Norwegian University
of Life Sciences

Master's Thesis 2019 30 ECTS
Faculty of Bioscience

Agricultural stakeholders' understanding of declining soil quality in southeast Norway

Ole Erik Lunder
Master of Science in Agroecology

Acknowledgements

First, I would like to thank my supervisor at NMBU, Professor Tor Arvid Breland. The input and guidance I have received has been vital for the research process and the final product. Gratitude to agroecology community at NMBU for inspiration and support since august 2018. This research was supported by NIBIO: Division of Environment and Natural Resources. Thanks to Rs. Frederik Bøe and Dr. Jannes Stolte from this division for introducing me on to the EU-project "SoilCare: SoilCare for profitable and sustainable crop rotation in Europe". The material from this work is based upon research from this project. A special mention to Dr. Niki Rust from the University of Newcastle for insight on methodology and highly valued feedback.

Sincere appreciation to the agricultural stakeholders who answered the questionnaire and made this research possible. A special thanks to Michael Aamold and Else Villadsen at Norsk Landbruksrådgivning. Thanks to family and friends, especially Emilie and Espen, for moral support throughout the entire research process.

Abstract

There has been declining soil quality in southeast Norway in the later years. This master's thesis explored agricultural stakeholders' understanding of causes and potential solutions to the problem and factors supporting and hindering such solutions in southeast Norway. Q-methodology, a combination of quantitative and qualitative methods, was applied to provide detailed descriptions of the subjectivity that exists among stakeholders on the topic.

Both consensus and contrasting views on causes and solutions to soil quality decline in southeast Norway were found. Not all respondents considered there to be declining soil quality, while results showed possible ignorance–knowing gaps and knowing–doing gaps. The social relation between stakeholders, the role of the extension service, and a productivity focus are all vital forces influencing respondents' understanding of problems and solutions. Raising awareness on the complexity of factors leading to soil quality decline is essential to increase stakeholders' understanding. A participatory, holistic approach and collaboration between agricultural stakeholders is needed for new solutions to arise to improve soil quality in southeast Norway.

Table of Content

1. Introduction

1.1 Soil, human population, and food production

The world's population is dependent on soil. Soils are living ecosystems with microscopic and larger organisms providing vital functions for both people and nature, supplying the human population with as much as 95% of the food consumed (Bini, 2009; FAO, 2015). In 2050 there will be a need to increase food production by 70% because of population growth and changing diets (Lal, 2015). Production of cereals is fundamental for global food supply, and an increase in production of 50% is needed as early as 2030 (Clark, 2011). The requirement to increase productivity poses tremendous challenges for future food production as about 70% of the earth's land surface is already affected by human use directly. Agriculture is by far the largest occupier of land and driver of land degradation worldwide (IPCC, 2019).

Soil is a non-renewable resource on a human time-scale, and degradation of soil is a massive constraint to meet the requirement of increased food production for an increasing human population (Lal, 2015). There is a need for development and widespread adoption of productive and profitable sustainable soil management practices to meet the challenges of land degradation and reduced soil quality (Thomas et al., 2018; Webb et al., 2017). FAO (2017) defined sustainable soil management as;

"Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity…" (p:3)

The need for sustainable agricultural practices is expressed 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, 2019). Halting land degradation and increasing soil quality is vital for food security on a global and local scale (Singh, 2011).

1.2 What is soil quality

Definitions of "soil quality" are continually developing and have progressed from focusing solely on productive functions to include a broader focus on the complexity of the soil (Erkossa et al., 2007). The focus on complexity is due to increased human impact on the environment, as soil link to several societal and environmental issues like food security, sustainability, carbon sequestration, and greenhouse gas emissions (Erkossa et al., 2007; FAO, I., 2015). The complexity of soil is recognized in the definition of "soil quality" in SoilCare, the project this research is a part of:

"*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)

A soil that "functions" means its capacity as "*A service, role, or task that meets objectives for sustaining life and fulfilling humanity*" (SoilCare, 2019)**.**

Among the factors that are important for soil to function are its soil structure, content of organic matter (SOM), and soil biodiversity, all interdependent (Bini, 2009). Soil structure is crucial for plant growth, influencing internal factors like root growth, soil water movement and retention, airflow in the soil, soil fauna, nutrient cycling and crop yield (Bronick & Lal, 2005; Pagliai, 2004). Good soil structure depends on the content of SOM, which is a vital indicator of soil quality (Arshad & Martin, 2002; Schjønning et al., 2004; Uhlen et al., 2017; Vågen, 2000). A high level of SOM has several advantages; it stores carbon, filters and retains water, gives structural stability, and provides the plants with nutrients (ibid.). SOM has a central role in the cycling of water and carbon and is a climate regulator by storing three times the amount of carbon existing in the atmosphere (FAO, I., 2015).

A high level of SOM equals a high level of soil biodiversity, which is vital for essential ecosystem services, above-ground biodiversity, and productivity (Montanarella, 2006; van der Putten et al., 2018). Providing the soil with active, i.e., readily decomposable, SOM is critical to maintain soil biological activity. A continuous feed of organic matter such as green manure, animal manure, and yield remains, feed the soil with active SOM, thereby maintaining a high level of biological life in the soil (Breland, 1992; Chen et al., 2019).

1.3 Norwegian cereal production and soil quality

Only 3,1% of the total land area in Norway is suitable for agriculture, and cereals can only grow on 1/3 of the total agricultural area due to severe natural conditions (Hegrenes et al., 2016; Tufte, 2012). The regional specialization policy, known as "kanaliseringspolitikken", has been fundamental for the outline of Norwegian agriculture since the after-war period. This policy has provided production throughout Norway by prioritizing cereal production in lower-lying areas while prioritizing animal husbandry to areas not suitable for producing cereals (Arnoldussen, 2014). This policy, combined with other factors, led to a threefold increase in Norwegian cereal production between 1950 and 1990 (Almås, 2002).

The farming in southeast Norway consists mainly of cereal production as a consequence of the regional specialization policy (Bunger & Tufte, 2016). This region, specified to the three counties Akershus, Østfold, and Hedmark, has in total 60% of the total Norwegian cereal production areal. In Østfold, 50% of the area is in some years used for wheat production, and only 20% of the agricultural area is ley (Stabbetorp, 2018). Organic cereal farming in Østfold, Akershus, and Hedmark consists only of, respectively, 1.7%, 0.7%, and 0.5% of the total cereal production area (Landbruksdirektoratet, 2018).

In later years, the agricultural sector has experienced substantial structural changes. The number of farms in Østfold, Akershus, and Hedmark has decreased by, respectively, 57%, 60%, and 66% after 1989. In the same period, leased agricultural area in these counties has increased by, respectively, 63%, 80%, and 80%. On a national scale, cereal farms have increased their average area from 10.7 ha to 27.1 ha in the same period, and over 40% of the cereal production is now on leased land (Bjørlo & Rognstad, 2019; Stabbetorp, 2014).

Over the last two decades, the total Norwegian cereal yield has declined. Two of the reasons for this decline are decreasing total production area and flattening in the potential of genetic progress for higher yields (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 by 20% in 2030 from 2010 levels, to meet the projected population growth in Norway (9, 2011). Several reports and research papers have pointed to the necessity of increasing focus on soil quality and soil-improving measures for both productive and environmental reasons (Olsen & Nyborg, 2014; Stabbetorp, 2018; Uhlen et al., 2017; Vagstad, 2013).

Soils in southeast Norway have had a steady decline in the content of SOM with an average decline of approximately 1% a year from 1991 to 2001. This loss has most likely been a trend since early 1950s, corresponding to changes in agricultural activity caused by the regional specialization policy (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). Soils in southeastern Norway, which at present have medium to high contents of SOM, will reach a critically low level in the future, below 3%, depending on the current content of SOM. Loss of SOM is a critical factor in soil degradation, and yields are affected negatively when levels of SOM are low (Grønlund, 2010; van der Putten et al., 2018).

More pressure on agricultural productivity in this region has likely led to increased soil compaction as a result of more massive machinery driving in unfavorable conditions. The considerable increase in leased soil has most likely led to less knowledge about the soil, which 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).

Rainfall in spring has increased by 10% from the period 1971-2000 to the period 1985-2014 (Hegrenes et al., 2016). Increased rainfall in spring and autumn has most likely led to more compaction and further degradation of soil structure (Uleberg, 2018; Vagstad, 2013). Measurements from Kise, Hedmark, indicate that soil temperature has increased with an average of 1 ℃ since the 1960s. Warmer soil most likely speeds up the degradation of SOM (Riley & Bakkegard, 2006).

A combination of measures is necessary to improve the soil quality in southeast Norway. Crop rotation and cover crops improve soil structure, nutrient availability and can increase SOM (Bøe et al., 2019; Riley et al., 2005; Uhlen et al., 2017; Waalen et al., 2019). Reducing tillage is essential as it prevents soil erosion and nutrient runoff and improve soil structure. Soils with reduced tillage systems are also more likely to maintain or increase SOM in the top 10 cm of the soil (Riley et al., 2017). Drainage of agricultural soils reduces the possibility of soil compaction, leads to less topsoil erosion, and decreases loss of nutrients by improving the soil structure (Hauge et al., 2011; Øpstad, 2016). Financial incentives in the form of subsidies have proved to be effective as measures to reduce tillage, increase drainage, and increase areal with cover crops in southeast Norway (Landbruksdirektoratet, 2019; Snellingen Bye et al., 2019; Stabbetorp, 2014).

1.4 Agricultural stakeholders' understanding of causes and solutions

Ignorance has been recognized as one of the main reasons for exploitation and decline of natural resources (Padgitt & Petrzelka, 1994). Moving from ignorance to awareness is considered the first step when implementing new sustainable agricultural practices (ibid.). Awareness of the problem must be supplemented by knowledge of practical solutions to close the "ignorance–knowing gap". However, awareness and knowledge are no affirmations for change of practice. The "knowing–doing gap" describes the distance between knowing what one should do, or knowing that something is essential, and doing it (Pfeffer & Sutton, 2000).

Stakeholders' understanding of a problem is affected by more than awareness. In the neo-classical economy, economic profitability is considered the farmer's greatest motivation to maintain, change or invest in the farm and the cropping system (Hoel et al., 2013; Vedeld et al., 2003). The "farmer treadmill", introduced by Cochrane (1958), explains how farmers are strained between environmental and economic considerations. The treadmill describes how farmers face a constant strive to become more efficient by implementing technology and increasing agricultural land to keep up with the demands of increased productivity. Investing in environmental measures often requires a belief in a long-lasting, more significant revenue from the farmer as these measures are considered long-term investments (Brobakk, 2017; Hoel et al., 2013).

Vatn (2007) pointed out that the farmer's understanding and practice depends on "good social context", where "Good agronomy" is a core concept. "Good agronomy" consists of norms and values like "independence" and "product orientation". These values are considered in the context of a satisfactory economic outcome, i.e., there is no "good agronomy" if there is small economic output (Vedeld et al., 2003). Good agronomical practice is continuously developing in the relationship between farmers, researchers, and the extension service. This relationship also provides researchers and advisors with an understanding that measures should not threaten farmers' economic base (Vedeld & Krogh, 1999).

The Norwegian extension service emphasizes practical and physical "down to earth"-advice. The advisors are often farmers in the local community and have tacit knowledge of the local agriculture developed over time and through experience. This tacit knowledge provides a high level of trust between the farmers and extension service, as the advisors have an experience-based understanding of "good agronomy" (Vedeld et al., 2003). Angstreich and Zinnah (2007) emphasized the importance of providing new information that relates to the farmer`s experience-based knowledge through participatory approaches. “Farm days” is one example of a participatory educational platform, where advisors and farmers can meet and translate scientific research into practical agricultural measures (Van de Ven & Johnson, 2006). This close relationship and participatory approach is considered vital to increase farmers’ environmental awareness and promote practical measures which improve environmental qualities (Sæther, 2010; Vedeld & Krogh, 1999).

Declining soil quality is a “wicked problem”, which does not have one single cause or solution (Nickum et al., 2018). Scientific traditions in the western part of the world have been criticized for a reductionist approach, where knowledge is “*taught and learned abstracted from the applied context*” (Brodnig & Mayer-Schönberger, 2000; Johnson, 1992). Improving soil quality requires a participatory and holistic approach where new solutions arise in collaboration between different stakeholders from the agricultural sector (Bruges & Smith, 2008; Ikerd, 1993; Knickel et al., 2009; Méndez et al., 2013; Pretty, 1995). It is essential to understand “the world” the agricultural stakeholders operate in, without reducing their actions to individual motivations and behavior removed from a broader political or economic context (Duram, 2000). Insight into stakeholders’ understanding of problems causing and solutions to declining soil quality in southeast Norway is needed to design measures to mitigate the problem.

1.5 Research Objectives

The objective of this research was to explore selected farmers’, scientists’, and advisors’ perspectives on declining soil quality in cereal farming in southeast Norway. The exploration focused on the causes of and potential solutions to the problem and factors supporting and hindering such solutions. Information was collected and analyzed according to the Q-methodology, which, based on stakeholders’ responses to a questionnaire, identifies unique and shared subjective perspectives on an issue. This method has been recognized as a valuable approach to environmental management (Gruber, 2011; Chamberlain et al., 2012).

2. Material and methods

Project context

This research has been conducted in collaboration with NIBIO: Department of Environment and Natural Resources, as a part of the EU project "SOILCARE: Soilcare for profitable and sustainable crop production in Europe". SOILCARE aims to identify and evaluate promising soil improving management practices and agronomic techniques, and increase profitability and sustainability across Europe. This research is a part of work-package 3, where the focus is on "Participatory selection of Cropping Systems". Work-package 3 aims to create multi-stakeholder advisory panels to guide and co-produce research in each study-site located around in 16 countries in Europe. This paper builds on research already conducted in England and concerns the Norwegian part of the work-package.

Agricultural stakeholders

"Agricultural stakeholders" were monoculture cereal farmers, organic cereal farmers, cereal farmers with crop rotation, scientists, and agricultural advisors. These groups are termed "stakeholder groups" in this paper. All respondents were from Østfold, Akershus or southern Hedmark, regarded as the region "southeast Norway". These counties are all included in Norsk Landbruksrådgivning Øst (NLR Øst), an extension service covering farmers from Akershus, Østfold and southern Hedmark. NLR Øst had a total member-base of 56.5% of all registered farming businesses in the region per 01.01.19 (personal announcement, Michael Aamold, 17.09.19), and were essential for the data collection.

Data collection

To capture the different perspectives from different stakeholders and stakeholder-groups, Q-methodology was applied. Q is a mixed methodology, i.e., a combination of quantitative and qualitative methods, exploring correlations between how respondents answer a set of questions methods (Davis, 2011; Herrington & Coogan, 2011). The first step in a Q-methodology analysis is developing a "concourse", a list of statements covering the diversity of responses on a topic. To collect this data, another member of the SOILCARE team conducted 18 interviews with a variety of agricultural stakeholders from across Europe to understand their perspectives on whether they think soil quality is declining. If so, why and what could fix this problem. Respondents were sourced by first interviewing one SOILCARE partner (usually a scientist/researcher) in a SOILCARE-participating country and then, through snowball sampling, being recommended a complementary respondent (usually an agricultural practitioner). The concourse statements were then created by analyzing the interview texts to find mentions of suggested causes and solutions to declining soil quality. The concourse was supplemented with an extensive literature review, which together created a list of 76 statements regarding problems and solutions on soil quality. Another literature review was conducted to ensure the subjectivity and context-specificity of the concourse that exists around soil quality, specifically in Norway (Herrington & Coogan, 2011). The review resulted in rewritten statements for the context of Norwegian agriculture, e.g., changed “EU agricultural policy” with “Norwegian agricultural policy”. Based on conversations with two Norwegian cereal farmers from Akershus, one problem statement and one solution statement focusing on drainage were included. In total, there were 42 “problem statements” and 36 “solution statements”; each list of statements is called a Q-set. These statements made up the quantitative structural interview, which was carried out as a questionnaire according to the principle of Brown (1980), where respondents are asked to rank predefined statements on a scale similar to a Likert scale (see Appendix 1 for statements). A detailed description of Q-methodology is found in appendix C.

Design

The Q-methodology survey, conducted in Google Form, contained statements with an unforced distribution. Unforced distribution means that the respondents could place each statement independently of each other. Some Q-methodology surveys are conducted where respondents are forced to place statements on a predefined structure, usually where they can only place a few statements on either end of the spectrum, with most having to be placed in the middle. However, this has challenges and can frustrate respondents, which is why it was decided to use an unforced distribution. The scale used was from “strongly agree” to “strongly disagree”, with five options in total. This is known as the Likert-scale and is considered optimal as it opens for a middle option (Bernard, 2006, Lietz, 2010). The questionnaire was divided into three sections, where the first section concerned problems causing soil quality decline. The second section concerned solutions to soil quality decline. At the end of the two first sections, the respondents were asked which factor they considered as the most important for causing soil quality decline and improving soil quality, which they could choose either from the predefined statements in the survey or from their own making. These qualitative, open-ended answers were first used to understand if there were essential factors not covered in the predefined statements, and secondly to determine what factor was subjectively considered the most important by each participant. The third section included an open-ended question with the opportunity to add final, qualitative comments. These comments opened for more respondent subjectivity. Open-ended answers were analyzed via thematic analysis whereby read and searched for common themes within the answers.

Sampling and Distribution

Respondents were sampled through purposeful sampling and snowball sampling (Bernard, 2006). A link to the survey was distributed in “Plantenytt” to sample answers from farmers. “Plantenytt” is a newsletter from the extension service Norsk Landbruksrådgivning Øst (NLR hereafter) which is distributed to 2691 farmers with cereal productions in Akershus, Østfold, and southern Hedmark. The survey was also distributed by mail to a “soil education group”, including thirty-two farmers in Østfold county. 2723 cereal-farmers in total had the possibility of answering the survey through the newsletter and mail. Forty-two cereal farmers responded on to the questionnaire, which makes up 1.36 % of the possible respondents. Sixteen agricultural advisors were contacted by mail correspondence. Six answers were registered, which make up 37.5 % of possible respondents. All the advisors contacted had their specialization in cereal production or environmental advising in agriculture. Fourteen scientists were contacted through an internal newsletter at NIBIO: Division of Environment and Natural Resources. Five scientists responded, which make a response rate at 28%. The total number of respondents who completed the survey was fifty-two, including thirteen monocropping cereal farmers, twenty-three cereal farmers with crop rotation, six organic cereal farmers, six agricultural advisors, and five scientists.

Analysis

A Q-sort is how a participant has ranked the list of statements. Answers from the Q-sorts were analyzed using KenQ (https://shawnbanasick.github.io/ken-q-analysis), a free online analysis-tool for the Q-method. This data tool me enabled to find correlations in how respondents ranked their Q-sorts that helped to describe the dataset and account for the variance in it. Through the respondents’ Q-sort, it was possible to identify the views that cluster respondents together through their similar ranking of Q-sorts. Running the analysis, the data was split into two different Q-sorts; a “Problem sort” and a “Solution sort”. For the “Problem sort”, 8 principal components with Eigenvalue above 1 were extracted through a principal component analysis (PCA) of the completed problem Q-sorts. This PCA identifies a correlation matrix where all Q-sorts are compared, and clusters of respondents are determined by those who rank Q-sorts similarly, which are called principal components or "factors". These factors explained 69% of the variation in answers, i.e., the PCA clustered respondents into eight distinct factors. These eight factors together explained 69% of the variance in the Q-sorts, meaning that 31% of the variance could not be explained by these eight factors. Most of the respondents loaded onto the first three factors, which together explained 51% of the variation, i.e. of all the ways in which Q-sorts were ranked, there were three main ways in which respondents ranked them, and these could be separated into three distinct factors which together explained a little over half of the variance. In Q-methodology analyses, factors with Eigenvalues greater than one are usually then carried forward for further inspection. In my analysis, all eight factors had Eigenvalues greater than one, but previous studies have found that for large datasets with lots of statements such as this one, Eigenvalues can be inflated (Herrington & Coogan, 2011) . I, therefore, decided to focus on the first three factors that covered more than half of the diversity of meanings. I applied Varimax rotation for these factors, which calculated the highest variability between factors. All respondents significantly loaded onto one of the factors for both the problem sort and the solution sort meaning that there were no respondents who ranked their Q-sorts significantly differently to these three factors. Disagreements and consensus between respondents were set where p<0.01, meaning the groups of respondents did not rank the statement differently at the 99% confidence level. For the "Solution sort", 8 factors with Eigenvalues above 1 were extracted, explaining 78% of the variance. Most respondents loaded onto factor 1-3, which together explained 63% of the variance. Again, as before, the first three factors were chosen. The rest of the "solution sort" followed the same procedures as the "problem sort". Factor groups were given short narrative names that best summarized the key difference between each group.

Quotes in the results section are used to highlight common sentiments as well as responses that stood apart from the rest. All quotes are translated from Norwegian to English and given a number, e.g., "q1" (See appendix B for original statements). Consensus statements on problems leading to declining soil quality were determined in the correlation analysis by those statements that were ranked significantly similar to each other at $p < 0.01$. All problem – and solution statements are displayed in Table 1/2; problem/solution sort, found in Appendix A. Statements from the Q-set are underlined when describing results. Quotes from the open-ended sections are translated from Norwegian to English and *written in italic with "quotation marks"*.

3. Results

3.1 Problems

Areas of consensus and agreement between factor groups

All respondents across factor groups (see explanation in "material and methods") 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". All factors also strongly agreed that "loss of SOM" and "soil compaction" were problems too, but there was not a significant consensus $p < 0.01$. However, loss of SOM was thought by some to be caused by underlying drivers; in the open-ended answers, one scientist stated; *"the most important reason is regulation, which led to lack of SOM in cereal areas*" (q3). Several respondents pointed at large machinery as the main reason leading to soil compaction (e.g., q10, q11, q13, see Appendix B).

Respondent characteristics of each factor

Figure 1 (page 18.) displays that farmers who performed crop rotations (shown in orange) were evenly split between the three groups, whereas farmers who undertook monocultures were mostly represented in Factor group 3, which is also where more advisors were found.

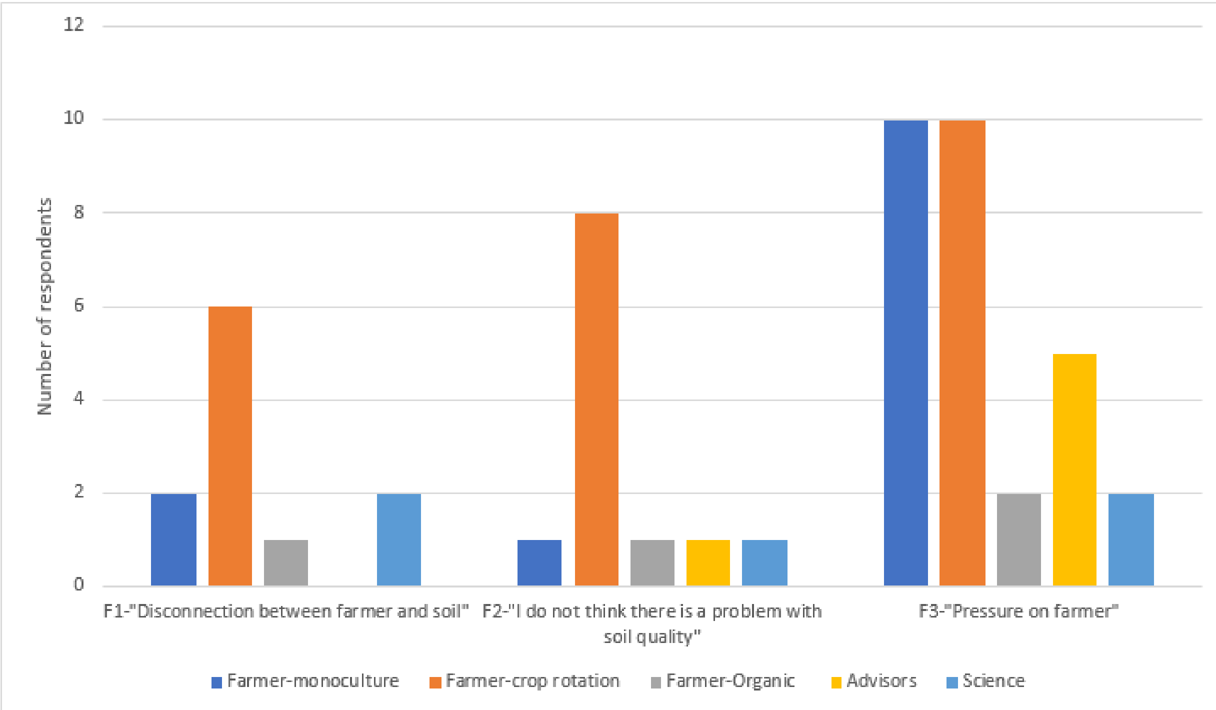

Figure 1. The three distinct factor groups identified in the Problems Q-sorts, with a breakdown of respondent professions within each factor. Each factor group is given "narrative names" that best summarizes key differences between groups. Areas of disagreement were also extracted (at p < 0.01) to determine the statements within each factor that were ranked significantly different from other groups. The following sections describe the differences between the groups.

F1, which was labeled "disconnection between farmer and soil", had respondents from all stakeholder groups except the extension service. 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 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 declining 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". Two farmers with crop rotation wrote; "*too little knowledge on soil, nutrients, and cultivation practice*" (q1) and; *"…farmers have little physical connection with our soil."* (q2), emphasizing the farmers' practices and knowledge to be the main problems.

Respondents in this group also emphasized that other aspects are influencing the farmers' practices. Some of the respondents linked practices and problems to structural changes in cereal production by agreeing on "Disconnection between nature-based agriculture and modern agriculture". A farmer with crop rotation called attention to this statement by writing; "*… all in all we need to become better at working with nature*" (q4), while another emphasized "*societies demand for cheap food…"* (Q4) as the most critical reasons to decline.

Respondents in factor 1 appeared not to consider factors outside the farmer's self-determination, like climate change and structural changes, as consequences leading to decreasing soil quality. They disagreed on "Too large farms". A crop rotation farmer emphasized this by writing; *"As farmers' we are in little physical contact with our soil…" (q2).* They disagreed more strongly than others on "Climate change", "Local weather and climate" and "Drought or flood" as causes to decline.

F2, labeled "I do not think there is a problem with the soil quality", included one respondent from all stakeholder groups except a considerable higher number of crop rotation farmers. F2 strongly agreed to the statement "I do not think there is a problem with soil quality", which distinguishing the respondents significantly from others. The monoculture farmer emphasized this statement; "*is it that obvious that soil quality has declined, is it documented?"* (q5). The scientist in this group wrote; "*it is a fact that lack of drainage and soil compaction is a problem for soil quality …. in general, decline in soil quality is not considered a fact in Norway"* (q6), while the advisor noted; "*uncertain if there is a decline in soil quality. Higher and higher yields are harvested with good quality…"* (q7).

Consequently, the respondents disagreed in that agricultural practices or – systems are reasons leading to a decline in soil quality. Respondents disagreed to the statements "Intensive agriculture to blame*"* and "Overuse of input like fertilizers and chemicals*".* They strongly disagreed with the statements "use of contractors", "Too much leased soil", or "Farmer has lost the finer touch with his land". The advisor emphasized; *"farmers are eager to learn, doing things correctly, and think ahead"* (q7), emphasizing that there is not a farm management problem. Furthermore, respondents in this factor agreed more strongly than others with the statement "Too little advice on soil-improving practices" and to the statement "Lack of knowledge-sharing between scientists, advisors, and farmers" as problems for soil quality, suggesting issues around knowledge exchange may have been more important for respondents loading onto this factor.

There were respondents from all stakeholder groups in Factor 3, which was labeled "Pressure on the farmer". All advisors except one loaded onto this factor. Respondents in Factor 3 considered there to be a problem with soil quality. However, respondents in factor 3 more strongly agreed to statements that are external to farmers' actions and responsibility. Respondents were significantly more likely to agree on "Pressure on the farmer to produce at low cost" and "Intensive agriculture". The respondents in this group more strongly agreed to structural characteristics like "Too large farms" and "High share of leased land" as causes to declining soil quality compared to other factor groups. Monoculture farmers in this factor stressed the most important reasons driving the decline to be; "*heavy machinery..*" (q8), "*Large farms with large machinery tilling at unfavorable times..*" (q9), and; "*soil compaction, especially from large units..*" (q10). Respondents were distinct in that they agreed to "Climate change" as a problem causing declining soil quality, another externality outside the farmer's self-determination. An organic farmer linked structural changes and climate change by writing; *"..wetter climate and larger machines"* (q11).

Respondents in this factor disagreed significantly with "Distrust of scientists among farmers", "Distrust between farmers and advisory agencies", "Peer-pressure", and "Fear of new practices and methods" as reasons to declining soil quality. A crop rotation farmer noted; "*too little focus on soil health*" (q12), and an advisor wrote; "...*Large scale agriculture stimulates the ones that are most interest in machinery, which usually do not have that much knowledge on soil or plants..*" (q13) as the most pressing problems.

3.2 Solutions

Areas of consensus and agreement between factors

All respondents across factor groups (see explanation in "material and methods") agreed or strongly agreed on "Less soil compaction" and "More variation in crop rotation" as measures to improve soil quality. Consensus was found on statements with educational aspects, e.g., "Investment in education and training" and "More farmer demonstration days", which were agreed or strongly agreed on. "Increase knowledge of different soil types" and "More drainage", while not a significant consensus, were agreed or strongly agreed on in all factors. "More drainage" was written by eight respondents as the most critical measure to improve soil quality in the open-answer section

More than half of the respondents who answered the open-ended question "what do you see as the most important solution to soil quality?" mentioned "soil organic matter", "cover crops" or "crop rotation". To exemplify, a scientist wrote; "*All measures which increase SOM"* (q20), while "use of cover crops" was explicitly written in 10 answers as the best solution to improve soil quality (q14, q15, q21-q28).

Respondents disagreed or strongly disagreed on *"*There is not much we can do with the cropping system to improve soil quality" and "There is not much we can do; problems are due to natural, climatic variations". All respondents strongly disagreed on "More use of financial penalties", while respondents were neutral to or disagreed with "financial incentives" as a solution.

Respondent characteristics of each factor

Figure 2. (page 22.) displays that farmers who performed monoculture and advisors (shown in blue and light blue) were evenly split between the three groups, whereas farmers who undertook crop rotation were more represented in Factor group A.

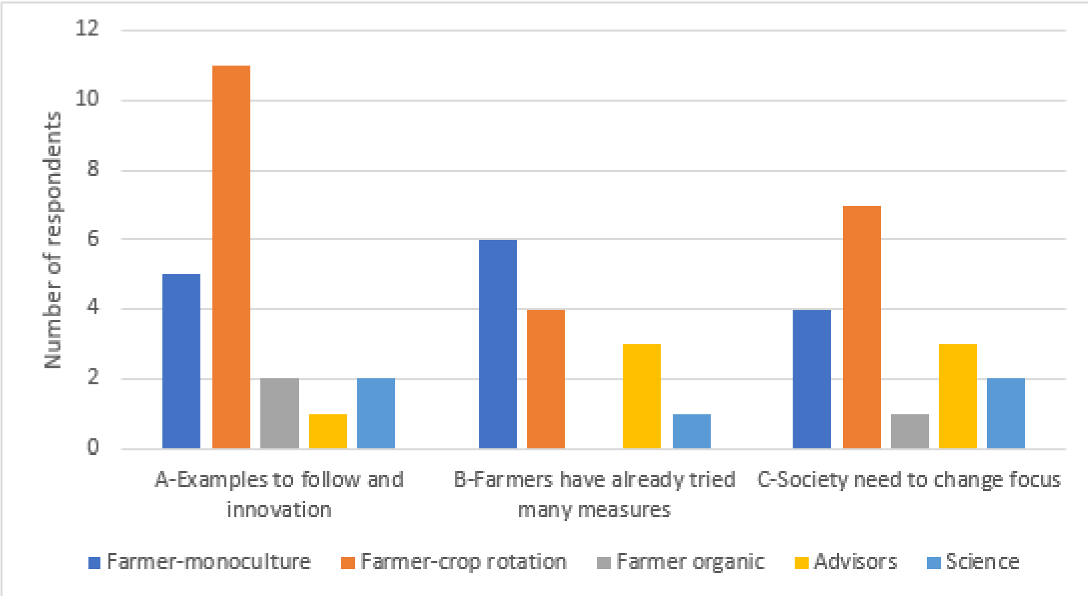

Figure 2. The three distinct factor groups, A-C, discovered in the Solution Q-sorts, with a breakdown of respondent professions within each factor. Each factor group have "narrative names" that best summarizes key differences between groups. Areas of disagreement were also extracted (at p < 0.01) to determine the statements within each factor that were ranked significantly different from other groups. The following sections describe the differences between the groups.

Factor A, which was labeled "Examples to follow and innovation", had respondents from all stakeholder groups. Respondents in this group 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 also strongly agreed on "More use of cover crops" as solutions, but this was not a distinguishing statement at $p < 0.01$. "Cover crops" or "crop rotation" were mentioned as the most important measures in the "open answer" section by 10 of the respondents in this group. Two monoculture farmers emphasized these measures by writing; "… *cultivate cover crops for soil penetration*" (q14) and; "*more use of cover crops with deep roots" (q15)*. This group disagreed more strongly than others on "more small farms" and "reduction of leased land" as solutions to improve soil quality. It was the only group that was neutral to "Reduce use of heavy machinery".

Factor B was labeled "Farmers have already tried many measures" and included respondents from all stakeholder groups except "organic farmers". Respondents in this group agreed on "Farmers have already tried many measures to improve soil quality", distinguishing them from other respondents. They disagreed on "More use of cover crops", "financial incentives", and strongly disagreed on "creation of a soil directive", "more regulation of fertilizer use", and "more regulation" as solutions. Several open-ended answers from respondents in this group emphasized the need to combine individual evaluation of measures on farm-level and necessity of several measures to improve soil quality. One advisor wrote; "*Good agronomy, doing the right things at the right time…"* (Q36), the scientist emphasized that; "*measures must be adapted to the soil-type"* (Q37) while a farmer practicing monoculture summarized; "*many factors coincide – everything is connected*" (Q16).

All stakeholder groups loaded onto factor C, which was labeled "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.

4. Discussion

4.1 Are the respondents' understanding in agreement with documented knowledge?

4.1.1 Understanding of problems causing soil quality decline

Trends of shared understanding across factor groups.

Through several consensus statements, the results indicated a high degree of knowledge on causes leading to soil quality decline in agreement with documented knowledge. Respondents' consensus on soil erosion and loss of soil structure as causes are in line with recent studies (Olsen & Nyborg, 2014). Soil erosion and loss of soil structure are linked to increased soil compaction and a high share of annuals in southeast Norway (Seehusen et al., 2019; Waalen et al., 2019). Soil compaction destroys soil structure, restrains root growth, reduces water and nutrient uptake by the plant, and, consequently, reduces yield and yield quality (ibid.). Soil compaction was agreed on as a cause leading to soil quality decline by most respondents. A further novel finding is that all respondents, also farmers practicing monoculture cereal farming, considered monoculture as a problem leading to soil quality decline. Monoculture practice is known to be unfavorable for soil quality, leading to a lack of supply of active organic matter and reducing the content of SOM (Breland, 1992; Chen et al., 2019).

Most respondents agreed to loss of SOM as a vital cause leading to soil quality decline, in line with documented knowledge (Arshad & Martin, 2002; Riley & Bakkegard, 2006). Notably, not all respondents agreed to the loss of SOM as a problem. This disagreement may indicate a knowledge gap among respondents, as recent studies show that there has been a decline in SOM in southeast Norway (ibid.). It could also indicate that the respondents who disagree have not experienced the general decline in SOM or any adverse effect of the decline. A decline in SOM is not necessarily detected, as increased use of input and improvement of other agronomic measures can cover up the harmful effects of decreasing SOM (Uhlen et al., 2017).

It is symptomatic for both consensus statements and statements with a high degree of agreement that they are in line with recent studies on soil quality decline. A limitation of this research is whether all statements on causes leading to soil quality decline are valid for respondents' understanding of the decline in southeast Norway, or an understanding of causes leading to a generic soil quality decline.

Contrasting views on understanding of problems across stakeholder groups.

The uniform understanding expressed by respondents' in factor group 1 agreed with current knowledge of soil quality decline in southeast Norway. Respondents recognized practical, structural, and educational aspects as reasons leading to soil quality decline, indicating that the respondents have an understanding of soil quality decline as a wicked problem (Nickum et al., 2018). F1 indicates that agricultural advisors give too little advice on soil-improving measures. Previous research (Vedeld & Krogh, 1997) point to advisors as vital to increase environmental awareness among farmers. The respondents in F1 strongly agreed to both lack of knowledge and poor soil management and pointed to "farmer's practices" and "disconnection between the farmer and his soil" as reasons to decline. Advisors' importance on increasing knowledge among farmers' is further discussed in 4.2.

F1 agreed on the agricultural policy as a cause leading to declining soil quality, and several respondents pointed to the regional specialization policy in the open-ended section. By emphasizing loss of SOM, lack of organic fertilizer, and too little crop rotation, respondents displayed an understanding of the negative consequences of this regional specialization policy, in line with the critique from Kolberg (2016). Respondents disagreed on "too large farms" as a problem while several mentioned that the machinery working the fields is too large in the open-ended section. These statements indicate that respondents consider the structural changes as an aspect, but that the farmer still is responsible for the field operations and, therefore, has the primary responsibility for declining soil quality.

Twelve respondents in F2 did not consider there to be a decline in soil quality in southeast Norway. There can be several reasons why respondents in this group significantly differed from respondents in F1 and F3 and disagreed with recent studies. One reason could be that respondents in this group have a different definition of soil quality than other respondents, as "Soil quality" is a dynamic term that has changed from focusing solely on productivity to a broader focus on the complexity of soil (Erkossa et al., 2007). A consultant wrote, "*I do not think that soil quality has gone down, farmers are harvesting higher and higher yields"* (q7), supporting a "productivity focus" on soil quality. If respondents perceive soil solely from a productivist perspective, they will probably not consider there to be a soil quality decline if yields are getting "higher and higher".

A second reason could be that respondents in this group have not experienced a decline in soil quality. Crop rotation improves soil quality, especially if ley is included (Uhlen et al., 2017; Waalen et al., 2019), and ten out of thirteen respondents in F2 were farmers with crop rotation. Crop rotation practices can indicate that there has not been a soil quality decline on their farm. On the other hand, the low amount of ley and high amounts of annuals in this area (Stabbetorp, 2018) suggest that the crop rotation practices will not maintain or increase levels of SOM. As crop rotation without ley is less likely to increase the content of SOM than crop rotation with ley, soil quality decline can still be apparent (Uhlen et al., 2017).

Respondents in factor 3 considered there to be declining soil quality in southeast Norway in line with recent studies. However, the respondents seemed to be less aware of the complexity of causes leading to decline compared to the respondents in F1. This group did not consider farmers' practices or their level of knowledge to be problematic but emphasized more external causes like political structures and climate change. Respondents' answers indicated a reductionist approach to a complex problem, which is typical in western tradition (Brodnig & Mayer-Schönberger, 2000; Johnson, 1992).

This group pointed to larger farms, leased land, and less SOM as causes, indicating that the regional specialization policy has had negative consequences for soil quality. The respondents' answers are in agreement with the significant structural changes registered in this region and the consequences of these changes (Bjørlo & Rognstad, 2019; Riley & Bakkegard, 2006; Stabbetorp, 2014). As the only group, F3 considered climate change to cause soil quality decline. Data collected display changes in weather in southeast Norway with increased rain in spring and higher soil temperatures, which can lead to more compaction and loss of SOM (Hegrenes et al., 2016; Riley & Bakkegard, 2006).

4.1.2 Understanding of solutions to improve soil quality

Trends of shared and contrasting understandings of solutions

Consensus on "less soil compaction" and "increase drainage" as solutions to improve soil quality are in line with recent studies. Øpstad (2016) connected these solutions by writing that increased drainage leads to less probability of soil compaction. Not all respondents agreed on "less use of heavy machinery" as a solution, although the trend of more massive machinery working the fields in southeast Norway is considered a significant factor leading to soil compaction (Seehusen et al., 2019).

Over half of the respondents pointed to the importance of increasing SOM in the open-ended section, indicating that respondents are aware of the importance SOM has for soil quality (Arshad & Martin, 2002). Riley (2012) pointed to the complexity of increasing SOM in this area due to the low amount of livestock and grassland. Results displayed conflicting understanding of how to increase SOM in cereal farming in southeast Norway. There was a consensus understanding of "more diverse crop rotation" as a solution, while not all respondents agreed to "more use of cover crops" or "more use of organic fertilizer" as solutions. Recent studies (Uhlen et al., 2017; Waalen et al., 2019) have emphasized the importance of crop rotation for several indicators of soil quality, but that increasing SOM is difficult without implementing ley. Although cover crops and organic fertilizer are known to improve soil quality (Bøe et al., 2019; Waalen et al., 2019), a combination of several measures is needed to improve soil quality (Riley, 2012).

Consensus was found on education as a solution, and recent studies have emphasized the importance of increasing knowledge as the first step towards implementing new sustainable practices (Padgitt & Petrzelka, 1994)**.** All respondents considered "more farmer demonstration days" as a solution to improve soil quality. Farm days function as a link between documented knowledge and practical agronomical measures and is a participatory approach towards increasing practical agricultural knowledge (Vedeld & Krogh, 1999). This arena is considered to be vital for farmers' environmental awareness (Sæther, 2010; Vedeld & Krogh, 1997).

That respondents were neutral or disagreed with financial incentives as a solution is an interesting result as it contrasts with previously documented effects of increasing subsidies on environmental measures. Prior implementation of subsidies for drainage, cover cropping, and reduced tillage have influenced farmers' practices in a wanted direction (Stabbetorp, 2014).

4.2 Hindering and supporting forces influencing respondents' understanding.

Social context

Previous research has emphasized how social context influences farmers' awareness, knowledge, and practice (Vatn, 2007; Vedeld et al., 2003). A high degree of agreement on "Setting examples to follow; if a farmer succeed others will follow" indicate a supportive agricultural environment. That farmers look to each other's practices can function as a supportive force. If farmers who implement measures improving soil quality succeed, i.e., practicing "good agronomy", other farmers are more likely to adopt these practices. Vice versa, the social context can be a hindering force if measures improving soil quality are not considered "good agronomy", e.g., by providing less economic output (Vedeld et al., 2003). Pfeffer and Sutton (2000) emphasized how strong social identity causes people to readily reject knowledge and practices that are different from how people in their group think and act. Consequently, soil-improving practices must be considered as "good agronomy" to be adopted by the broader agricultural community.

The role of the extension service

Results from this research indicate that the extension service can function as both a hindering and a supportive force towards agricultural stakeholders' understanding of decline and improving soil quality. Both lack of advice on soil-improving practices from the extension service and lack of knowledge-sharing were emphasized by respondents, though not at consensus. Previous research has criticized advisors for supporting an industrial view on agriculture, which is leading to environmental degradation (Sæther 2010). The close relationship between farmers and advisors can function as a hindering force towards improving soil quality if the advisors do not emphasize the importance of soil quality in their contact with farmers.

The results suggest that the extension service also functions as a supporting force towards understanding the problem and increasing soil quality. Results indicated a close connection and high trust between the different stakeholder groups. The extension service plays a vital role as a link between the farming community and scientific research, and "good agronomy" is formed in the relationship between farmers and advisors (Vedeld et al., 2003). Consequently, the advisors can influence "good agronomy" to concern soil-improving practices through their tacit knowledge of farmers' practices.

Productivity focus leading to decline

Respondents in F3 criticized the agricultural policy and strongly agreed with the statement "Pressure on the farmer to produce at a low cost" as a cause leading to declining soil quality. This perception indicates that a productivity focus is a hindering force towards increasing soil quality. Thus, farmers might be strained between economic and environmental factors, what Cochrane (1958) described as "the farmer treadmill". If farmers feel trapped in the treadmill, measures that increase soil quality are most likely given less priority if it results in lower economic profitability (Brobakk, 2017). Hoel et al. (2013) wrote that decreased profitability in cereal farming could have made farmers even more cynical towards profit maximation. Environmental measures might be given lower priority as they often are considered as long-term investments, which correlates to the neo-classical perspective on farmers' greatest motivation to be economic profitability. Consequently, soil quality is losing against a productivity focus and profit maximation. A similar argument was made by Kolberg (2016), who argued that short-term focus on maximation of grain yields, combined with the consequences of the regional specialization policy, has led to a decline in soil fertility.

Possible ignorance–knowing gap and knowing–doing gap

Most respondents agreed to there being a lack of knowledge on soil amongst farmers, and the results showed possible ignorance among some respondents on soil quality decline in southeast Norway. Ignorance on soil quality decline can also be because respondents do not have a noticeable soil quality problem, as discussed in "4.1.1". Paradoxes regarding problems and solutions were also discovered in the results. One example is that there was consensus on the problem statement; "<u>no cover crops over winter</u>", while; "<u>more cover crops</u>" was not considered a solution among all respondents. On the other hand, this paradox could also indicate that respondents have different perceptions on solutions to the problem, and not necessarily be a consequence of lack of knowledge.

Results showed possible "knowing–doing" gaps among respondents. Consensus agreement on "monoculture" as a reason to soil quality decline, even by the farmers practicing monoculture, could be one example of a knowing-doing gap. This gap is evident as consensus was found on "more diverse crop rotation" as a solution to improve soil quality. Farmers practicing monoculture know that their practice is causing soil quality decline and are aware of solutions, but do not know or ignore implementing the measures needed. A second example is that most respondents agreed to more cover cropping as a solution. Respondents' understanding of the positive effects of cover crops is not reflected in practical measures out on the field as there has been a significant decrease in the use of cover crops in southeast Norway since the early 2000s (Snellingen Bye et al., 2019; Stabbetorp, 2014).

A combination of raising awareness and increasing knowledge about practical soil-improving measures is needed to reach soil sustainability (Nickum et al., 2018; Webb et al., 2017). All respondents disagreed with "there is nothing we can do to improve soil quality" and "There is not much we can do; problems are due to natural, climatic variations". That respondents recognize that measures can be implemented is a supportive force towards improving soil quality.

4.3 Steps towards improving soil quality

Raising awareness through participatory approaches

Consensus on educational aspects indicates that all respondents were positive towards increasing awareness and knowledge to improve soil quality. Raising awareness of soil quality decline and knowledge of practical solutions is the first step towards implementation of new sustainable practices (Padgitt & Petrzelka, 1994). The results showed that soil quality decline is a possible “tension-zone” between agricultural stakeholders where there is disagreement among respondents on causes and solutions. Vedeld and Krogh (1997) stressed the importance of “understanding-oriented competence development” on tension-zones and areas with disagreement. A participatory educational approach where awareness and competence are co-created is necessary to implement environmental measures (Bruges & Smith, 2008).

“Farm days” is an example of a participatory educational approach that already exists in the farming community. Arenas like farm days provide the farmers with research input in a practical context. This arena is vital to increase awareness and knowledge on environmental measures among farmers (Sæther, 2010; Van de Ven & Johnson, 2006; Vedeld & Krogh, 1999; Vedeld et al., 2003). Naturally, a focus on improving soil quality from the extension service on these days would increase awareness of the problem and knowledge of solutions throughout the farming community.

Results showed consensus or high agreement on several soil-improving factors among respondents, e.g., increasing SOM and more diverse crop rotation. Advisors can use their tacit knowledge combined with a participatory approach on farm days or other arenas to exemplify practical soil-improving measures. One of the strengths of the extension service is its capability to convert research to practical measures that relate to the farmers’ experience-based knowledge. The combination of high trust in the farming community, an understanding of farmers’ practices, and a close connection to the research community provide the advisor with a critical role to raise awareness and increase knowledge of soil-improving practices (Angstreich & Zinnah, 2007; Van de Ven & Johnson, 2006).

Vedeld and Krogh (1997) argued that the implementation of environmental measures requires the approval of the farming community at large and not only from individuals. Consequently, soil-improving measures need to agree with what is considered “good agronomy”. Advisors play a vital role in the continuous development of this social context through their role of adapting research into practical measures (Sæther, 2010). The extension service needs to promote soil-improving measures as “good agronomy” in collaboration with other stakeholder groups.

Holistic and participatory approach and future research

Results showed a possible reductionistic approach to soil quality decline among many respondents, in contrast to the description of soil quality decline as a “wicked” problem (Nickum et al., 2018). Brodnig and Mayer-Schönberger (2000) identified a reductionist approach as typical in western tradition, where also local knowledge is second to scientific knowledge. There is a need to move away from a conventional, reductionist view on components, and towards a holistic, cross-sectoral, and non-linear approach to reverse the trend of declining soil quality. All stakeholders need to consider biological, physical, social, and financial components of soil quality and include both scientific and local knowledge to improve soil quality (Bruges & Smith, 2008; Ikerd, 1993; Méndez et al., 2013).

Further research could repeat this study with a larger random sample size to ensure representation from a broader population. Research from a broader population is necessary to provide policy recommendations.

5. Conclusion

This research showed both consensus and conflicting perspectives among agricultural stakeholders on problems causing, and solutions to, declining soil quality in southeast Norway. Farmers, agricultural advisors, and scientists all agreed to agricultural practices as a cause leading to soil quality decline. Consensus statements corresponding to recent studies were found on both causes to decline and solutions. However, not all respondents considered there to be a problem with declining soil quality in southeast Norway. Results showed possible knowledge gaps and knowing-doing gaps. Increasing awareness on the importance of soil organic matter and knowledge of practical soil improving measures were identified as vital factors to improve soil quality.

The results identified a positive approach to increasing awareness and knowledge of practical agricultural measures among all stakeholders. New information and practices must relate to the farmers' experience-based knowledge and be accepted as "good agronomy". Hindering and supportive forces that influence respondents' understanding of problems and solutions to soil quality decline were identified. It is essential to understand how farmers' influence each other's practices by understanding the social context, i.e., what is considered "good agronomy". A productivity focus was identified as a possible hindering force leading to soil quality decline. The extension service can function as both a hindering and supporting force as it has a vital role as the link between documented knowledge and practical agricultural measure. Advisors can use their tacit knowledge and high trust in the farming community to raise awareness of soil-improving practices trough, e.g., farm days. Participatory approaches like farm days are crucial to increase awareness and knowledge on measures that improve soil quality.

This paper concludes by arguing that there is a need to move away from a reductionist understanding of soil quality. Soil quality decline is a complex issue where there are no single solutions, and a holistic approach is needed. Agricultural stakeholders need to consider soil quality in every aspect of the farming operations to improve soil quality in the future.

Bibliography

9, M. S. (2011). *Landbruks-og matpolitikken–Velkommen til bords*: Landbruks-og Matdepartementet, Regjeringen Oslo.

Almås, R. (2002). *Frå bondesamfunn til bioindustri : 1920-2000*, vol. 4. Oslo: Samlaget.

Angstreich, M. G. & Zinnah, M. M. (2007). A meeting of the minds: farmer, extensionist, and researcher. *Journal of International Agricultural and Extension Education*, 14 (3): 85-95.

Arnoldussen, A. H., Forbord, M., Grønlund, A., Hillestad, M. E., Mittenzwei, K., Pettersen, I., & Tufte, T. (2014). *Økt matproduksjon på norske arealressurser*. Oslo, Norway: AgriAnalyse AS.

Arshad, M. A. & Martin, S. (2002). Identifying critical limits for soil quality indicators in agro-ecosystems. *Agriculture, Ecosystems & Environment*, 88 (2): 153-160.

Bini. (2009). *Soil: A precious natural resource*: Nova Science Publishers: Hauppauge, NY, USA. pp. 1-48.

Bjørlo, B. & Rognstad, O. (2019). *Nesten ikke til å kjenne igjen*. In SSB (ed.). Grønt Skifte. https://www.ssb.no/jord-skog-jakt-og-fiskeri/artikler-og-publikasjoner/nesten-ikke-til-a-kjenne-igjen: SSB (accessed: 28.19).

Breland, T. A. (1992). *Organisk materiale og biologiske prosessar i jorda*. Ås: Statens fagtjeneste for landbruket.

Brobakk, J. (2017). Klima for endring? *Norsk statsvitenskapelig tidsskrift*, 33 (03-04): 21.

Brodnig, G. & Mayer-Schönberger, V. (2000). Bridging the gap: the role of spatial information technologies in the integration of traditional environmental knowledge and western science. *The Electronic Journal of Information Systems in Developing Countries*, 1 (1): 1-15.

Bronick, C. J. & Lal, R. (2005). Soil structure and management: a review. *Geoderma*, 124 (1-2): 3-22.

Bruges, M. & Smith, W. (2008). Participatory approaches for sustainable agriculture: A contradiction in terms? *Agriculture and Human Values*, 25 (1): 13-23.

Bunger, A. & Tufte, T. (2016). Den norske landbruksmodellen. *Agri Analyse, Rapport*: 6-2016.

Bøe, F., Bechmann, M., Øgaard, A. F., Sturite, I. & Brandsæter, L. O. (2019). Fangvekstenes økosystemtjenester–Kunnskapsstatus om effekten av fangvekster. *NIBIO Rapport*.

Chen, X., Henriksen, T. M., Svensson, K. & Korsaeth, A. (2019). Long-term effects of agricultural production systems on structure and function of the soil microbial community. *Applied Soil Ecology*: 103387.

Clark, B. (2011). Only clever science will yield crop results. *Journal of Farm Management*, 14 (4): 319-328.

Cochrane, W. W. (1958). *Farm prices: myth and reality*: U of Minnesota Press.

Davis, C. H., Michelle, C. (2011). Q methodology in audience research: Bridging the qualitative/quantitative 'divide'. *Participations: Journal of Audience and Reception Studies*, 8 (2): 559-593.

Duram, L. A. (2000). Agents' perceptions of structure: How Illinois organic farmers view political, economic, social, and ecological factors. *Agriculture and Human Values*, 17 (1): 35-48.

Erkossa, T., Itanna, F. & Stahr, K. (2007). Indexing soil quality: a new paradigm in soil science research. *Soil Research*, 45 (2): 129-137.

FAO. (2015). *Healthy soils are the basis for healthy food production*. http://www.fao.org/soils-2015/news/news-detail/en/c/277682/ (accessed: 16.08.).

FAO. (2017). Voluntary Guidelines for Sustainable Soil Management.

FAO, I. (2015). *Status of the world's soil resources (SWSR)–main report*. Rome, Italy: Food and agriculture organization of the United Nations and intergovernmental technical panel on soils.

Grønlund, A., de Zarruk, K.K. & D.P. Rasse (2010). Klimatiltak i jordbruket – binding av karbon i jordbruksjord. *Bioforsk Rapport*, 5 ((5)): 34.

Hauge, A., Kværnø, S., Deelstra, J., Bechmann, M., Hovland, I. & Stornes, K. (2011). Dreneringsbehov i norsk landbruk-økonomi i grøftingen. *Bioforsk rapport*, 6 (128-2011): 61.

Hegrenes, A., Mittenzwei, K. & Prestegard, S. S. (2016). *Norsk jordbrukspolitikk : handlingsrom i endring*. Bergen: Fagbokforl.

Herrington, N. & Coogan, J. (2011). Q methodology: an overview. *Research in Teacher Education*, 1 (2): 24-28.

Hoel, B., Abrahamsen, U., Strand, E., Åssveen, M. & Stabbetorp, H. (2013). Tiltak for å forbedre avlingsutviklingen i norsk kornproduksjon. *Bioforsk rapport*, 8: 14-95.

Ikerd, J. E. (1993). The need for a system approach to sustainable agriculture. *Agriculture, Ecosystems & Environment*, 46 (1-4): 147-160.

IPCC. (2019). *Summary for Policymakers*. Climate Change and Land.

Johnson, M. (1992). Research on traditional environmental knowledge: its development and its role. In *Lore: capturing traditional environmental knowledge*: IDRC, Ottawa, ON, CA.

Knickel, K., Brunori, G., Rand, S. & Proost, J. (2009). Towards a better conceptual framework for innovation processes in agriculture and rural development: from linear models to systemic approaches. *Journal of Agricultural Education and Extension*, 15 (2): 131-146.

Kolberg, D. (2016). Regional Specialisation Policies in Norwegian Agriculture Should be Revised. *Guidelines for Authors*, 6 (14).

Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability*, 7 (5): 20.

Landbruksdirektoratet. (2018). *Produksjon og omsetning av økologiske landbruksvarer 2018*.

Landbruksdirektoratet. (2019). *Drenering av jordbruksjord*. https://www.landbruksdirektoratet.no/no/miljo-og-okologisk/drenering/om-tilskudd-til-drenering-av-jordbruksjord#hvilke-dreneringstiltak-gir-rett-til-tilskudd- (accessed: 22.11).

Méndez, V. E., Bacon, C. M. & Cohen, R. (2013). Agroecology as a transdisciplinary, participatory, and action-oriented approach. *Agroecology and Sustainable Food Systems*, 37 (1): 3-18.

Montanarella, L. (2006). The importance of soil biodiversity and bio-indication within the EU thematic strategy for soil protection. *BIO-BIO project, RM Cenci and F. Sena, Editors, EU-JRC*: 15-22.

Nickum, J. E., Bjornlund, H. & Stephan, R. M. (2018). Wicked problems facing integrated water quality management: what IWRA experts tell us. *Water International*, 43 (3): 336-348.

Olsen, H. & Nyborg, Å. A. (2014). Jordkvalitet.

Padgitt, S. & Petrzelka, P. (1994). Making sustainable agriculture the new conventional agriculture: social change and sustainability. *Sustainable agriculture systems*: 261-285.

Pagliai, M. V., N.;Pellegrini, S. . (2004). Soil structure and the effect of management practices. *Soil and Tillage Research*, 79 (2): 131-143.

Pfeffer, J. & Sutton, R. I. (2000). *The knowing-doing gap: How smart companies turn knowledge into action*: Harvard business press.

Pretty, J. N. (1995). Participatory learning for sustainable agriculture. *World development*, 23 (8): 1247-1263.

Riley, H. & Bakkegard, M. (2006). Declines of soil organic matter content under arable cropping in southeast Norway. *Acta Agriculturae Scandinavica, Section B – Soil & Plant Science*, 56 (3): 6.

Riley, H. (2012). Reversing organic matter decline in Norwegian arable soilsa challenging task. *Bioforsk Fokus*, 7 (2).

Riley, H., Borresen, T., Ekeberg, E. & Rydberg, T. (2017). Trends in reduced tillage research and practice in Scandinavia. In *Conservation tillage in temperate agroecosystems*, pp. 23-45: CRC Press.

Riley, P., Eltun, R. & Korsæth, A. (2005). *Endringer i jordstrukturen ved ulike dyrkingssystem: Forsøkserfaringene fra systemforsøket på Apelsvoll 1988-2003*: Grønn kunnskap.

Schjønning, P., Elmholt, S. & Christensen, B. (2004). Soil quality management—synthesis. In *Managing Soil Quality: Challenges in Modern Agriculture*, pp. 315-333: CAB International.

Seehusen, T., Riggert, R., Fleige, H., Horn, R. & Riley, H. (2019). Soil compaction and stress propagation after different wheeling intensities on a silt soil in South-East Norway. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science*, 69 (4): 343-355.
Singh, B. P. C., Annette L. ; Chan, K. Yin. . (2011). *Soil Health and Climate Change*, vol. 29. Berlin: Springer Berlin Heidelberg.
Snellingen Bye, A., Aarstad, P. A., Løvberget, A. I., Rognstad, O. & Storbråten, B. (2019). Jordbruk og miljø 2018. Tilstand og utvikling.
SoilCare. (2019). *SoilCare for Profitable and Sustainable Crop Production in Europe*. https://www.soilcare-project.eu/ (accessed: 16.08).
Stabbetorp, H. (2014). *Landbrukets utvikling siden 1950. Utviklingstrekk av betydning for vannkvaliteten*. Vannforeningen, pp. 89-96: Vann.
Stabbetorp, H. (2018). Dyrkingsomfang og avling i kornproduksjonen. *Jord-og Plantekultur 2018. Forsøk i korn, olje-og proteinvekster, engfrøavl og potet 2017*.
Sæther, B. (2010). Agricultural extension services and rural innovation in inner Scandinavia. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography*, 64 (1): 1-8.
Thomas, D. T., Moore, A. D., Bell, L. W. & Webb, N. P. (2018). Ground cover, erosion risk and production implications of targeted management practices in Australian mixed farming systems: Lessons from the Grain and Graze program. *Agricultural systems*, 162: 123-135.
Tufte, T. (2012). Stagnasjon i norsk produksjon–importvolum i vekst. *Rapport 4-2012*.
Uhlen, A. K., Børresen, T., Deelstra, J., Waalen, W., Strand, E., Bleken, M. A., Seehusen, T., Kværnø, S., Sundgren, T. & Lillemo, M. (2017). Økt kornproduksjon gjennom forbedret agronomisk praksis. En vurdering av agronomiske tiltak som kan bidra til avlingsøkninger i kornproduksjonen. *NIBIO Rapport*.
Uleberg, E., & Dalmannsdottir, S. . (2018). Klimaendringenes påvirkning på landbruket i Norge innenfor ulike klimasoner. *NIBIO Rapport*.
UN. (2019). *Sustainable Development Goal 15: Life on land*. Sustainable Development Goals. https://www.un.org/sustainabledevelopment/biodiversity/: United Nations (accessed: 10.12).
Unger, P. W. & Kaspar, T. C. (1994). Soil compaction and root growth: a review. *Agronomy Journal*, 86 (5): 759-766.
Vågen, T. (2000). Effects of management practice on soil organic matter content. *Effects of management practice on soil organic matter content.* (38): 115-122.
Vagstad, N. A., U.; Strand, E.; Uhlen, A. K.; Lund, H. J.; Rognlien, A.; Solberg, H. . (2013). Økt norsk kornproduksjon. Utfordringer og tiltak. *Rapport fra ekspertgruppe til LMD*, 39.
Van de Ven, A. H. & Johnson, P. E. (2006). Knowledge for theory and practice. *Academy of management review*, 31 (4): 802-821.
van der Putten, W., Ramirez, K. S., Poesen, J., Winding, A., Lemanceau, P., Lisa, L., Simek, M., Moora, M., Setala, H. & Zaitsev, A. (2018). *Opportunities for soil sustainability in Europe*, 3804738982.
Vatn, A. (2007). *Institutions and the Environment*: Edward Elgar Publishing.
Vedeld, P. & Krogh, E. (1997). *Farmers, Information and Environmental Policy*. Department of Economics and Social Sciences: Agricultural University of Norway. Unpublished manuscript.
Vedeld, P. & Krogh, E. (1999). Rationality is in the eye of the actor. *Soil and water conservation policies and programs: successes and failures*: 285-318.
Vedeld, P., Krogh, E. & Vatn, A. (2003). *Good agronomy. Social institutions among Norwegian farmers and public sector governance*. XX ESRS Congress. Sligo, Irland.
Waalen, W., Abrahamsen, U. & Stabbetorp, H. (2019). Vekstskifte-forsøk og praksis. *Jord-og Plantekultur 2019. Forsøk i korn, olje-og proteinvekster, engfrøavl og potet 2018*.

Webb, N. P., Marshall, N. A., Stringer, L. C., Reed, M. S., Chappell, A. & Herrick, J. E. (2017). Land degradation and climate change: building climate resilience in agriculture. *Frontiers in Ecology and the Environment*, 15 (8): 450-459.

Øpstad, S. (2016). Drenering.

Appendices

A – Q Sort

Problem statements – Q sort

Table 1. Displays average Q-sort for each of the three factors identified as problems causing decline in soil quality, where; **-2**=Strongly disagree, **-1**=Disagree, **0**=Neutral, **1**=Agree, **2**=Strongly Agree.

Bold numbers indicate a distinguishing statement at $p < 0.01$ in each factor; underlined numbers indicate consensus statement across factors.

Factors loading on to statements *Problem statements*	**Factor 1**	**Factor 2**	**Factor 3**
Compaction	2	2	**2**
Soil tillage practices	1	0	1
Lack of use of new technology and innovation	**-2**	0	-1
Use of entrepreneurs/external labor	1	**-1**	1
Intensive agriculture	0	**-1**	1
Not enough knowledge being shared between scientists, advisors and farmers	0	1	**-1**
Loss of organic matter	2	2	2
Soil erosion	<u>2</u>	<u>2</u>	<u>2</u>
Fear of new practices and methods	0	1	**-1**
Local weather and climate	**-1**	1	1
Lack of knowledge on soil amongst farmers	2	1	**0**
Distrust of scientists among farmers	-1	0	**-2**

Soil being used to other types of agriculture (grazing/other plant production)	-2	**-1**	-2
Flooding or drought	**-2**	0	1
Pressure on farmer to produce at a low cost	0	1	**2**
Soil has become too saline	-1	-1	-2
Too little advise on soil-improving practices	**1**	**2**	**-1**
Peer-pressure	-1	-1	**-2**
Choice of crops (cropping system)	1	1	1
Too much environmental regulation	**-2**	**0**	**-1**
Too large farms	**-1**	**-2**	**1**
Topography of the land	**-2**	0	0
Loss of number of wild species	**0**	-2	-2
Farmer has lost touch with the finer understandings of his land	**1**	**-2**	**-1**
Climate change	**-2**	**0**	**1**
Farmer has little control over his own land	-1	-2	-1
Loss of soil structure	2	1	2
Declining level of nutrient status	0	1	0
Distrust between farmers and advisory agencies	-1	-1	**-2**
Poor management of the soil/poor soil management	**2**	1	0
Too many regulations	-2	**0**	-1
Overuse of input like fertilizers and pesticides	**1**	**-2**	**-1**
I do not believe that there is a problem with soil quality	-2	**2**	-2

No cover crop over winter	1	2	1
Disconnection between nature-based agriculture and the modern agriculture	**1**	**-1**	**0**
Product demand from the market	0	**-2**	0
Repetition of same crop year after year; monoculture	<u>2</u>	<u>1</u>	<u>2</u>
Norwegian agriculture policy	1	**-1**	0
Agriculture has become too quantified, everything is to be measure	-1	-1	**0**
High share of leased land	**0**	**-2**	**1**
Too little drained land	**0**	**2**	2

Solution statements – Q sort

Table 2. Displays average Q-sort for each of the three factors identified as solutions to improving soil quality, where; **-2**=Strongly disagree, **-1**=Disagree, **0**=Neutral, **1**=Agree, **2**=Strongly Agree Average Q-sort

Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statement across factors.

Factors **Solution Statements**	Factor A	Factor B	Factor C
Regulation of water usage	-2	-1	-1
More communication and sharing of knowledge between farmers on a local level	0	1	1
Investment in education and training	1	1	2
More use of local knowledge and experience	**0**	2	1
More regulations for fertilizers	**-1**	**-2**	**0**
Less use of heavy machinery	**0**	1	2
More farmer demonstration days	1	1	1
Change the timing of tillage	0	0	-1
More research done in collaboration with farmers	1	0	1
More small farms	**-2**	0	0
Improve trust between farmers and institutions	**-1**	0	0
More resting soil	-1	-2	-2
More innovations	**1**	-1	-1
There is not much we can do with the cropping system to improve soil quality	**-2**	-2	**-2**

Financial incentives (e.g. subsidies)	0	**-1**	0
Setting examples to follow; if a farmer succeed others will follow	**2**	1	0
Creation of a "Soil Directive"	**-1**	**-2**	**-1**
There is not much we can do; problems are due to natural, climatic variations.	**-2**	**-1**	**-2**
Less soil compaction	2	2	2
More diverse crop rotation	2	2	2
More education on environmental impacts	1	**0**	1
More use of organic fertilizer	1	1	0
Society needs to change focus on what farmers produce	0	0	**2**
More advise on use of technology	**0**	0	-1
More targeted mapping of soil threats	**1**	0	0
More cover crops	2	**-1**	2
More traditional agricultural practices	-1	-1	-1
Farmers have already tried many measures to improve soil quality	-1	**1**	-1
More regulation	-1	**-2**	-2
Increase adoption of new techniques	0	-1	-1
More financial penalties	-2	-2	-2
Increase knowledge of soil types	2	2	**1**
Reduce share of leased land	**-2**	1	0
More drainage of agricultural land.	2	2	**1**

B – Quotes from the open-ended sections

Referred quotes are translated to English in the text. The original quotes in Norwegian are displayed below.

Abbreviations:

- MK: Bonde med monokoltur (monoculture farmer)
- VK: Bonde med vekstskifte (crop rotation farmer)
- ØK: Økologisk kornbonde (Organic cereal farmer)
- R: Rådgiver (Advisor)
- F: Forsker (Scientist)

Problems Faktor 1:

Q1, VK: «For lite kunnskap om jord, næringsstoffer og dyrkingspraksis»

Q2, VK: «Vi som er bønder er lite i fysisk kontakt med jorda. Dagens maskiner takler forhold der det egentlig ikke burde blitt kjørt».

Q3, F: «Viktigste faktor er regulering, som førte til mangle av organisk material i kornområder».

Q4, VK: «Samfunnets krav om billig mat tvinger fram dyrkingsteknikker som vi kjenner de idag, der resultatet er ei jord som har blitt drevet på en måte de siste 70 åra som har frigjort en stor mengde nødvendig co2. Med tap av co2 henger sammen med struktur, tap av co2 som selve limet i jorda utarmerer jorda for liv og organisk materiale der vi sitter igjen med jord som lett lar seg pakke, tørke ut og drukne i mangel på alt. Så oppsummert må vi bli flinkere til å jobbe med naturen.»

Q36, VK: «Mindre husdyrgjødsel tilgjengelig på gårdene, men nå er det økt fokus på fangvekster og det å ha fotosyntese større deler av året som vil bidra til mer biomasse i jorda. Samtidig er lagelighet svært avgjørende, samt andre "verktøy" som dekktrykk mm. viktig for å jobbe for ei god fruktbar jord.»

Problems Faktor 2

Q5, MK: Er det så skråsikkert at jordkvaliteten har gått ned, er det dokumentert?

Q6, F: Det er anerkjent i Norge at manglende drenering og jordpakking er et problem, og at det kan gi redusert jordkvalitet. Utover dette mener jeg at det i fagkretser ikke er sett på som et faktum at jordkvaliteten her i Norge går ned. Det er sett på som et større problem at matjord går ut av produksjonen fordi den tas i bruk til andre formål, f. eks. til nedbygging og til veg og jernbane.

Q7, R: Usikker på om det står så dårlig til med jordkvaliteten. Det høstes stadig større og større avlinger, med god kvalitet i vårt område. Gårdbrukere er lærevillige, gjør veldig mye rett og tenker fremover.

Q28, VK: Dårlig vekstskifte. Men vi ser at jordkvaliteten straks blir bedre, så jeg mener bildet ikke er så svart hvitt som denne undersøkelsen skal ha det til. Det går fint an å begynne å utføre tiltak (vekstskfiten, grøfting, kalking, fokus på jordpakking) som raskt får effekt.

Q29, VK: Mangel på dekkvekst, fangvekst

Q30, VK: For mye pløying, vi må få marken tilbake til matjordlaget.

Q31, ØK: Monokultur, pløying, mangel på dekkvekster og fangvekster. Kunstgjødsel og kjemikalier ødelegger mikrolivet i jorda som er essensielt for godt næringsinnhold i matvarene

Problems Factor 3

Q8, MK: Tungt utstyr / for lite redusert jordarbeiding / ensidig planteproduksjon.

Q9, MK: Store driftsenheter med store maskiner som utfører arbeid på ugunstig tidspunkt. Jordpakking

Q10, MK: Jordpakking særlig fra de som forpakter mye jord= meget stort utstyr med hardpumpede dekk for å kunne kjøres raskt mellom jordene.

Q11, ØK: Lite vekstskifte, våtere klima og større maskiner

Q12, VK: For lite fokus og kompetanse om jordhelse.

Q13, R: For dårlig vekstskifte og at arealene har blitt for store slik at de ikke rekker å være på rett sted når jorda er lagelig. Stordrift stimulerer ofte de mest maskinintreserte, og ofte har ikke disse så god kunnskap om jord og planter. Men heldigvis finnes det flere og fler gode unntak.

Q29, VK: Større bruk genererer større maskiner og mer jordpakking og mindre individuell vurdering av jordene. Kanaliseringspolitikken hvor mye ku på Jæren og korn på østlandet er ikke bra for jord kvaliteten eks vis.

Q30, R: For dårlig vekstskifte og at arealene har blitt for store slik at de ikke rekker å være på rett sted når jorda er lagelig. Stordrift stimulerer ofte de mest maskinintreserte, og ofte har ikke disse så god kunnskap om jord og planter. Men heldigvis finnes det flere og fler gode unntak.

Q31, R: 1 jordpakking pga.tunge maskiner og kjøring før jorda er lagelig, 2 tap av organisk materiale pga.ensidig korndrift, vegetasjon en liten del av året (ingen fangvekster) kombinert med intensiv jordarbeiding

Q32, R: Tunge maskiner, fuktig klima og mangelfull drenering

Q33, F: Intensivt jordbruk med fokus på høy produksjon. Det er kanskje større fokus på kortsiktig avling, og mindre fokus på å ta godt vare på jorda (langsiktig tankegang

Q34, VK: Klimaforandringer

Solutions faktor A

Q14, MK: Tilføre karbon i jorda. Dyrke egnede fangvekster for jordpenetrering.

Q15, MK: Mer bruk av fangvekster med dyptgående røtter.

Q21, MK: Grøfting og bruk av dekkvekster

Q22, VK: Mer bruk av dekkvekster

Q23, VK: Mindre jordarbeiding og holde jorda grønn hele året

Q24, ØK: det viktigste er å unngå pløying og bruk av kjemikalier. Eng er viktig i vekstskiftet, samt å ha grønt plantedekke hele året for å hindre overflateavrenning av humus samt tap av næringsstoffer til vassdrag via dreneringen.

Q25, ØK: Mer variert vekstskifte og fangvekster

Q35, F: Samfunnet og myndighetene må få et større fokus på jord. Tilgjengelig informasjon må frem til bønder, og myndighetene bør jobbe for en bedre forvaltning av jord gjennom subsidier o.l.

Solutions faktor B

Q16, MK: Flere sammenfallende faktorer, - alt henger sammen med alt

Q17,MK: Kalking og grøfting

Q18, VK: Færre gigastore jordleiere

Q19, VK: Mindre leiejord og høyere pris for avlingene

Q36, M: God agronomi, gjøre ting til rett tid med riktige og nødvendige innsatsmidler i riktig mengde er viktigst for å opprettholde en god jordkvalitet.

Q37, F: Tiltakene må tilpasses jordtypen. Generelt tror jeg tiltak som kan gi bedre jordstruktur og mer aggregatdannelse i matjordsjiktet er viktig. Tiltak for å oppnå dette kan være økt tilførsel av organisk materiale i jord med lavt organisk innhold, i kombinasjon med god dreneringstilstand, bruk av maskiner med et marktrykk innenfor det jorda kan tåle og kjøring på tidspunkt som jorda er egnet.

Solutions faktor C

Q20, F: Alle tiltak som øker organisk materiale i jordene.

Q26, VK: På tyngre jordtyper (silt og spesielt leire) Er det 2 ting som er helt vesentlig og må være på plass. Det ene er grøfting, godt grøftet jord er det aller viktigste. Nest etter det er det å kalke så vi får PH opp på 6.5. Da dette er på plass er det å se på dyrkingsteknikker, Aller helst bare direktesåing, men idag er det lite jord som vil fungere med dette, pga for lavt moldinnhold. Da er redusert jordarbeiding tingen (for all del kutt ut plog og fres) Så er det bedre vekstskifte enn ensidig korn, og evnt samdyrking med andre vekster. Fangvekster sådd om våren og etteravgrøder. (Grønt dekke hele tida)

Q27, ØK: Dekkvekster/organisk gjødsel

Q28, R: 1 jordpakking pga.tunge maskiner og kjøring før jorda er lagelig, 2 tap av organisk materiale pga.ensidig korndrift, vegetasjon en liten del av året (ingen fangvekster) kombinert med intensiv jordarbeiding

Q42, Økt bevissthet rundt problemet samt økonomiske insentiver fra staten slik at bønder lettere kan ta «de rette valgene».

Final comments

Q38, VK: Stor interesse for jordhelse og kompetansebygging hos mange bønder.

Q39, R: Bevissthet om bondens praksis vil gi bedret/ redusert jordkvalitet vil være viktigst. Uten en slik bevissthet vil teknologi, reguleringer osv ikke ha noen effekt. Et positivt økonomisk utslag av forbedret jordkvalitet vil være beste mulighet til tiltak. Utfordringen er også små garder og at de økonomiske utslagene dermed blir små, selv om tiltak forbedrer jordkvaliteten.

Q40, R: Du hadde et spørsmål om mer kursing var aktuelt - forsåvidt er det det - men ofte har gardbukere mange andre ting de må møte på. derfor er jeg litt mer for at vi har små innlegg om jordtema på møter de likevel må på. Små drypp. dessuten - er det jo krava rasjonaliseringa som setter litt stopper for at gardbrukeren faktisk tar hensyn til jorda si. Fler og fler ser det - men får nok ikke alltid gjordt noe med det. Dette er nok enda mer utbredt i grønnsaksdyrkinga. Spennende oppgave! Gleder meg til å høre resultatet. Lykke til 😊

Q41, VK: Det må forskes mer på alternative dyrkningssystemer og effekten av de.

C - Q-methodology

Gruber (2011) argued that Q-methodology can identify unique and shared perspectives about an issue, and it has been recognized as a valuable approach in environmental management. In Q-methodology, interviews are first conducted to understand respondents' subjectivity in the area being investigated. These interviews are combined with an extensive literature review, to ensure the subjectivity of concourse that exists around the issue under consideration (Herrington & Coogan, 2011) This data is the basis for the statements provided for the structured quantitative interview. The structured interview often take form as a questionnaire, where respondents are asked to rank predefined statements on a scale (Brown, 1980) The different perspectives from respondents found in the structured interview are then mapped based on the ranking (Chamberlain et al., 2012).
Eyvindson et al. (2015) argue that Q-methodology can yield an in-depth understanding of subjective perceptions, but that generalization of results is limited. Yin (2003) describes the problem of scientific generalization as a problem for all methods in science. The answer, he argues, is that methods are generalizable to theoretical propositions and not to populations or universes. This means that the results gathered through Q cannot be generalized but can provide a rich understanding of the subjective views of the respondents involved (Chamberlain et al., 2012).

Norges miljø- og biovitenskapelige universitet
Noregs miljø- og biovitskapelege universitet
Norwegian University of Life Sciences

Postboks 5003
NO-1432 Ås
Norway