers are now turning to their peers for advice and support has also

been observed in more recent studies on this topic (Joffre et al. 2020; mckitterick et al. 2019) as it is believed other farmers do not have a conflicting agenda, and instead have applied, practical experience most relevant to the innovating farmer (Inman et al. 2018). This suggests a change in the main source of agricultural information over time - from advisor-to-farmer into farmer-to-farmer - as farmers believe that information shared from their own profession is more useful than from others, especially where this information has already demonstrated value and benefits to other farmers in their peers' network. In effect, farmers see themselves as the experts (Palmer, Fozdar, and Sully 2009). That farmers in our study were more trusting of other farmers and more likely to change their soil management based on farmers' recommendations supports the persuasion theories, indicating that social learning through trusted, similar peers - such as other farmers - is important for farmers to be persuaded to act on that information. Our findings are also in line with the Diffusion of Innovation theory (Rogers, 2003) whereby farmers raise their own awareness of soil issues via their social network, which leads to evaluation (i.e. Verification) and then on to trials.

Farmers in our study often trusted agricultural levy boards and researchers at agricultural colleges due to their longstanding relationship with farmers, which allowed these institutions to build up credibility over time (Sutherland et al. 2013). This is consistent with other trust studies (Idrissou et al. 2013; Lewicki, Tomlinson, and Gillespie 2006) where farmers were influenced by perceived expertise and trustworthiness of information sources, based on longstanding relationships and a common history when assessing information on new farming practices, again reflecting persuasion theories. This suggests that intermediaries sharing information - such as advisers - are more trusted than researchers who produce the knowledge. Farmers interviewed here also thought that it was important for the information provider to have the farmers' best interests at heart - a factor shown to increase trust (Head 2012). Farmers here believed that levy boards had this empathetic trait as these institutions were paid for by farmers and were thought to have shared values. Empathy and social similarity towards the farmer were therefore key in building trust (Neef and Neubert 2011); aspects "outsider" scientists were perceived to be lacking (Healy 1999). However, what is 'farmer's best' interests can be contested. Farmers and scientists may have a slightly different opinion about what best interests is (e.g. around best possible income). But what is certain is that in the long run the best interests is sustainable farming; and in the short term, choosing options that is remunerative, as well as sustainable and towards which concerted efforts is required from all concerned.

When it came to distrusted sources, farmers here did not trust "outsider scientists" (such as those not from agricultural levy boards or agricultural colleges). Fabricated media stories - such as biased research produced by research institutions partnering with agrichemical industries (Blakemore 2018) - can undermine farmers' perceptions of the research community (Stroud

2018). Along with a perceived lack of empathy, another reason why farmers in our study did not trust outsider scientists was due to the way in which the information was communicated. Recommendations from researchers can be dismissed by farmers if the advice provided is too technical to understand (Halabi and Carroll 2015); this can reduce trust in that information (de Vries et al. 2015). For information to be more readily trusted and used, it needs to be communicated in ways information seekers can understand, relate to and easily apply (mckitterick et al. 2019). Building farmers' trust in scientific recommendations for sustainable soil management technologies may, in addition to using a trusted, perceived similar third party, require careful translation of academese into communication styles more applicable for different farmer groups (Clark and Murdoch 1997).

Another reason for the distrust by farmers towards scientists was reportedly because scientists had different goals to farmers: outsider scientists were thought to want journal article publications and research funding rather than create direct benefits for farmers. In effect, there was a perceived lack of homophily between farmers and outsider scientists, supporting the Diffusion of Innovation theory. While farmers may perceive outsider scientists as possessing expertise, they were not trusted as their motivations were not aligned to those of the farmers. Prior research shows that farmers can find scientists arrogant, as they fail to understand there is more than one way of knowing and thinking about the world, alienating farmers from scientists (Palmer et al. 2009), leading to farmers thinking that scientists are out of touch with reality (Wynne 2006). British farmers interviewed noted that it was hard to build a trusted relationship with government scientists and advisers as there is a high staff turnover, which can result in personal relationships being difficult to build (mckitterick et al. 2019). The lack of trust in government and outsider scientists suggests that institutional trust trumps interpersonal trust in some instances: where a farmer does not trust an institution, they will not trust the information that emanates from that institution (mckitterick et al. 2019). It is important to recognise differences of opinion on what should be the goal is also important. E.g. the first goal of the farmer is probably to make a living, while the main goal of scientists may be to make farming more sustainable (or reduce environmental impact, or increase carbon sequestration, or reduce emissions, or limit climate impacts amongst others. Therefore, it may require a prolonged positive interaction with an empathetic person from that institution for farmers to trust employees from an untrusted institution.

In our study, farmers and advisers verified information in different ways: advisers were more likely to use scientific sources to check information, whereas farmers would go by "gut feeling" or verification by seeing the practice/product in action on someone else's farm. Farmers prefer to learn by doing (known as kinesthetics) or through their senses (Franz et al. 2010; Wood et al. 2014). This different process of verification may, in part, be due to advisers needing generalisable findings to help with their range of clients, whereas farmers only need to know

if it will work on their farm, so prefer local knowledge and evidence of proof shared by trusted peers in their farm network (mckitterick et al. 2019). This finding could also suggest that, as in non-agricultural studies on trust (Hardwig 1991; Sinatra and Nadelson 2012), farmers and researchers may also see the world in different ways, having different epistemologies for what knowledge is and how it is produced and verified. As farmers and researchers perceive soil problems and solutions differently (Rust, Lunder, et al. 2020), the different epistemologies used by these stakeholders could contribute to farmers being less trusting of researchers and indeed researchers less trusting of farmers (Ramisch 2014). This emphasises the different types of knowledge realms that farmers and researchers work in, with the former often relying more on tacit knowledge and the latter on scientific knowledge (Lyon 1996). This has deep implications for how knowledge exchange and collaborative projects are undertaken between researchers and farmers and underlines the importance of intermediaries and knowledge brokers.

Conclusion

We have found that as more farmers get online, they are building digital relationships with other farmers to form communities of practice. Farmers from Hungary and the UK were found to be using farming social media as a key source of agricultural information and some were motivated to change their farming practices based on information received from digital farmer influencers and validated by their peers. Proponents of sustainable soil management can funnel information through identified online influencers who can help increase legitimacy of the information, build trust between providers and stakeholders, and build bridging social capital to encourage innovation. But it is also important to recognise that the influencer in all likelihood may also funnel information s/he trusts her/himself. As more businesses become digital-first, the power of the internet - including social media - is likely to continue to grow, shaping our lives in ways previously unimaginable. Whilst our study found social media to play a more minor role in influencing the majority of farmers interviewed to change their farming practices, it is possible that, over time, its influence may grow, and farmers may find new experts upon which to rely.

This research also found that trust in people, institutions and information often influences farmers' implementation of new soil management practices, where farmers primarily rely on close peers as trusted sources and verifiers of soil information. We found farmers from Hungary and the UK felt there was a cultural distance between farmers and certain types of "experts", such as the "outsider scientists" from governments and non-agricultural academic institutions, meaning advice from these sources was often not used, trusted or acted upon. We suggest that some farmers may indeed have "had enough of [some] experts", instead now

relying more their own peer networks to learn and innovate. The direct influence of certain "outsider experts" on farmers is minimal and their indirect influence is highly mediated by a pluralistic, messy, ever-changing and complex advisory network. Despite moving away from traditional 'experts' and a growing reliance on farmer-farmer knowledge exchange networks, there may be a more important role for trusted intermediaries than ever before. These knowledge brokers can enhance the exchange of ideas between groups, who might not naturally gain trust directly via homogenous in-groups. This may be particularly important to enable farmers and researchers to learn about innovations arising from each other's work.

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5. GENDER, PERCEPTION AND REPRESENTATION IN SUSTAINABLE AGRICULTURE

5A. Gender analysis of sustainable soil practices in "Farmers Weekly" magazine of the UK

Introduction

Despite the fact that women have made significant contributions to agricultural production, including agricultural sustainability throughout history; policymakers, extension workers, and scientists have often undervalued farm women's contribution (Boserup, 1970; Whatmore, Chiappe and Butler, 1998). Leading scholars suggest that "gender analysis remains on the margins of the sociology of agriculture" (Allen and Sachs 2007:4) despite studies showing more than three fourths of the women involved in farming are likely to engage in sustainable farming practices (Trauger,2004; Sachs et al. 2016). Farming continues to be seen as a masculine enterprise but this gendered space in increasingly being questioned and critiqued around questions of land, inheritance, policy-making, gender relations and power (Whatmore, 1991; Shortall, 1990; 2020). However, the agrarian structure is witnessing a change. For instance, according to the Office of National Statistics, in 2018 about 17% of farmers were women, up from 7% in 2007-2008[3]. Female students now outnumber men almost 2:1 on agriculture and related higher education courses, making up 64% of the 2017-18 cohort, according to the Higher Education Statistics Agency. Meanwhile, some 44% of agriculture, horticulture and animal care apprentices have been women in 2017-18 - up from 39% in 2014-2015, according to data from the Department for Environment, Food and Rural Affairs (DEFRA). Also, estimates suggests that the number of women who lease or rent land for farming and allied activities have increased in the last couple of years. These positive developments are appreciable; but it is critical to examine the representations of the countryside and how it is created, circulated and consumed, and its possible influence on material actions (Fish & Phillips, 1997). Media products (magazines, newspaper articles, social media) are understood as partial and value-laden, composed within distinctive contexts by journalists and farmers following particular conventions, ideologies, and editorial policies (Morris and Evans 2010). In short, the media 'operate to promote certain views of the world that favour existing social relationships,

[3] See Holly O'Neill, Tim Lewis and Sirin Kale 'We're stewards of our land': the rise of female farmers. The Guardian. Sun 16 Aug 2020 Accessed on 4th May 2021

preferences and gender identities, which may not necessarily be reflective and representative of the views and experiences of different categories of farmers (Burgess, 1990). Gender and media studies in different fields including agriculture has analysed and discussed the relational aspects of the representation of women and men within the main sections of agricultural papers and magazines (Walter & Wilson, 1996; Brandth, 1995; Liepins, 1996). A common conclusion from most of these studies has been that on the technical dimension of production or policy developments it is heavily dominated by men. Walter & Wilson's (1996, p. 227) research on 'farming success stories' in the North American agricultural press has revealed that women tend to be neglected in these accounts, creating and perpetuating a 'domestic ideology' in agriculture which constructs 'men as farmers and women as nurturer, mother, wife, helpmate and homemaker'. This view is also supported in Australia and New Zealand (Liepins, 1996, 2000; Pini, 2005), in the UK (Morris and Evans 2001) and Europe (Brandth, 1994; Brandth & Haugen, 2007; Baylina and Gunnerud, 2010).

In this analysis, an attempt is made to understand how the most circulated farmers' magazine, the 'Farmers Weekly, UK' engage or do not engage with the question of gender. Thus, the analysis primarily focuses on two questions. First, how sustainable farming and sustainable soil practices are discussed in the farmers weekly? Second, whether and how women are represented in those discussions. If yes, what are the typical roles do they perform? The chapter concludes with a discussion of findings and their implications for the (re)production of gender identities and inequities in British agriculture; which perhaps can be paid attention to, so that more women can be encouraged for greater and effective participation towards sustainable agriculture, and in particular soil management practices.

Method

A mix of hard copies of the Farmer's Weekly Magazine as well as the soft copies was accessed during the period December 2020 to June 2019. From each month, randomly one copy was selected for analysis. So in total, 18 copies were thoroughly scanned for the 18 months. The magazine has many dedicated sections such as 'News', 'Business', 'Livestock', 'Machinery', 'Arable', and 'Land and Farms' and the sections which were specially paid attention to was the 'Arable section' and 'Farmer Focus' within the Arable section. In addition, events related to sustainable soil management and practice was examined, more particularly the 'Soil in Practice' conference. The analysis were both qualitative and quantitative (descriptive statistics) in nature.

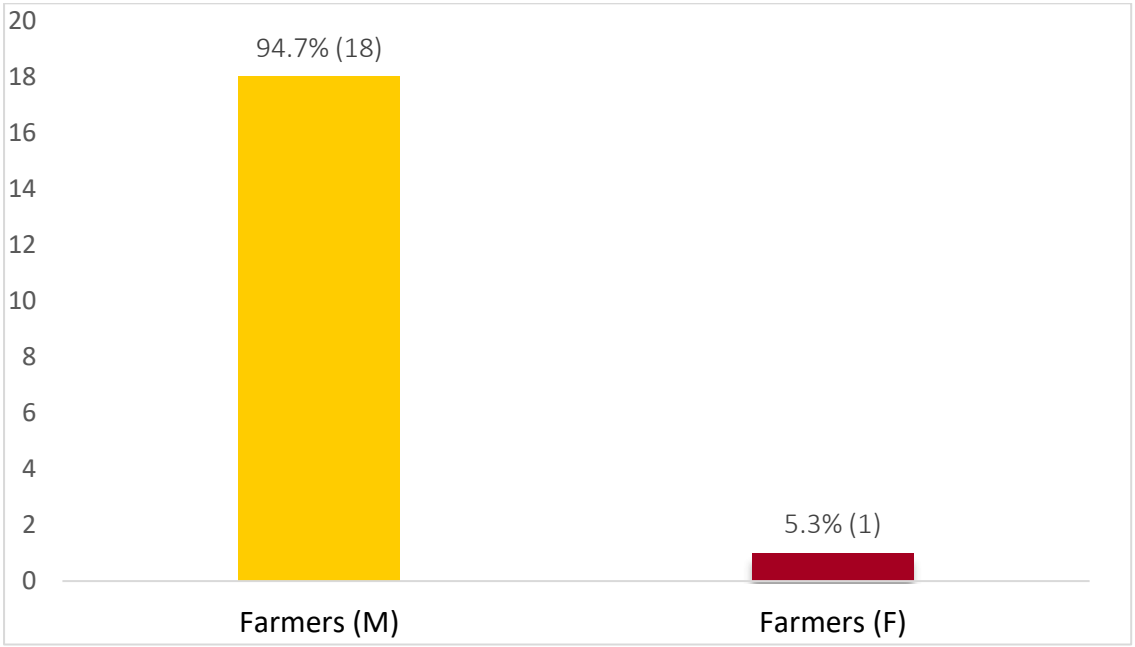
Results

The Arable section of the magazine presents leading concerns, issues, and innovations associated with arable farming in the UK. Articles discuss recent policy changes in the sector and how farmers can meet and deal with the challenges of producing crops efficiently and profitably in a rapidly changing policy and business environment (e.g. concept of carbon code).

FARMER FOCUS

'Farmer Focus' is a dedicated section within the Arables where about two-three farmers each week contribute not more than 500 worded articles. These farmers essentially share their experiences of growing a range of crops from wheat, rapeseed to maize, dealing with machinery, seeds, soil, pest and water management issues. All articles are highly informative, written in easy-to-read and understand format. The different stories each week, from across different geographies highlight the dynamic policy and physical environment in which farmers operate and how they keep themselves updated, experiment and innovate based on their specific circumstances.

Fig 6: Gender-wise break-up of the farmer representation in the 'Farmer Focus' section (n=19)



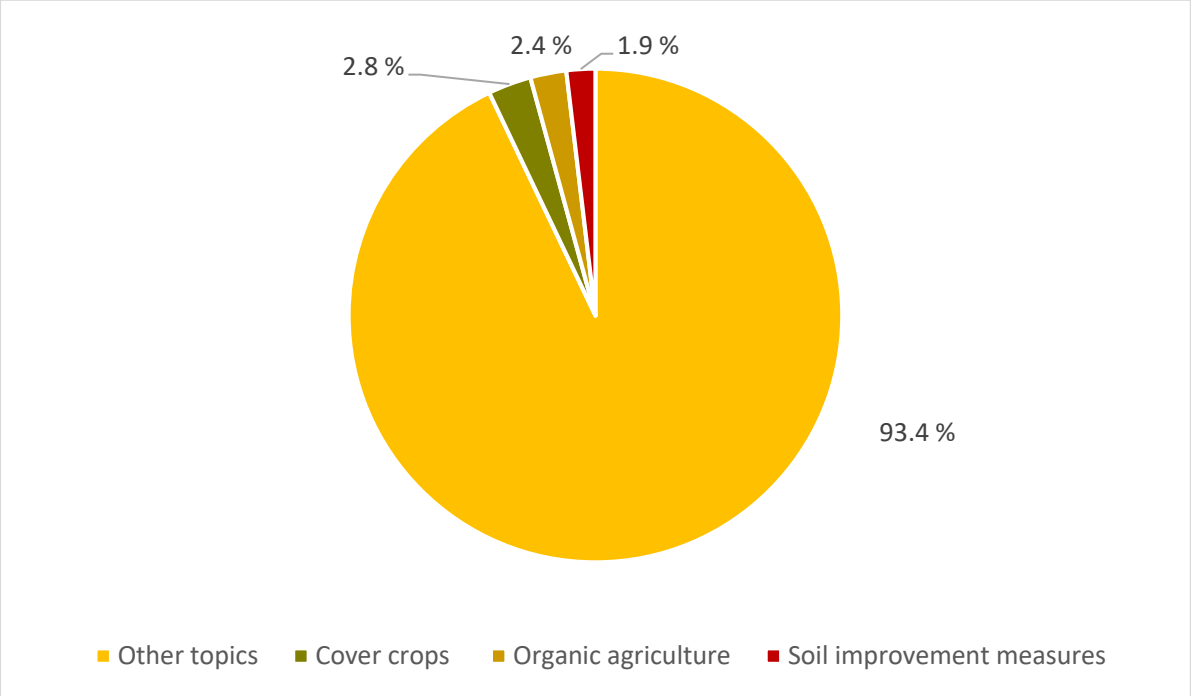
As is evident from Fig. 6 approximately 95% representation (n= 19) in the 'Farm Focus' section is of male farmers. The female farmer representation was by only one farmer. Though Minette

Batters, the first female president of the National Farmers Union (NFU) by featuring in almost all the issues of Farmers Weekly compensates for this lack of gender representation.

As far as the geographical areas are concerned, there is a general representation of farmers from across geography in the UK (England- Cambridgeshire, Norfolk, Suffolk, North York Moors, Hampshire, Canterbury, Cornwall, Wiltshire, Berwickshire, Leicestershire, Herefordshire; Northern Ireland – Downpatrick, Belfast; Scotland - Aberdeenshire). There is occasional international guest representation from countries such as Australia and South Africa. On an average each farmer contributed 11 articles in the 18 months period. From one article submission by a farmer to 17 (North York Moors) article submissions by another farmer. Most farmers, nine of them in total contributed about 13 (4) and 14 (5) articles in this time period. Even the lone woman farmer contributed 13 articles in this period. There was only one farmer (male) from Suffolk who raised the issue of the masculine nature of arable farming and the need to break the male monoculture. This person's article featured in the middle of the 18 month period of analysis, none before or after him raised this issues including the women farmer, suggesting the strong internalisation of the *status quo* as arables being a highly gendered space.

Now in terms of the topics that were covered by these farmers in this section, less than 6 % of the topics covered (see fig 7) were on soil improving practices (e.g. cover crops, organic agriculture, subsoiling).

Fig 7: *Farmer focus* and topics covered in Farmer's Weekly

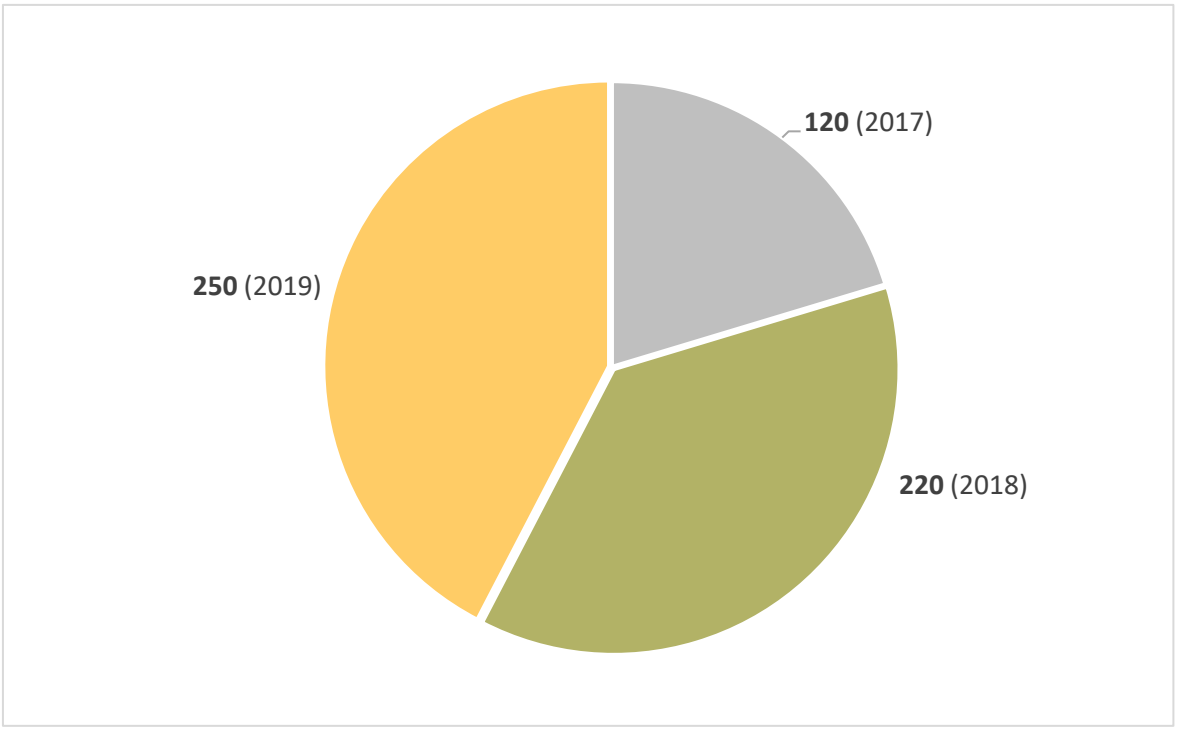


Most of the issues dealt with 'other topics' were around standard farming issues about crops, weeds, soil compaction, and pest, nutrients and flood management.

'SOILS IN PRACTICE'

Since the last four years (2017 onwards), *Farmer's Weekly* magazine with the help of different partnering institutions and sponsors has been hosting the annual 'Soils in Practice conferences. This event is seen as an opportunity to bring together top researchers, industry experts and farmers to discuss the biggest challenges around the topic of soil science across the UK and how soil health can be ensured through an integrated approach. The conference includes exhibition, panel discussions, networking breaks and practical in-field demonstrations. The conference is usually broken into three parts; the first, the *Policy section* focuses on key *policy debates* related to sustainable soil management; the second part is more of a *Research/theoretical session* where recent research on soil science especially with respect to assessment, measurement and monitoring of the soil carbon, biodiversity and nutrients are shared and discussed; and finally, the most popular session is the *practical session* where researchers and industry experts through an interactive and often field-based demonstrations engage on the more practical aspects of soil improvement measures.

Fig 8 '*Soils in Practice*' conference - Total number of participants (2017-2019)



The broad range of topics discussed in the conference include topics on measuring soil components, nutrient management and pest mitigation, cover crops, organic matter utilisation and the likely implications of incoming legislations on soil health and expectations from farmers. As is evident from Fig.8 there has been an increasing trend in the number of participants since its inception in 2017.

The gender break-up of the participants in these three years is not available. But two areas which serves as a proxy for gender representation are a) the conference photographs and b) the workshop agenda. From the conference photographs it seems approximately one-third of the total participants are women. In terms of the capacity in which these women conference attendants participate and engage are as agricultural graduates, researchers, scientists, industry experts and as policy makers. This becomes evident when we examine the different speakers in these conferences. For instance, in 2019 two conferences were held; one in the South (Duxford, Cambridgeshire) and the second one in the North (Coldstream, Scotland) with the aim of capturing the different soil realities of these geographies. In both the conferences, there were 17 speakers, with seven women speakers (approx. 41%) in each of the conferences, and with representation in each of the three segments (policy, research and practical sessions). But the session in which there were more women presence was the research/theoretical session where recent research on sustainable soil from scientists and researchers were shared. Some of the broad topics covered by these women researchers include: organic matter content

and its impact on soil nutrition strategies, bugs and invertebrates as indicators of soil health, measurement of soil carbon emissions, and application of soil management research into practice amongst others. It in pertinent to point at this stage is that the representation of women in these farming events (conferences and seminars) are much different as compared to their total representation in different sections in this magazines such as 'Farm focus' (5%).

5B. Perception of public about the role of women in sustainable farming practices in the UK and Spain

The common perception of farming is that it is a masculine enterprise with very little space for women farmers. Though feminist enquiry on gender and agriculture and social relations of production has challenged this view on the grounds that masculine nature of farming is a result of social construction of gender (Whatmore, 1991, Shortall 2008), patriarchal inheritance patterns and laws (Riley, 2009) and men and women essentially performing their masculinity and femininity in the countryside farm and that is the reason why the agrarian structure and the policy-making is the way it is (Little, 2002). However, gender roles and responsibilities and spatial practices are not fixed and is changing and there is an increasing interest from young women to consider farming as a space of work and employment. For instance, a 2014 survey by Farmers Weekly showed that 59% of women felt that agriculture was at least as good as other industries in equal opportunities for women. Similarly, in the popular TV show Farmer Apprentice[4], which aims to provide young people (18-24 years) a foot onto the farming ladder there is an increasing number of women participants. 12 out 23 entrants for the 2020 Farmer Apprentice Boot camp were women. Also, 6 out of the 10 finalists were women. It is pertinent to bring in the point about the general inclination of women to consider sustainable farming practices in the small farming plots they are able to rent, lease or own (Trauger, 2004; Sachs et al 2016). These background information is important for us to link and reflect with the small study which was undertaken to understand the general perception of the public regarding women and sustainable farming practices in the UK and Spain. The key idea was how to situate the findings from this research to contribute to the debate about 'public money for public good' and the potential role of women in advancing the mandate of sustainable, soil improving practices in the UK and Europe.

[4] For more details, https://www.fwi.co.uk/ms/events/farmersapprentice/

Method

Online surveys with the help of independent research agency were administered to 1000 respondents in the UK and Spain in order to understand the general perception of the public on different facets of women in sustainable farming practices. The response rate was quite high, with 968/1000 response in the UK context and 929/1000 in the case of Spain. Different questions were administered which sought to understand why and how women can and cannot play effective role in sustainable farming practices and what measures could potentially enhance their participation effectively. The options comprised of the following five options: 'strongly agree', 'agree', 'neutral', 'disagree' and 'strongly disagree'. Similarly there were other questions which had to be ranked based on how important or less important a particular intervention was from the perspective of effective participation

From Fig. 9 and Fig 10 what becomes evident is the distribution of perception is more or less the same between both the countries. In both the countries, respondents thought women play and active role in sustainable farming practices and that they should be encouraged through policy mechanisms in small-scale farming.

Figure 9. Distributions of UK respondents' views on women's role in agriculture (n=968)

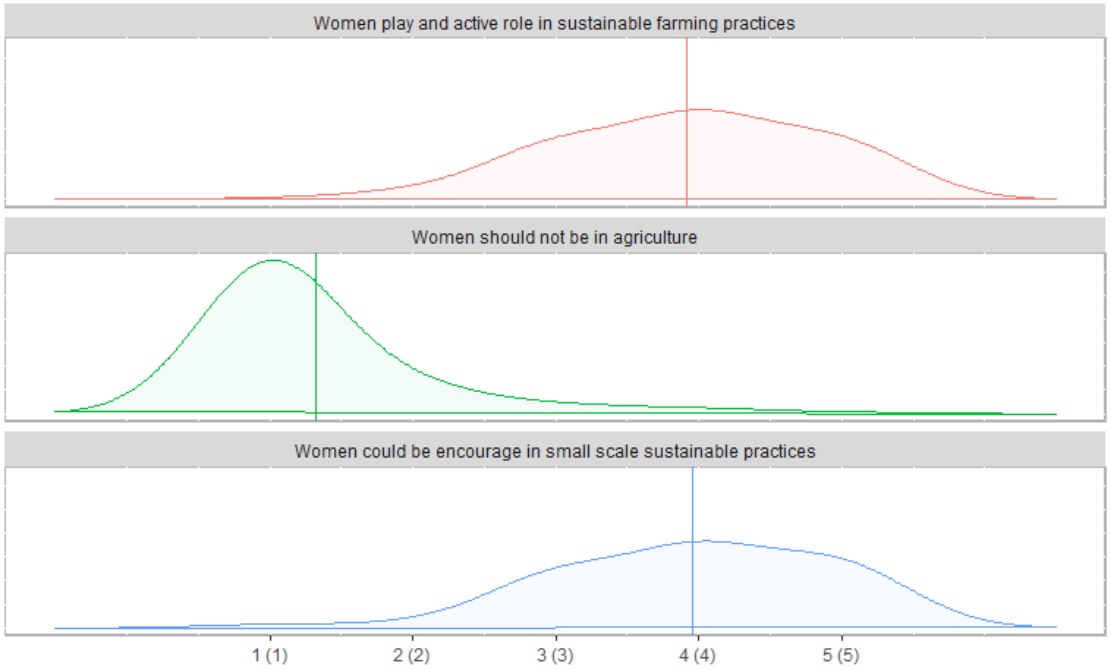
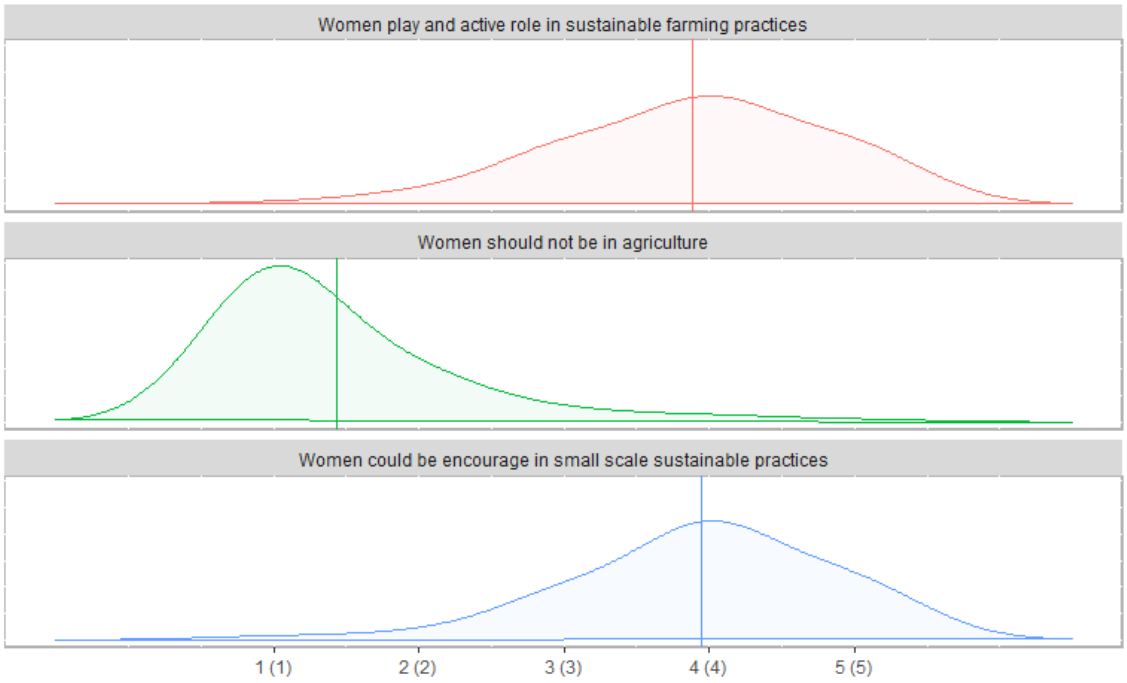


Figure 10. Distributions of Spanish respondents' views on women's role in agriculture (n=929)



Respondents were also asked what in their opinion limited active participation of women in farming, as evident in Fig 3 and Fig 4 is the general perception farming being a male occupation. Since it was a close ended question it is not clear whether the perception emerged from the predominant notion that farming is a physical labour demanding occupation and hence women are not suited that much, or indirectly indicating the structural reasons (social norms of masculinity and femininity, inheritance patterns) that limit their participation. And that no matter how much and how well a woman engages in farming, her identity as a farmer is still far from being acceptable.

Figure 11. UK respondents views on factors limiting women's effective participation in sustainable farming practices (n=968)

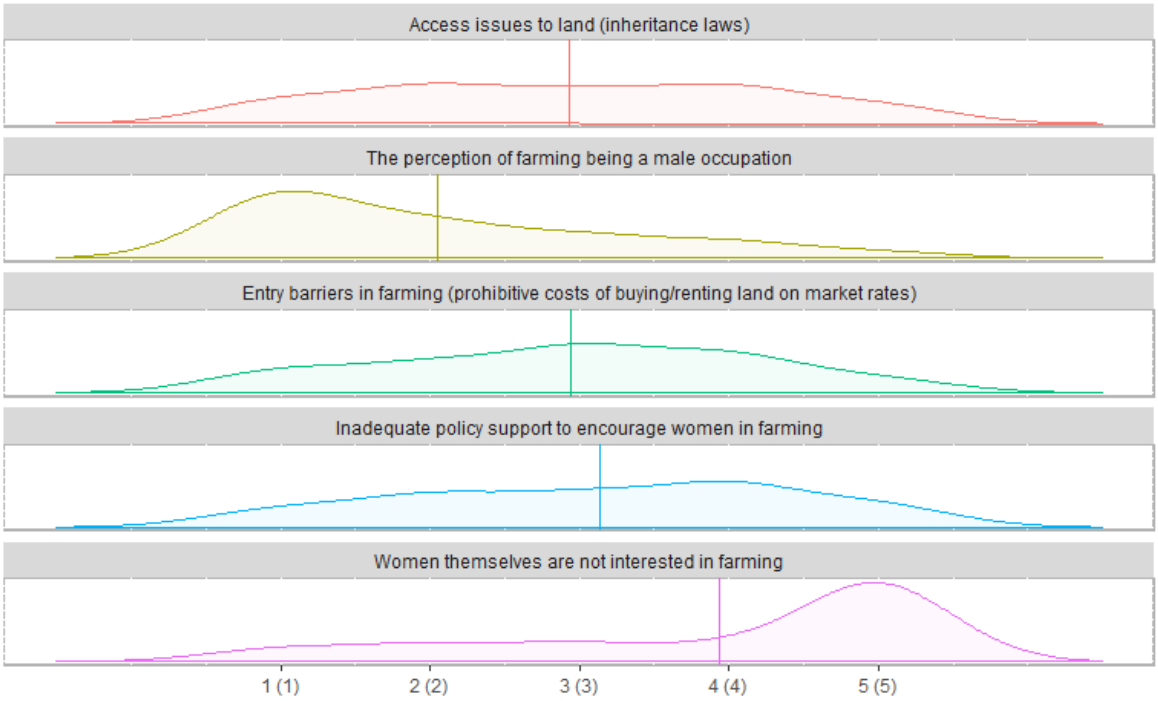
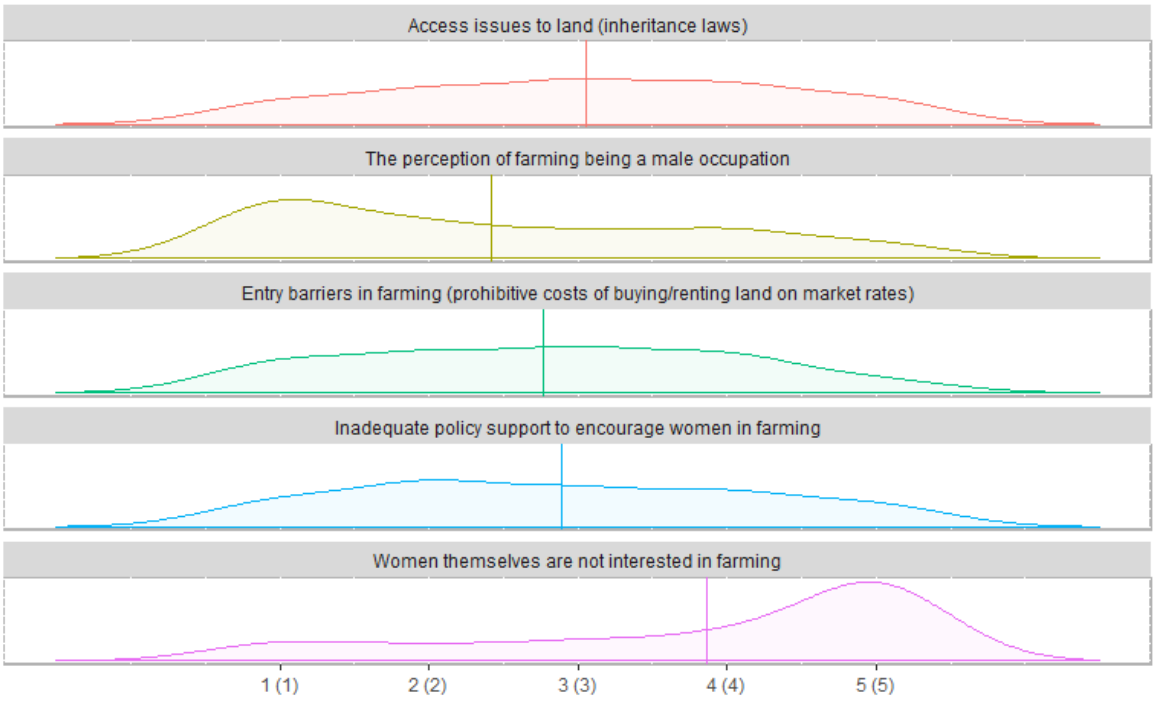


Figure 12. Spanish respondents views on factors limiting women's effective participation in sustainable farming practices (n=929)



Shortall (2014) demonstrates why despite all the progress in the past four decades and change in the labour market presence of women in farming; farm women's gender identity has not changed significantly. Part of the reason the author argues is the continued dominance of the male bread winner's role and how through everyday interaction and public representation of women and men and undervaluing of women's work, the existing work identities (women as farm wives, and in a supportive, instead of active role) gets reinforced, maintained and sustained. The positive aspect, however, which is also evident in this survey finding is that there is a strong consensus on the idea it is not likely that women themselves do not want to engage in farming. This conservative idea is increasingly being rejected, also evident with the growing interest of women in farming (e.g. UK 2020 Farmer Apprentice TV reality show; 'Soils in Practice' conference).

Even a gender-wise break up of respondents as in both men and women respondents in the UK (M - 454 and F- 501) and Spain (M– 450 and F – 474) is of the view that women can play an integral role in sustainable farming practices and that policy measures should encourage their greater participation.

UK respondents

Figure 13. UK male respondents' views on women's role in agriculture (n=454)

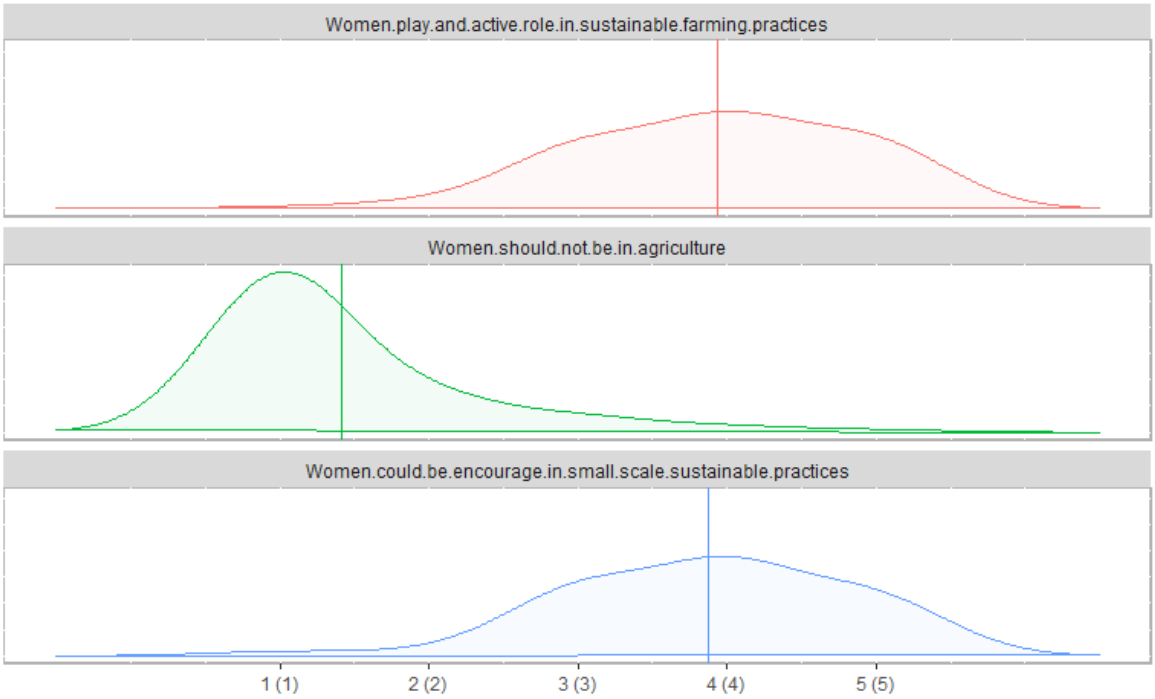
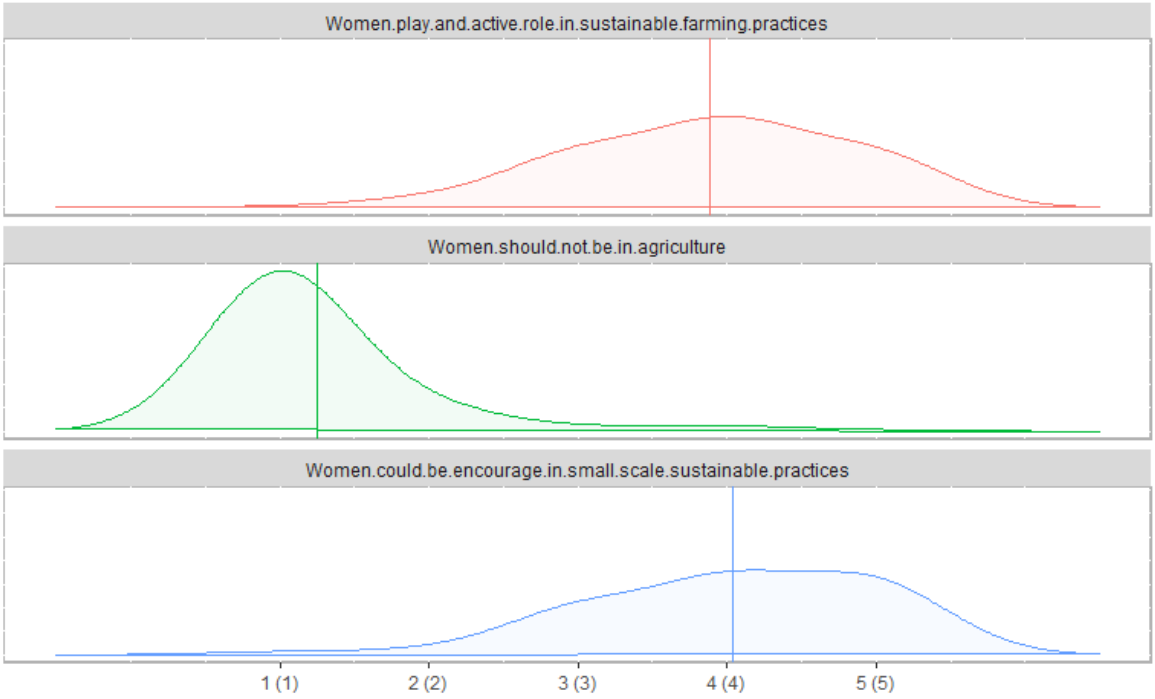


Figure 14. UK female respondents' views on women's role in agriculture (n=501)



Spain respondents

Figure 15. Spanish male respondents' views on women's role in agriculture (n=450)

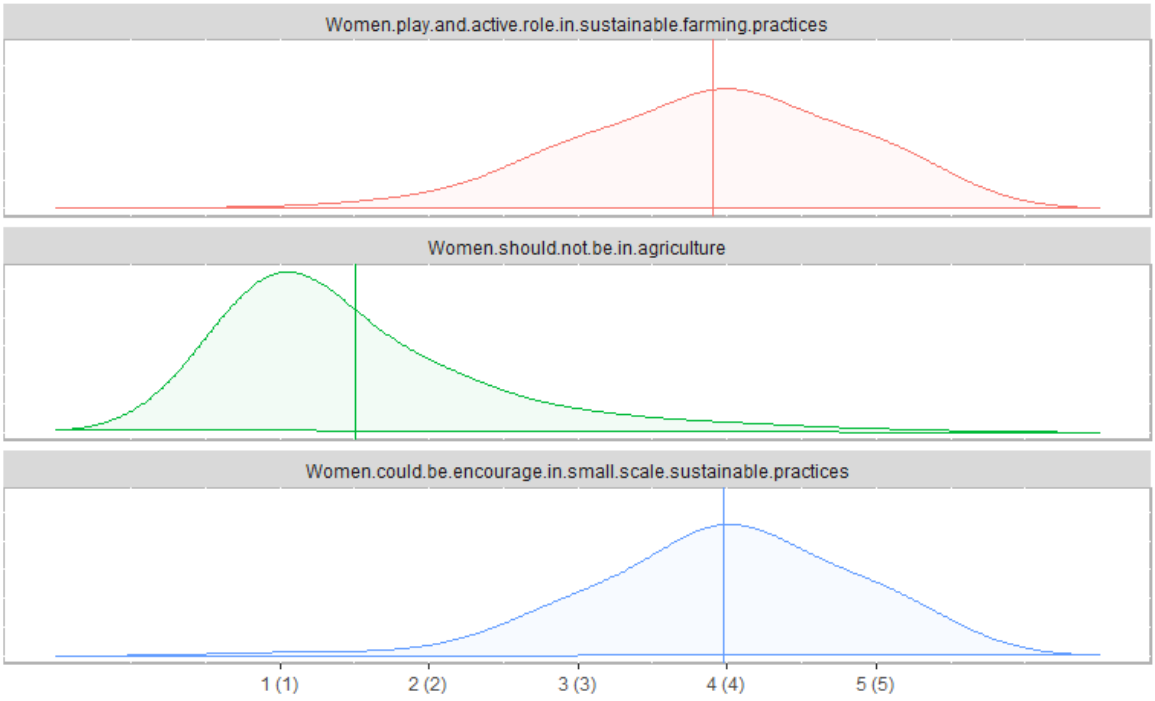
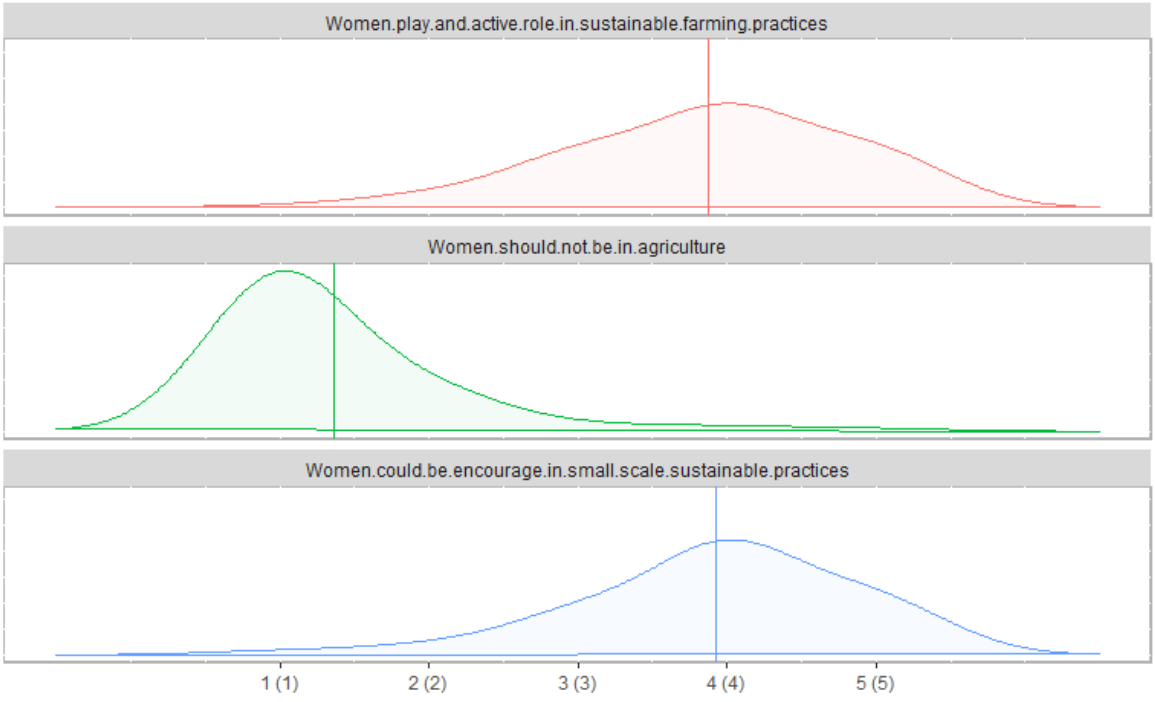


Figure 16. Spanish female respondents' views on women's role in agriculture (n=474)



Why despite the difference in agrarian structure and land holding patterns the responses towards women and sustainable farming practices is more or less the same in both these countries? This definitely requires a more in-depth investigation and outside the scope of this small research, but on a cursory level one could argue that the general public is conscious of the value of sustainable farming practices for both future food and farming security and sustainability.

Discussion

There is a continued skewness in terms of gender representation in British agriculture, despite the growing interest in British farming by women. Younger women are consciously opting in to be a part of the farming sector. From the 'Soils in Practice' conference, it is evident that there exists lot of skills and talent amongst young women who are interested in sustainable farming practices. However, 'Farmer Focus' column also reveals that great amount of efforts is required to ensure a shift from the standard, predominantly efficiency and profit-driven agricultural model to the one which is more socially inclusive and sustainable. But the crucial question is how can there be better gender representation in the arable sector and how can the share of each of the pies in the pie-chart (fig) as far as soil improving practices are concerned can be increased? The perception that women could potentially contribute to this current global challenge through sustainable soil and farming practices by the general public is important and could be leveraged positively. Similar survey findings on a large-scale can be used to advance the debate on 'public money for public good' by underscoring that small-scale existing women farmers who are inclined towards sustainable farming also become part of the policy process to collectively contribute in addressing the sustainable soils challenge. For this, it is also critical that barriers to effective participation by women (e.g. lack of access to land) is creatively removed and are enabled through effective policy-making. To make a strong case on this front, some cue can be drawn from the 2008-2009 Financial crisis, where it was argued that a more balanced — gender-diverse workforce, including in the board room and all decision-making spaces could perhaps acted as the necessary checks and balances to an otherwise hyper masculinised, testosterone-driven risk taking behaviour of men, where profitability became the main driving force for most decisions (Pearson and Elson, 2015; Palvia et al 2015). As the UN has warned, the crisis and the danger of imminent soil loss and our ability to sustainably produce in the future is real, some cross-learnings and effective policy making can go a long way?

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CONCLUDING REMARKS

The different chapters on social capital, trust, norms, and connectedness amongst others indicate the value of these intangible factors in enabling behavioural change towards new soil management practices. Some of these aspects however, require more research for better understanding, but what it underscores is that farmers rely on close peer as trusted sources and verifiers of soil information. Even influencers and champions have a critical role to play in lending legitimacy to important sources of information. As far as gender is concerned it is indeed a positive shift to see greater representation in events and meetings; but much more needs to be done structurally to enable greater participation of women (access to land, capital). The perception that women could potentially contribute to this current global challenge through sustainable soil and farming practices by the general public is important. Similar survey findings on a large-scale can be used to advance the debate on 'public money for public good' by underscoring that small-scale existing women farmers who are inclined towards sustainable farming also become part of the policy process to collectively contribute in addressing the global challenge on soils. So, overall, even though the study sites were few in number (UK, Hungary, Spain, and Norway) and the findings in that sense limited; but similar studies can be designed and conducted in other sites as well to get a broad overview of the scale of challenges and opportunities for appropriate policy interventions.

APPENDICES

Appendix 1

Q METHODOLOGY SURVEY

Problems causing and solutions to declining soil quality

Invitation and Brief Summary

You are being invited to take part in a research study. This research is part of a study called SOILCARE: Soilcare for profitable and sustainable crop production in Europe. SOILCARE is a European Union-funded research project running from 2016-2021 and aims to identify and evaluate promising soil improving management practices and agronomic techniques increasing profitability and sustainability across Europe.

As part of this work, we want to understand if people think there is declining soil quality in Europe and, if so, what solutions there are to fix this. This information will then be used to help inform and improve our research, as well as provide policy recommendations. We are contacting a number of agricultural stakeholders to study this topic. If you agree to take part, you will be asked to complete a questionnaire, which comprises 6 questions and should take no more than 15-20 minutes to finish.

We will not collect any information from you that can be used to identify you. We will, however, ask what industry you work in. The rest of the questionnaire will ask your opinions on whether you feel there is declining soil quality, if so, what you think is causing declining soil health and what the solutions are.

For more information on SOILCARE please visit www.soilcare-project.eu or contact Dr Niki Rust, Agriculture Building, Newcastle University, Newcastle, NE1 4LU, UK, niki.rust@ncl.ac.uk

PLEASE NOTE: the survey works best on a PC, laptop or tablet rather than a phone

1. Which country do you live?
2. What is your profession?

Tick the one that is the most relevant

- Farmer
- Agronomist
- Civil servant

- Policymaker
- Scientist
- Nature conservationist
- Agricultural supply chain employee
- Adviser
- Other

Problems causing soil quality decline

Please rank each statement based on to what extent you agree or disagree it is CAUSING declines in soil quality
Items should be ranked relative to one another rather than independently

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

1. Compaction
2. Soil tillage practices
3. Some traditions of farmers are damaging
4. Distrust of new technology and innovations by farmers
5. Use of contractors
6. Intensive use of soil without time to recover
7. Not enough knowledge being shared
8. Loss of organic matter
9. Soil erosion
10. Fear of doing something new
11. Natural local climate constraints
12. Lack of knowledge of soils amongst farmers
13. Distrust of scientists by farmers
14. Land is being used for other purposes (e.g. Grazing, housing, industry)
15. Flooding or drought
16. Pressure on farmers to produce at low cost
17. Soil has become too saline
18. Help towards improvements are not given fairly

19. Peer pressure by others
20. Choice of cropping system
21. Too much environmental regulation
22. Farms have become too big
23. Topography of the land
24. Loss of numbers of wild species
25. Farmers have lost touch with the finer understandings of their land
26. Climate change
27. Farmers have little control over their own land
28. Loss of soil structure
29. Declining level of nutrient status
30. Distrust between farmers and advisory agencies
31. Poor management
32. Too many regulations
33. Overuse of inputs like fertilisers and pesticides
34. I do not believe that there is a problem with soil quality
35. No crop cover over winter
36. Disconnection between nature-based land use and modern agriculture
37. Product demand from national/international markets
38. Modern machinery is too large
39. Repetition of the same crops, year after year
40. EU agriculture policy
41. Farming has become too quantified, where everything is measured

3. What do you think is the leading cause of declining soil quality?

This can be from the above list or a different cause that is not included above

Your answer

3a. Why do you think this?

Solutions to improve soil health

4. Please rank each statement based the extent you agree or disagree it is a SOLUTION to improve soil quality

Items should be ranked relative to one another rather than independently

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

1. More regulations for water usage
2. More communication and sharing of knowledge between farmers on a local scale
3. Invest in education and training
4. More local knowledge and experience
5. More regulations for fertilisers
6. Less use of heavy machinery
7. More farmer demonstration days
8. Change the timing of tillage
9. More research done in collaboration with farmers
10. Maintain small farms
11. Improve trust between farmers and regulatory agencies
12. More resting/recuperating of the soil
13. More innovations
14. There is not much new we can do in terms of soil management
15. More financial incentives
16. Setting examples to follow - If someone sees a person do well, they will do the same
17. Creation of a 'Soil Directive'
18. We cannot do much as the problems are down to natural climatic constraints
19. Reduce compaction
20. More diverse crop rotations
21. More education on environmental impacts
22. More organic fertiliser
23. Society needs to change focus on what we want to produce
24. More technical advice
25. More targeted mapping of soil threats
26. More cover crops
27. More traditional farming practices
28. Farmers have already tried lots of things to improve soil quality
29. More regulation

30. Increase early adoption of new techniques
31. More freedom for the farmers to manage their land as they would like
32. More financial penalties
33. Increase knowledge of difference in soil types
34. Keep updated with new information
35. What do you think is the most important solution to help improve soil health?

    This can be from the above list or something not included above

    Why is this?

36. Is there anything else you would like to add on this topic?
37. If you would be interested in a follow-up interview, please provide your contact details below
38. What do you think is the most important solution to help improve soil health?

This can be from the above list or something not included above

Why is this?

39. Is there anything else you would like to add on this topic
40. If you would be interested in a follow-up interview, please provide your contact details below

Appendix 2

SEMI-STRUCTURED INTERVIEW GUIDE ON TRUST

Thanks for agreeing to take part in this interview. This is part of a project called Soilcare which is looking at ways we can improve our agricultural soils in Europe. This interview focuses on changes in soil management practices on your farm. We are interviewing farmers to learn about where they go to get information on soil management. This information will be used to write a report but the interview will be anonymous so we will not use your name. The report will be sent to the EU. Is this OK for you?

[If you are recording the interview: because I have a bad memory and can't type quickly, is it OK if I also record the interview? It will just be used to help type my notes up later and then the recording will be destroyed]

[if you need to explain what "soil management practices" are] We call soil management practices those agronomic practices that are intended to improve/impact soil. This can include anything from using a new piece of technology like machinery or software, to changing your ploughing or harvesting regime, to using different seeds or crops, and so on.

CHANGES IN SOIL MANAGEMENT PRACTICES

1. First of all, it would be great to hear a little more about you and your farm. [e.g. How long have you been farming, what do you farm?]
2. Now, I'd like you to think of a time when you tried a new soil management practice on your farm (Nudges: for instance, trying a cover crop, a crop rotation, a new piece of machinery, a new tillage regime, a new fertiliser or way of applying fertiliser). Can you tell me more about this?
   2.1. Can you remember what prompted you to make this change? (Nudges: was it because of a new payment or regulation, a friend/family member recommended it, an adviser told you about it, you saw it in Farmers Weekly or on twitter etc?)
   2.2. Did this create uncertainties or risks for you as farmer/practices/family? How did you deal with this? What where the consequences?
   2.3. Who or where did you learn about this new management practice from? Why these people, why this place?
   2.4. Did you trust the information provided? Why? What did you trust/what not?
   2.5. What made you trust that this information would be applicable for your farm's context?
3. I'd like you to think of a time when you heard about a new soil management practice, but you decided NOT to use this on your farm. Can you tell me more about this?

3.1. Can you remember where you learnt about this management practice from?
3.2. Can you remember what made you decide not to use this new practice? (Nudges: was it because it was too expensive, you didn't trust that it would work, it seemed too risky, you didn't have time to learn how to use the technology, you didn't need it?)
3.3. Is there anything you can think of that would have persuaded you to try this new practice?

TRUST IN INFORMATION FLOWS

4. Who or where do you go to when you want to find out more information about soil management? (Nudges: this could be a person such as your neighbour or agronomist, a media outlet such as a farming magazine or radio show, an institution such as an agricultural union or the agricultural department of government, a demonstration you see at an agricultural event, or something else). Why these people/places? Is trustworthiness an issue?
4.1. How do you decide whether a new piece of information you learn about soil management is trustworthy?
4.2. Which are the top 3 sources of agricultural information you have the most trust in when it comes to finding out information about soil management? E.g. Not just people but also publications, institutions, etc.
4.3. Why do you trust these the most?
4.4. Which 3 sources of agricultural information do you have the least trust in when it comes to finding out information about soil management? E.g. Not just people but also publications, institutions, etc.
4.5. Why do you trust these the least?
4.6. Can you think of a definition of the word "trust"?
4.7. What do you think is the most important component of trust (Nudges: for instance, is it the information being credible, knowing the person/organisation well, scientifically-verified information, the person or organisation being reliable, the person or organisation having authority, the person/organisation being highly experienced, etc.)
4.8. Has your trust in different information sources changed over time? If so, why? [for instance, when you began farming you may have trusted agricultural magazines but now you trust fellow farmers]
4.9. Thinking back to when you made changes to your soil management, what could an individual or organisation have done to make the information they shared about soil management more trustworthy?
4.10 Thinking back to when you made changes to your soil management, what could an individual or organisation have done to make the information they shared about soil management less

trustworthy?