Perceived Causes and Solutions to Soil Degradation in the UK and Norway

Rust, Niki; Lunder, Ole Erik; Iversen, Sara; Vella, Steven; Oughton, Elizabeth A.; Breland, Tor Arvid; Glass, Jayne H.; Maynard, Carly M.; McMorran, Rob; Reed, Mark S.

Published in:
Land

DOI:
10.3390/land11010131

First published: 14/01/2022

Document Version
Publisher's PDF, also known as Version of record

land

Article

Perceived Causes and Solutions to Soil Degradation in the UK and Norway

Niki Rust [1], Ole Erik Lunder [2], Sara Iversen [3], Steven Vella [4], Elizabeth A. Oughton [1], Tor Arvid Breland [2], Jayne H. Glass [5], Carly M. Maynard [5], Rob McMorran [5] and Mark S. Reed [6,*]

[1] Centre for Rural Economy, Newcastle University, Kings Road, Newcastle NE2 1HA, UK; niki_rust@hotmail.co.uk (N.R.); Elizabeth.Oughton@newcastle.ac.uk (E.A.O.)
[2] Faculty of Biosciences, Norwegian University of Life Science, 1432 Aas, Norway; Ole@greenhouse.bio (O.E.L.); tor.arvid.breland@nmbu.no (T.A.B.)
[3] Department of Agroecology, Aarhus University, Blichers Allé, 8830 Tjele, Denmark; sara.iversen@agro.au.dk
[4] School of the Built Environment, Birmingham City University, 15 Bartholomew Row, Birmingham B5 5JU, UK; stevenvella@gmail.com
[5] Rural Policy Centre, Department of Rural Economy, Environment & Society, Scotland's Rural College (SRUC), Peter Wilson Building, Kings Buildings, West Mains Road, Edinburgh EH9 3JG, UK; Jayne.Glass@sruc.ac.uk (J.H.G.); Carly.Maynard@sruc.ac.uk (C.M.M.); Rob.McMorran@sruc.ac.uk (R.M.)
[6] Thriving Natural Capital Challenge Centre, Department of Rural Economy, Environment & Society, Scotland's Rural College (SRUC), Peter Wilson Building, Kings Buildings, West Mains Road, Edinburgh EH9 3JG, UK
* Correspondence: mark.reed@sruc.ac.uk

Citation: Rust, N.; Lunder, O.E.; Iversen, S.; Vella, S.; Oughton, E.A.; Breland, T.A.; Glass, J.H.; Maynard, C.M.; McMorran, R.; Reed, M.S. Perceived Causes and Solutions to Soil Degradation in the UK and Norway. *Land* **2022**, *11*, 131. https://doi.org/10.3390/land11010131

Academic Editors: Guido Wyseure, Julián Cuevas González, Jean Poesen and Christine Fürst

Received: 24 November 2021
Accepted: 13 January 2022
Published: 14 January 2022

Abstract: Soil quality is declining in many parts of the world, with implications for the productivity, resilience and sustainability of agri-food systems. Research suggests multiple causes of soil degradation with no single solution and a divided stakeholder opinion on how to manage this problem. However, creating socially acceptable and effective policies to halt soil degradation requires engagement with a diverse range of stakeholders who possess different and complementary knowledge, experiences and perspectives. To understand how British and Norwegian agricultural stakeholders perceived the causes of and solutions to soil degradation, we used Q-methodology with 114 respondents, including farmers, scientists and agricultural advisers. For the UK, respondents thought the causes were due to loss of soil structure, soil erosion, compaction and loss of organic matter; the perceived solutions were to develop more collaborative research between researchers and farmers, invest in training, improve trust between farmers and regulatory agencies, and reduce soil compaction. In Norway, respondents thought soils were degrading due to soil erosion, monocultures and loss of soil structure; they believed the solutions were to reduce compaction, increase rotation and invest in agricultural training. There was an overarching theme related to industrialised agriculture being responsible for declining soil quality in both countries. We highlight potential areas for land use policy development in Norway and the UK, including multi-actor approaches that may improve the social acceptance of these policies. This study also illustrates how Q-methodology may be used to co-produce stakeholder-driven policy options to address land degradation.

Keywords: conservation agriculture; deliberative democracy; q-methodology; regenerative agriculture; soil conservation; sustainable land management

1. 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. Soils are the foundation of terrestrial food production, supporting directly or indirectly 95% of our food production [1]. 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 [2]. However, demand for food, increasing human populations and the effects of climate change are placing unprecedented pressures on soil. Over the last 70 years, the supply of global per capita food calories increased by about one-third, with the use of irrigation water roughly doubling and use of inorganic nitrogen fertiliser increasing nearly nine-fold [3]. At the same time, climate change has led to faster rates of warming on land than the global mean and altered precipitation patterns, which have contributed to altered growing seasons and regional crop yield reductions [4]. With rising human populations, coupled with increased individual wealth, it is expected that food demand will grow by as much as 70% by 2050; an estimated 46% of that demand needs to come from increasing food production [5]. This increase in food productivity must be achieved whilst significantly reducing greenhouse gas emissions from agriculture, if warming is to be restricted "well below" 2 °C, as proposed in the Paris Agreement [6]. How this is achieved without negatively impacting soils any further remains a challenge.

Soil quality[1] in many parts of the world is declining due to a combination of physical, chemical and biological degradation coupled with socio-economic drivers, reducing the soil's ability to undertake these important ecosystem functions [7]. Globally, 20–30 gigatons of soil are lost each year due to water erosion [7] and climate change is projected to increase erosion from water and reduce levels of soil organic carbon, especially in drylands [4]. There is thus an urgent need to develop and encourage widespread adoption of effective and profitable sustainable soil management practices [8,9]. 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" [10], and its Land Degradation Neutrality target which aims to counterbalance expected losses with measures to achieve equivalent gains within the same type of land [11].

There are many competing methods 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. These policies typically seek changes in management at farm and field scales, for example through the adoption of soil-improving cropping systems and other sustainable land management technologies and approaches (e.g., WOCAT [12]). The lack of scalable policy options was cited in the UNCCD's Global Land Outlook [9] 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 [8]. Again, the attractiveness and appropriateness of different options for policy and practices differ 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 and stakeholder engagement in the policy formulation process is crucial for this complex issue, given the subjective and value-laden nature of both the causes of and solutions to the challenge. Effectively representing diverse stakeholder perspectives in decision-making processes can lead to better informed, more durable, and flexible outcomes across a wide range of contexts (De Vente et al., 2016). Policies created through deliberative democracy can align better with social and cultural norms, resulting in increased trust and ownership of problems and solutions; together, this can lead to decisions that are more likely to be accepted and implemented, helping to achieve environmental goals more effectively [13,14].

As interest has grown in participatory approaches to policy making and other forms of deliberative democracy, methods have been sought to represent and integrate the range of perspectives, values and beliefs held by citizens in the policy-making process [15]. The application of Q-methodology to the co-production of policy options with stakeholders has been used by Rust [16] and Addams and Proops [17] 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.

In this study, we used Q-methodology to understand a wide range of stakeholder perspectives that could inform the design of socially acceptable options in agricultural soil management policy and practice. To address the lack of scalable policy options noted above by the UNCCD, this was done in the UK and Norway which are two countries experiencing similar types of soil degradation that are broadly representative of soil quality issues and climatic variation across northern temperate regions of Europe. The countries have contrasting agricultural policy environments, with Norway not being a part of the EU and the UK in the process of leaving the EU when the research was conducted. The countries also have quite different models of social democracy in land governance [18], which provides an opportunity to consider how the different land tenure regimes influence policy formulation and application. Both countries are interested in the co-development of policies to increase food production whilst reducing the environmental impacts of agriculture. By understanding where agricultural stakeholders agreed and disagreed over causes and solutions to declining soil quality in each country, we sought to highlight potential scalable options for land use policy development. This study also illustrates how Q-methodology may be used to co-produce stakeholder-driven policy options to address land degradation.

2. Materials and Methods

2.1. Study Sites

2.1.1. 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. About 25% of the total land area of the UK is suitable for arable cropping, with an average farm size of 81 hectares [19]. Currently, soil erosion exceeds the rate of soil formation in many areas in the UK, with around 17% of arable land showing signs of erosion, although as much as 40% may be at risk of further degradation [20]. The cost of soil erosion to the UK has been estimated at £45 million a year, including £9 million in lost production [21]. UK soil is being lost at a rate ten times that which it is created [2], with dramatic economic implications.

A comparison of soil nutrient balances from the year 2000 to 2019 shows a 24% decrease for nitrogen and a 46% decrease for phosphate (in kg per hectare) [19]. Soil erosion, compaction and loss of organic matter are thought to cost arable farmers an average of £5584 per year [22] and English water companies spend £21 million a year on addressing soil erosion [23]. Improving soil management in the UK is therefore not only an environmental but also an economic imperative. 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 [21,24].

2.1.2. Norway

Only 3.1% of the total land area in Norway is suitable for arable cropping, with an average farm size of 23.9 hectares in 2016; cereals can only be grown on one third of this area due to limiting natural conditions [25]. Although agricultural policies in Norway advocate multifunctional agriculture [26], regional agricultural specialisation, known as "kanaliseringspolitikken", was introduced in the after-war period, which led to increased agricultural production by incentivising cereal production in lower-lying areas [27]. In the last two decades, the total Norwegian cereal yield has declined due to a reduction in the area used for cropping [28]. Despite this decline, the Norwegian government has set a target of increasing food production by 20% by 2030 from 2010 levels, to meet projected population growth in Norway [29]. Three counties (Akershus, Østfold, and Hedmark) in southeastern Norway produce 60% of the country's cereal; however, soil organic matter (SOM) content has declined in the region, with an average loss of 1% of SOM a year from 1991 to 2001, which is not sustainable [30]. The underpinning governance and institutions (both formal and informal) are strongly communal in character [26]. The long history of collective land management, the regulation of the Norwegian land market and the self-imposed limits to farm scale are in contrast to the generally unregulated land market and existence of larger-scale farms in the UK.

2.2. Research Design

Q-methodology is a mixed-methods approach using interviews to explore participants' subjective understanding of a topic using Q sorts where respondents rate the extent to which they agree with statements, which are then analysed using by-person factor analysis, correlating people with others who hold similar opinions based on their Q-sorts. Q-methodology was chosen due to its capacity to shed light on complex, subjective phenomena where individuals hold differing views and values [30]. 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 [31,32]. 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 [16,33]. This makes the method particularly useful for this study due to the above benefits.

2.3. Data Collection

The research undertaken in the UK took place in late 2018 (when the UK was still part of the EU) and in Norway in mid-2019. Q-methodology studies commonly begin by using a 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, followed by a structured, quantitative interview where participants rank the concourse statements, usually based on the extent to which they agree/disagree. During these interviews, qualitative information is gathered from participants on their decision-making processes and preferences. Because the concourse is designed to cover as closely as possible all perspectives on a topic, and participants are chosen to cover the range of views, then 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, and to find points of convergence or divergence of opinion.

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 other landowners) were interviewed. An interview guide was used, which was piloted on a subset of the sample population and amended due to feedback. Interview themes and prompts are shown in Table 1. 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.

Table 1. Interview guide used to develop the concourse.

Questions	Prompts
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?	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	

A narrative review was undertaken, based on a broad-based search for relevant material, to provide further evidence to supplement the interviews and further expand the concourse. This review was to ensure that 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 was obtained from across all interviews and the 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 both studies, some statements arising from the literature were 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. For the UK study, this resulted in 41 statements for the "problems" Q-set and 34 statements for the "solutions" Q-set, and in Norway, this resulted in 42 problem statements and 36 solution statements (see Tables A1–A4, Appendix A).

A "Q-sort" is the ranking of the Q-set by participants. Data collection for the Q-sort was undertaken via an online survey using Google Forms. 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). The UK survey was distributed via soil-specific newsgroups, British agricultural union members and by sharing on agricultural social media channels. A total of 61 UK respondents undertook the survey: 19 scientists, 19 farmers, 16 agricultural advisers, three water company employees who work in agriculture, two nature conservationists, one agricultural union representative and one 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 six agricultural advisers and five scientists, totaling 53 respondents. The substantial weighting towards farmers in the Norwegian study was deemed acceptable due to the smaller average farm size in Norway and the historical legacy of communal land management which is embedded in national agricultural institutions [26]. However, the findings of our analysis may need to be interpreted in light of the greater diversity of stakeholders in the UK study.

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 statement. These open-ended questions were used to find out what, subjectively, respondents thought were the most important drivers for causing declining soil quality and how to fix these. Data from these open-ended questions were analysed via thematic analysis. 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.

2.4. 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 a "loaded factor". Flags were automatically added to respondents that significantly loaded onto these factors at $p < 0.05$.

For the UK study, the PCA for the problem Q-sort revealed eight 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 [34]. 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 because their inclusion gives little information about the clustering of opinions. 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 eight 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 sort, eight 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 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.

3. Results

This section describes results from the problems Q-sorts (Table A1, Appendix A: UK; Table A2, Appendix A: Norway) and solutions Q-sorts (Table A3, Appendix A: UK; Table A4, Appendix A: Norway). The number of respondents loading onto each factor (i.e., who ranked statements similarly) is shown in Figure 1 (UK problem Q-sort), Figure 2 (Norway problem Q-sort), Figure 3 (UK solution Q-sort) and Figure 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 the main defining traits of each factor. Key areas of consensus and disagreement that emerged across these different groupings are then highlighted.

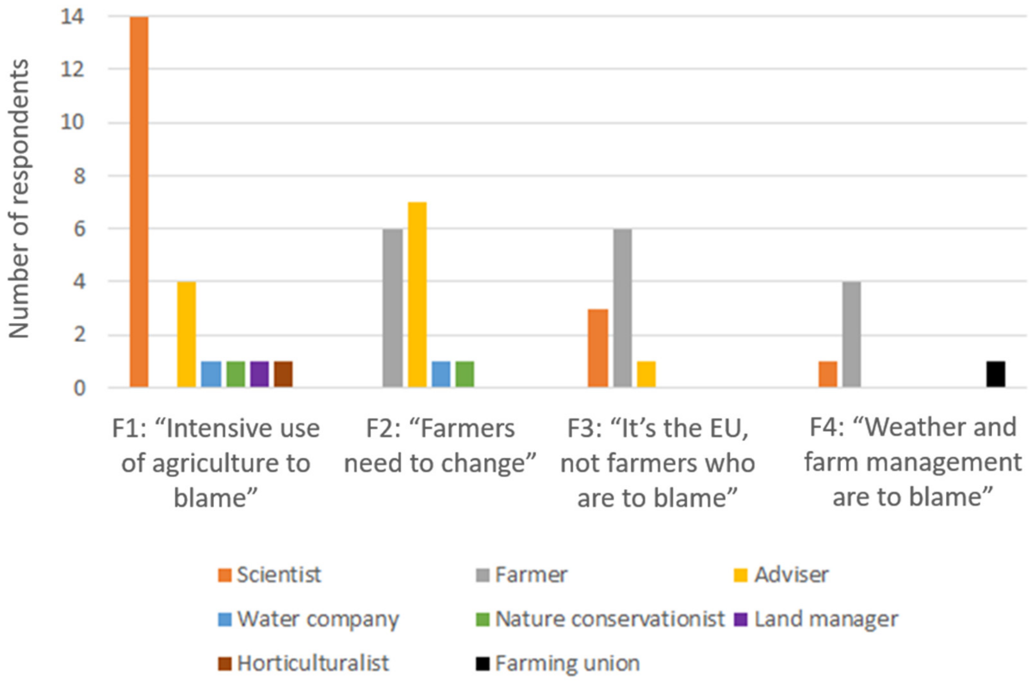

Figure 1. Professions of UK respondents loading onto the four problem factor groups.

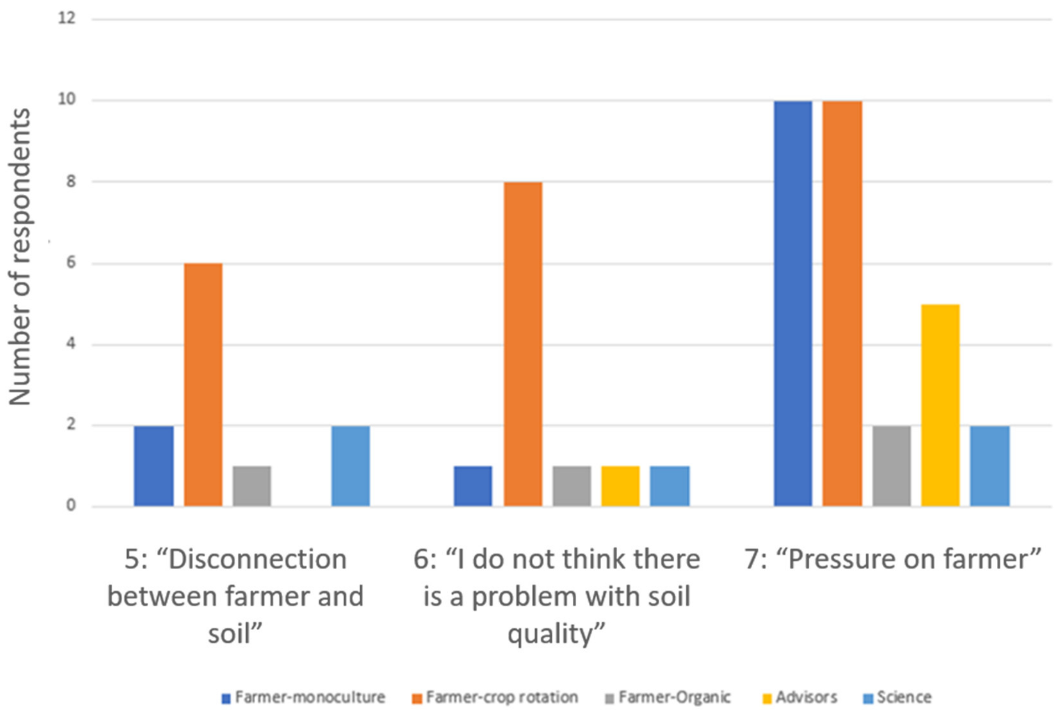

Figure 2. Professions of Norwegian respondents loading onto the three problem factor groups.

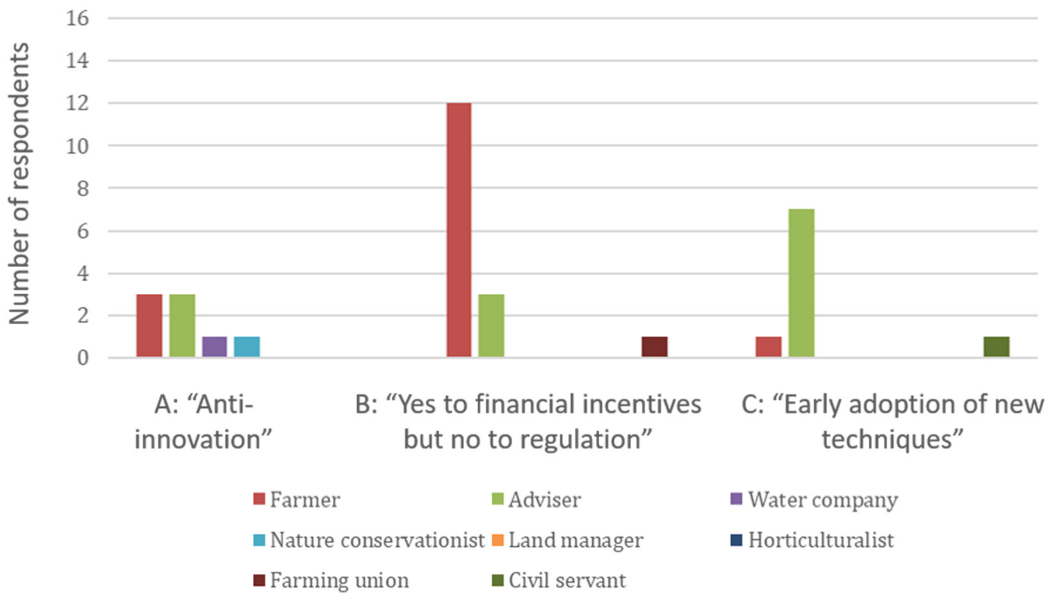

Figure 3. Professions of UK respondents loading onto the three solution factor groups.

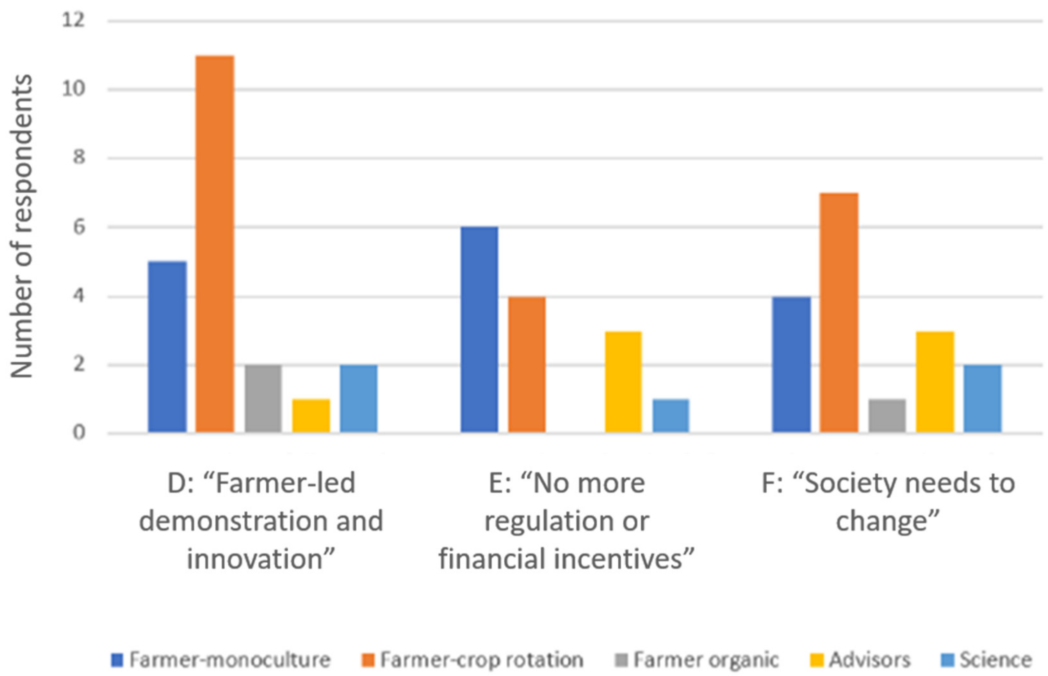

Figure 4. Professions of Norwegian respondents loading onto the three solution factor groups.

3.1. *Perceived Problems Causing Declining Soil Quality*

3.1.1. UK Study

Factor 1: "Intensive Agriculture to Blame"

This factor was defined by respondents who were 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 with these statements than other factors. In contrast, they strongly disagreed that the problem was caused by the fact that "soil has become too saline", ranking this statement more negatively than other factors.

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 regarding "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 with the idea that "EU agricultural policy" was the cause of declining soil quality, along with "lack of knowledge of soils amongst farmers" and "natural local climate constraints". 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 regarding "lack of knowledge of soils amongst farmers", "overuse of inputs" and "distrust of scientists by farmers" were causing problems, when 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/strongly agreed that compaction, soil erosion, loss of organic matter and insufficient knowledge exchange were other causes (Table 1). In contrast, they did not think that the causes were due to farmers having little control over their land or due to 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).

Leading Causes of Declining Soil Quality

There were two themes that were frequently mentioned by 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 was a cause for declining soil quality. This sentiment is captured by an agricultural adviser (UK2) 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 rotation, 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 (UK4) 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.

3.1.2. 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 for declining soil quality, such as “farmer has lost the finer touch with his land”, “overuse of input like fertiliser and chemicals”, and “lack of knowledge of soil amongst farmers”.

Factor 6: “There Is no 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 fertilisers 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 statements “too little advice on soil-improving practices” and “lack of knowledge-sharing between scientists, advisors, and farmers” as problems for soil quality.

Factor 7: “Industrialised/Intensive Agriculture to Blame”

Respondents in this factor 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 about structural characteristics like “too large farms” and “high share of leased land” as problems of declining soil quality compared with other factor groups.

Areas of Agreement and Disagreement

Respondents in the three factors agreed/strongly agreed that soil quality was declining because of “soil erosion”, “repetition of the same crop, year after year”, and “loss of soil structure”. There were also numerous areas of statistical disagreement between the factor groups (Table A2, Appendix A), such as knowledge/education, environmental conditions and management of the farm.

Leading Causes of Declining Soil Quality

There were two common perceived causes of declining soil quality. The first was an increase in use of large machinery causing soil compaction, captured by the statement (N5):

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

The second aspect was lack of crop rotation, which respondents felt contributed to declining levels of SOM, while some connected monocultures to the regional specialisation policy.

3.2. Perceived Solutions to Address Declining Soil Quality

3.2.1. UK Study

Factor A: "Anti-Innovation"

This factor was defined by respondents more strongly agreeing 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.

Factor B: "Yes to Financial Incentives but no to 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 were 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 agreed in investing in education and training (Table A3, Appendix A). They also agreed that we should work towards improving trust between farmers and regulatory agencies and initiatives to reduce compaction. Respondents did not think changing the timing of tillage would improve soil quality. There was disagreement on numerous solutions, particularly around maintaining small farms, increasing the early adoption of new techniques and giving more freedom to farmers to manage their land.

The Most Important Perceived Solutions to Addressing Soil Quality Decline

There were two main themes that emerged in the responses to the open-ended question, with the first (and most common) requesting improved 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 researcher (UK5) 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, rotation and less use of heavy machinery.

3.2.2. Norway Study

Factor D: "Farmer-Led Demonstration and Innovation"

Respondents in this factor were more likely to rank "setting examples to follow; if one farmer succeeds 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".

Factor E: "No More Regulation or Financial Incentives"

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 fertiliser use", and "more regulation" as solutions.

Factor F: "Society Needs to Change"

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

Respondents agreed on "less soil compaction" and "more variation in crop rotation" as ways to improve soil quality (Table A4, Appendix A), as well as on statements related to education, such as "investment in education and training" and "more farmer demonstration days". Respondents did not think "there is not much we can do with the cropping system to improve soil quality" or that the "problems are due to natural, climatic variations". Further, respondents were strongly against "more use of financial penalties" and were neutral or disagreed with "financial incentives" as a solution.

The Most Important Perceived Solution to Declining Soil Quality

More than half of the respondents mentioned "soil organic matter", "cover crops" or "crop rotation" in the open-ended section as solutions to improve soil quality. In addition, more drainage was mentioned by eight respondents as the most critical measure to increase soil quality in the open-answer section, a factor not discussed at all in the UK survey.

4. Discussion

Understanding the range of stakeholder perceptions of the causes of, and solutions to, declining soil quality is useful as it can highlight potential tensions and agreement that might affect the acceptability of land management policies and measures. In our work in the UK and Norway, whilst there were disagreements between respondents on the perceived causes of soil degradation, there was consensus on numerous soil-specific factors, e.g., compaction, soil erosion and loss of organic matter. Both groups agreed that the underlying drivers of declining soil quality were related to wider issues around industrialised agriculture and demand for cheap food, which many farmers felt were out of their control. When it came to solutions, some stakeholders felt that society needs to change in order to address these underlying drivers. Knowledge exchange between agricultural stakeholders was also seen as key. However, many respondents were against further regulation or financial mechanisms including both incentives and penalties.

When focusing on the causes of declining soil quality, studies show that UK soils are threatened by soil erosion, compaction and organic matter decline [21], which reflected the main problems that UK respondents believed were causing declining soil quality. Respondents in Norway also thought soil degradation was due to soil erosion and loss of soil structure, reflecting findings in southeast Norway, where erosion and loss of soil structure have been linked to increased soil compaction [35]. However, Norwegian respondents considered lack of crop rotation as a problem causing soil decline, which was not noted in the UK study, perhaps reflecting the fact that crop rotations were at the time incentivised in the UK via the EU Common Agricultural Policy's three crop rule [36].

Reducing compaction was agreed to be key to improving soil quality for UK and Norwegian respondents. 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 (e.g., [35,37,38]). This suggests compaction is a salient issue for respondents. However, 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.

Industrialisation of the agri-food sector was thought to be a driver of soil degradation. This perception reflects the significant structural changes in southeastern Norway, described by Bjørlo and Rognstad [39] in their report "Barely recognisable" (translated from Norwegian). When analysing the answers to the open-ended question about the main problem causing declining soil quality, both British and Norwegian respondents often highlighted the complex nature of soil degradation, related to external pressures along the food supply chain such as consumers demanding cheap food and agricultural policy and supermarkets 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". Competing demands were thought to be placed on farmers, pulling them in different directions and this was thought to 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 pressure for farmers to produce more food as cheaply as possible appeared to be part of the symptom of industrialised agriculture where farmers felt trapped and unable to improve their soil quality due to these powerful external market forces.

Whilst respondents in the UK study felt there had been a decline in soil quality, many respondents in factor 6 of the Norwegian study ("I do not think there is a problem with soil quality") did not agree. There can be several reasons to why this may be, such as respondents in factor 6 conceptualising "soil quality" in a different way to others, thereby not considering 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". This might reflect a more historic definition of the term "soil quality" that focused on productivity rather than wider ecosystem services [40], where continued application of fertiliser and pesticides can mask underlying soil quality issues [41]. In addition, the larger proportion of non-farmers in the UK study group may have resulted in a greater emphasis on declining soil quality, with the scientists in the UK group most commonly identifying industrial agriculture as a causal factor in declining soil quality.

When it came to improving soil quality, many respondents in both studies were neutral towards or disagreed with financial measures, including penalties and incentives. This is a finding also established in other studies [16,42] whereby farmers felt financial incentives in particular were bribes to coerce farmers into doing what others wanted them to do. Whilst there may be some reluctance to agree to using financial incentives to change farmer behaviour, when implemented effectively they can change farmer practices and produce environmental benefits [43,44]. Leaving the EU presents the UK with an opportunity to revolutionise its agricultural policy and there is increasing interest in paying farmers for providing essential ecosystem services, such as soil conservation [45]. However, given that numerous respondents in this study did not think financial incentives could reduce soil degradation, it remains to be seen whether this approach will result in widespread uptake or improved soil quality, especially if fundamental drivers of soil degradation are not also addressed. For instance, if supermarkets and consumers continue to demand and purchase high quantities of cheap food, it is possible that market forces may undermine Government incentive schemes if the profits that farmers make from selling cheap, industrially produced food is more than what the Government can offer. Equally, supermarkets often tie farmers into contracts, with strict requirements on yield and quality of food but limited attention towards how the food is produced. To transform the agri-food system, supermarkets should also start requiring food to be produced in more sustainable ways [46].

Many UK and Norwegian farmers in this study did not believe EU or national intervention could improve soils, such as by creating a Soils Directive, and were also more negative with regards to any form of regulation. In the UK, this may partly be as a result of longstanding political opposition on the issue; in 2012, UK Ministers, together with Germany, France, The Netherlands and Austria, played a key role in blocking an EU Soils Directive [47]. This finding may also reflect the fact that the survey ran during the EU "Brexit" negotiations, where trust in the EU by many UK citizens was at a low point, suggesting a lack of faith in the UK's national application of the Common Agricultural Policy. It remains to be seen whether trust can be rebuilt between British farmers and policymakers as the UK leaves the EU and devises its own agricultural policies.

Investing in education and training were additional solutions that respondents agreed upon. Research has shown that education and training can be effective at spreading awareness and encouraging uptake of more sustainable agricultural practices [48,49]. This may work best with farmers who are more open to learning about new topics and trying novel approaches. 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 [50] 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 though one way of addressing this could be to frame knowledge exchange events in ways that attract these farmers by focusing on aspects they are passionate about, and where the event is run by someone whom they respect and relate to. In particular, local peer-to-peer knowledge exchange events have been identified as offering scope for strengthening land manager networks and facilitating behavioural change through exchange of information and experience [51,52]. Opportunities also exist to use online information and integration to influence farmers to change their practice, although more understanding of the effectiveness of this type of approach is needed [53]. Another solution agreed upon by many respondents 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 [54]. 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, and grounding research in non-academic stakeholder experiences and knowledge, as well as others [55]. This collaborative approach may help stakeholders understand their epistemological differences and build trust to work together more effectively and respect each other's perspectives. 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 an agreed solution to improve soil quality, where researchers, extension services and farmers meet to discuss both theoretical and practical aspects of agriculture. These demonstration days could provide a valuable opportunity for knowledge exchange between researchers, farmers and other stakeholders. Similar events are held in the UK and have been met with great success from the farmers attending.

5. Conclusions

To be well-informed, equitable and transparent, public decision-making needs to take account of the views of the diversity of stakeholders they may affect. Taking these perspectives into account in the policy-making process has the potential to deliver more robust decisions that are more beneficial for the environment and more likely to be implemented. Participatory processes can elicit a more inclusive range of perspectives than conventional consultative processes, revealing areas of consensus and disagreement that can inform policy development. They are also able to capture the likely social impacts of proposed policies, which are often neglected in favour of more straightforward environmental and economic appraisals [16,56]. Using Q-methodology to analyse the diversity of stakeholder perspectives, this research has shown that there is a diversity of perspectives on the problems of and solutions to declining soil quality across different professions within the agricultural sector in Norway and the UK.

Respondents in both countries found it easy to agree on the physical processes causing declining soil quality (in both countries, respondents pointed to a loss of soil structure and soil erosion). It was harder to find agreement on social and political drivers from the Q-sorts, other than a lack of knowledge exchange in the UK. However, analysis of qualitative data suggested that respondents primarily blamed industrial agricultural methods, which in turn, they blamed on market drivers, pushing down farm-gate prices (in the UK) and regional specialisation policies (in Norway). Although these drivers of declining soil quality are difficult to address in the short term, and market drivers are outside the control of policymakers, the proposed solutions were pragmatic, focusing primarily on capacity building measures. Respondents in both countries agreed that more investment was needed in training for farmers to use soil-improving cropping systems as an important way of improving soil quality. Respondents in Norway were strongly against the use of financial penalties to encourage the use of these cropping systems, and UK respondents believed that trust needed to be built between farmers and regulators, and that more research needed to be done in collaboration with farmers. It may be possible to engage farmers in action research, including the development of evidence-based training tailored to their needs, drawing on both existing evidence and findings from new collaborative research.

Linked to this, future research might integrate Q methodology with Delphi or other structured elicitation techniques to further triangulate and increase the robustness of findings. Notwithstanding the sample sizes in this research, it is important to note that Q methodology alone should not be used to generalise findings to wider populations, and so these findings should be seen as indicative of the views of some stakeholders in each country, rather than as an authoritative representation of the perspectives of these groups in general.

Although the limited sample makes generalisations inadvisable at national scales, areas of consensus are important for policy makers to understand, as they could indicate areas where policy changes might be more acceptable to a range of stakeholders, addressing the challenge of creating scalable policy options noted by the UNCCD. It is also useful to highlight areas of disagreement among stakeholders, so that further consultation can be carried out to understand the basis of dissensus and its likely impact on policy implementation. For example, in this study we highlighted the diverging view of perspectives on the underlying causes of declining soil quality, which variously blamed farmers (who "have lost touch with their land and are afraid of doing something new"), policy-makers ("it's EU policy, not farmers that are to blame"), the industrial system ("intensive agriculture to blame") and external forces from society ("pressure to produce at low cost").

As policymakers in the UK, Norway and other countries grapple with the challenge of feeding growing populations whilst mitigating climate change, there is a greater need than ever before to develop policies that are acceptable, implementable and sustainable. In this context, policies are needed that address the widest possible range of real and perceived causes of declining soil quality, harnessing the adaptability and ingenuity of farmers and other stakeholders as part of wider attempts to address systemic market and policy failures across the agri-food system. Dealing with soil degradation requires tackling underlying drivers and this study has highlighted numerous solutions for addressing this challenge that are acceptable to a range of agricultural stakeholders.

Author Contributions: Conceptualization: M.S.R., E.A.O.; Data curation: N.R., O.E.L., N.R., S.I., S.V., E.A.O., T.A.B.; Formal analysis: N.R., O.E.L.; Funding acquisition: M.S.R.; Investigation: N.R., O.E.L., S.I., S.V., E.A.O., T.A.B., M.S.R.; Methodology: N.R., O.E.L., S.I., E.A.O., T.A.B., M.R.; Supervision: M.R., N.R., T.A.B.; Project administration: M.S.R., N.R.; Writing - original draft: N.R., O.E.L., N.R., S.I., S.V., E.A.O., T.A.B., M.S.R.; Writing - review & editing: J.H.G., C.M.M., R.M., M.S.R. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by EU Horizon 2020 project 'SoilCare' (Soil Care for profitable and sustainable crop production in Europe, H2020-SFS-2015-2). This funder had no role to play in the design, data collection, analysis or interpretation of results.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Newcastle University SAGE Faculty Ethics Committee.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request and approval from the study sites representative co-authors.

Conflicts of Interest: MR is CEO of Fast Track Impact Ltd and Research Lead for IUCN UK Peatland Programme. The other authors declare no competing interests.

Appendix A

Table A1. Average Q-sort scores for each of the four factors identified as causing problems by UK respondents. Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from -2 (strongly disagree) to 2 (strongly agree).

Factors* Problem Statements	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)	<u>0</u>	<u>−1</u>	<u>−1</u>	<u>0</u>
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	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>
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	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
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
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	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>
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

* Factor 1—Intensive use of agriculture to blame; Factor 2—Farmers need to change; Factor 3—It's the EU, not farmers that are to blame; Factor 4—Weather and farm management are to blame.

Table A2. Average Q-sort scores for each of the four factors identified as causing problems by Norwegian respondents. Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from −2 (strongly disagree) to 2 (strongly agree).

Problem Statements / **Factors***	**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	<u>2</u>	<u>2</u>	<u>2</u>
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**
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	<u>2</u>	<u>1</u>	<u>2</u>
28. Declining level of nutrient status	<u>0</u>	<u>1</u>	<u>0</u>
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	<u>2</u>	<u>1</u>	<u>2</u>
38. Norwegian agriculture policy	1	**−1**	0
39. Agriculture has become too quantified, everything is to be measured	−1	−1	**0**
40. High share of leased land	**0**	**−2**	**1**
41. Too little drained land	**0**	**2**	2

* Factor 5—Disconnection between farmer and soil; Factor 6—There is no problem with the soil quality; Factor 7—Industrialised agriculture to blame.

Table A3. Average Q-sort scores for each of the four factors identified as solutions to improve soil by UK respondents. Bold text indicates distinguishing statement at $p < 0.01$, underlined text indicates consensus statements; scale from −2 (strongly disagree) to 2 (strongly agree).

Solution Statements / Factors *	A	B	C
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

*Factor A—Anti-innovation; Factor B—Yes to financial incentives but no to regulation; Factor C—Early adoption of new techniques.

Table A4. Underlined text indicates consensus statements; scale from −2 (strongly disagree) to 2 (strongly agree).

	Solution Statements Factor*	D	E	F
1.	Regulation of water usage	−2	−1	−1
2.	More communication and sharing of knowledge between farmers on a local level	0	1	1
3.	Investment in education and training	1	1	2
4.	More use of local knowledge and experience	**0**	2	1
5.	More regulations for fertilizers	**−1**	**−2**	**0**
6.	Less use of heavy machinery	**0**	1	2
7.	More farmer demonstration days	1	1	1
8.	Change the timing of tillage	0	0	−1
9.	More research done in collaboration with farmers	1	0	1
10.	More small farms	**−2**	0	0
11.	Improve trust between farmers and institutions	**−1**	0	0
12.	More resting soil	−1	−2	−2
13.	More innovations	**1**	−1	−1
14.	There is not much we can do with the cropping system to improve soil quality	**−2**	−2	**−2**
15.	Financial incentives (e.g., subsidies)	0	**−1**	0
16.	Setting examples to follow; if a farmer succeed others will follow	**2**	1	0
17.	Creation of a "Soil Directive"	**−1**	**−2**	**−1**
18.	There is not much we can do; problems are due to natural, climatic variations.	**−2**	**−1**	**−2**
19.	Less soil compaction	2	2	2
20.	More diverse crop rotation	2	2	2
21.	More education on environmental impacts	1	**0**	1
22.	More use of organic fertilizer	1	1	0
23.	Society needs to change focus on what farmers produce	0	0	**2**
24.	More advise on use of technology	**0**	0	−1
25.	More targeted mapping of soil threats	**1**	0	0
26.	More cover crops	2	**−1**	2
27.	More traditional agricultural practices	−1	−1	−1
28.	Farmers have already tried many measures to improve soil quality	−1	**1**	−1
29.	More regulation	−1	**−2**	−2
30.	Increase adoption of new techniques	0	−1	−1
31.	More financial penalties	−2	−2	−2
32.	Increase knowledge of soil types	2	2	**1**
33.	Reduce share of leased land	**−2**	1	0
34.	More drainage of agricultural land	2	2	**1**

*Factor D-Farmer-led demonstration and innovation; Factor E—No more regulation or financial incentives; Factor F—Society needs to change.

Note

1. 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 [7]. 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" [57].

References

1. Dominati, E.; Patterson, M.; Mackay, A. A Framework for Classifying and Quantifying the Natural Capital and Ecosystem Services of Soils. *Ecol. Econ.* **2010**, *69*, 1858–1868.
2. Moncrieff, C.; Draisey, Z. *Saving the Earth: A Sustainable Future for Soils and Water*; WWF: Woking, UK, 2018.
3. Rusinamhodzi, L. *The Role of Ecosystem Services in Sustainable Food Systems*; Elsevier: Amsterdam, The Netherlands, 2020.
4. Intergovernmental Panel on Climate Change. *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*; Intergovernmental Panel on Climate Change; Geneva, Switzerland, 2019.
5. Keating, B.A.; Herrero, M.; Carberry, P.S.; Gardner, J.; Cole, M.B. Food wedges: Framing the global food demand and supply challenge towards 2050. *Glob. Food Secur.* **2014**, *3*, 125–132.
6. UNFCCC. *Adoption of the Paris Agreement, 21st Conference of the Parties*; United Nations: Paris, France; 2015.
7. FAO and ITPS. *State of the World's Soil Resources*; United Nations Food and Agriculture Orgaisation: Rome, Italy, 2015.
8. Thomas, D.T.; Moore, A.D.; Bell, L.W.; Webb, N.P. Ground Cover, Erosion Risk and Production Implications of Targeted Management Practices in Australian Mixed Farming Systems: Lessons from the Grain and Graze. *Agric. Syst.* **2018**, *162*, 123–135.
9. UNCCD. *Global Land Outlook*; United Nations: Bonn, Germany, 2017.
10. UN. *The Sustainable Development Goals Report*; United Nations: New York, NY, USA, 2016.
11. Cowie, A.L.; Orr, B.J.; Sanchez, V.M.C.; Chasek, P.; Crossman, N.D.; Erlewein, A.; Louwagie, G.; Maron, M.; Metternicht, G.I.; Minelli, S.; et al. Land in Balance: The Scientific Conceptual Framework for Land Degradation Neutrality. *Environ. Sci. Policy* **2018**, *17*, 25–35.
12. WOCAT. *Where the Land Is Greener: Case Studies and Analysis of Soil and Water Conservation Initiatives Worldwide*; Liniger, H., Critchley, W., Eds.; World Overview of Conservation Approaches and Technologies: Bern, Switzerland, 2007.
13. De Vente, J.; Reed, M.S.; Stringer, L.C.; Valente, S.; Newig, J. How Does the Context and Design of Participatory Decision Making Processes Affect Their Outcomes? Evidence from Sustainable Land Management in Global Drylands. *Ecol. Soc.* **2016**, *21*, 24.
14. Jager, N.W.; Newig, J.; Challies, E.; Kochskämper, E. Pathways to Implementation: Evidence on How Participation in Environmental Governance Impacts on Environmental Outcomes. *J. Public Adm. Res. Theory* **2019**, *30*, 383–399.
15. Dryzek, J.S. Democratization as Deliberative Capacity Building. *Comp. Political Stud.* **2009**, *42*, 1379–1402.
16. Rust, N.A. Can Stakeholders Agree on How to Reduce Human–Carnivore Conflict on Namibian Livestock Farms? A Novel Q-Methodology and Delphi Exercise. *Oryx* **2017**, *51*, 339–346.
17. Addams, H.J.; Proops, L.R. Cheltenham *Social Discourse and Environmental Policy: An Application of Q Methodology*; Edward Elgar Publishing: Cheltenham, UK, 2000.
18. Bryden, J.; Riddoch, L.; Brox, O. Conclusions. In *Northern Neighbours: Scotland and Norway since 1800*; Bryden, J., Brox, O., Riddoch, L., Eds.; Edinburgh University Press: Edinburgh, UK, 2015; pp. 282–286.
19. UK National Statistics, Agriculture in the United Kingdom 2020. Report compiled by: Department for Environment, Food and Rural Affairs (England); Department of Agriculture, Environment and Rural Affairs (Northern Ireland); Welsh Government, Knowledge and Analytical Services; The Scottish Government, Rural and Environment Science and Analytical Services. 2020. Available online: https://www.gov.uk/government/collections/agriculture-in-the-united-kingdom (accessed on 23 November 2021).
20. Environment Agency. The State of the Environment: Soil. 2019. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf (accessed 23 November 2021).
21. Defra. Safeguarding Our Soils—A Strategy for England. 2009. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69261/pb13297-soil-strategy-090910.pdf (Accessed on 20 December 2021).
22. Tipper, W.A. *Protecting Our Assets: Using Natural Infrastructure Schemes to Support Sustainable Agriculture*; Green Alliance: London, UK, 2017. Available online: https://www.green-alliance.org.uk/resources/protecting_our_assets.pdf (accessed 23 November 2021).
23. O'Neill, D. *The Total External Environmental Costs and Benefits of Agriculture in the UK*; Environment Agency: Bristol, UK, 2007.
24. Boardman, J. Soil Erosion in Britain: Updating the Record. *Agriculture* **2013**, *3*, 418–422.
25. Hegrenes, A.; Mittenzwei, K.; Prestegard, S.S. *Norsk Jordbrukspolitikk: Handlingsrom i Endring*; Fagbokforl: Bergen, Norway, 2011.
26. McKee, A.; Vinge, H.; Bjørkhaug, H.; Almås, R. Agricultural Models in Scotland and Norway: A Comparison. In *Land Reform in Scotland: History, Law and Policy*; Combe, M., Glass, J., Tindley, A., Eds.; Edinburgh University Press: Edinburgh, UK, 2020; pp. 388–409.
27. Arnoldussen, A.H.; Forbord, M.; Grønlund, A.; Hillestad, M.E.; Mittenzwei, K.; Pettersen, I.; Tufte, T. *Økt Matproduksjon På Norske Arealressurser*; AgriAnalyse AS: Oslo, Norway, 2014

28. Vagstad, N.' Abrahamsen, U.; Strand, E.; Uhlen, A.K.; Lund, H.J.; Rognlien, A.; Stuve, L.F.; Stabbetorp, E.M.H.; Mangerud, K.; Solberg, H. Økt norsk kornproduksjon. Utfordringer og tiltak. *Rapport fra ekspertgruppe til LMD*: 39, 2013
29. Stortinget, M. *Landbruks-Og Matpolitikken–Velkommen Til Bords*; Landbruks-og Matdepartementet: Regjeringen Oslo, Norway, 2011.
30. Kolberg, D. Regional Specialisation Policies in Norwegian Agriculture Should Be Revised. *NMBU Stud. J. Life Sci.* **2016**, *6*, 14–17.
31. Brown, S.R. Q Methodology and Qualitative Research. *Qual. Health Res.* **1996**, *6*, 561–567.
32. Rastogi, A.; Hickey, G.M.; Badola, R.; Hussain, S.A. Diverging Viewpoints on Tiger Conservation: A Q-Method Study and Survey of Conservation Professionals in India. *Biol. Conserv.* **2013**, *161*, 182–192.
33. Deary, H.; Warren, C. Trajectories of rewilding: A taxonomy of wildland management. *J. Environ. Plan. Manag.* **2019**, *62*, 466–491.
34. Coogan, J.; Herrington, N. Q Methodology: An Overview. *Res. Second. Teach. Educ.* **2011**, *1*, 24–28.
35. Seehusen, T.; Riggert, R.; Fleige, H.; Horn, R.; Riley, H. Soil Compaction and Stress Propagation after Different Wheeling Intensities on a Silt Soil in South-East Norway. *Acta Agric. Scand. Sect. B—Soil Plant Sci.* **2019**, *69*, 343–355.
36. Rural Payments Agency, The Basic Payment Scheme in England; Guidance for farmers about the Basic Payment Scheme in 2015, UK Government. 2015. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/649753/BPS_Handbook_-_final_v1.0.pdf (accessed 23 November 2021).
37. De-Ville, S.; Pattison, I.; Frost, M. COMPACT: A frequency analysis of Ground Penetrating Radar to identify agricultural soil compaction. *AGU Fall Meet. Abstr.* **2018**, *2018*, NS13B-0596.
38. Jordon, M.W. Does mixed vs separate sheep and cattle grazing reduce soil compaction? *Soil Use Manag.* **2021**, *37*, 822–831.
39. Bjørlo, B.; Rognstad, O. Nesten Ikke Til å Kjenne Igjen. 2019. Available online: https://www.ssb.no/jord-skog-jakt-og-fiskeri/artikler-og-publikasjoner/nesten-ikke-til-a-kjenne-igjen (accessed on 28 November 2021).
40. Erkossa, T.; Itanna, F.; Stahr, K. Indexing Soil Quality: A New Paradigm in Soil Science Research. *Soil Res.* **2007**, *45*, 129–137.
41. Uhlen, A.K.; Børresen, T.; Deelstra, J.; Waalen, W.; Strand, E.; Bleken, M.A.; Seehusen, T.; Kværnø, S.; Sundgren, T.; Lillemo, M.; et al. Økt kornproduksjon gjennom forbedret agronomisk praksis. En vurdering av agronomiske tiltak som kan bidra til avlingsøkninger i kornproduksjonen. *NIBIO Rapp.* **2017**, *Volume 3*.
42. Rust, N.A. Media Framing of Financial Mechanisms for Resolving Human–Predator Conflict in Namibia. *Hum. Dimens. Wildl.* **2015**, *20*, 440–453.
43. Stabbetorp, H. *Landbrukets Utvikling Siden 1950. Utviklingstrekk Av Betydning for Vannkvaliteten*; Vann: Vannforeningen, Norway, 2014.
44. Piñeiro, V.; Arias, J.; Dürr, J.; Elverdin, P.; Ibáñez, A.M.; Kinengyere, A.; Morales Opazo, C.; Owoo, N.; Page, J.R.; Prager, S.D.; et al. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nat. Sustain.* **2020**, *3*, 809–820.
45. Defra. *A Green Future: Our 25 Year Plan to Improve the Environment*; HMSO: London, UK, 2018.
46. Rust, N.A.; Ridding, L.; Ward, C.; Clark, B.; Kehoe, L.; Dora, M.; Whittingham, M.J.; McGowan, P.; Chaudhary, A.; Reynolds, C.J.; et al. How to transition to reduced-meat diets that benefit people and the planet. *Sci. Total Environ.* **2020**, *718*, 137208.
47. Glæsner, N.; Helming, K.; De Vries, W. Do Current European Policies Prevent Soil Threats and Support Soil Functions. *Sustainability* **2014**, *6*, 9538–9563.
48. Ingram, J. Framing Niche-Regime Linkage as Adaptation: An Analysis of Learning and Innovation Networks for Sustainable Agriculture across Europe. *J. Rural Stud.* **2015**, *40*, 59–75.
49. Mills, J.; Gaskell, P.; Ingram, J.; Dwyer, J.; Reed, M.S.; Short, C. Engaging farmers in environmental management through a better understanding of behaviour. *Agric. Hum. Values* **2017**, *34*, 283–299.
50. Kilpatrick, S.; Williamson, J. Farmer Participation in Training. *Rural Soc.* **1996**, *6*, 3–12.
51. McMorran, R. *Key Drivers for Land Manager Decision Making in Loch Lomond and the Trossachs National Park and Opportunities for Addressing Constraints to Woodland Creation*; SEFARI Fellowship report; SEFARI, Edinburgh, UK, 2021.
52. O'Brien, L.; Morris, J.; Marzano, M.; Dandy, N. Promoting sustainability behaviours through forestry. *Forestry* **2017**, *90*, 88–98.
53. Rust, N.A.; Stankovics, P.; Jarvis, R.M.; Morris-Trainor, Z.; de Vries, J.R.; Ingram, J.; Mills, J.; Glikman, J.A.; Parkinson, J.; Toth, Z.; et al. Have farmers had enough of experts? *J. Environ. Manag.* **2021** https://doi.org/10.1007/s00267-021-01546-y.
54. EIP-AGRI. Horizon 2020 Multi-Actor Projects. 2018. Available online: https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_brochure_multi-actor_projects_2017_en_web.pdf (accessed on 23 November 2021).
55. Acquaye-Baddoo, N.A.; Ekong, J.; Mwesige, D.; Neefjes, R.; Nass, L.; Ubels, J.; Visser, P.; Wangdi, K.; Were, T.; Brouwers, J. Multi-actor systems as entry points for capacity development. *Capacity.Org J.* **2010**, *41*, 4–7.
56. Kenter, J.O.; O'Brien, L.; Hockley, N.; Ravenscroft, N.; Fazey, I.; Irvine, K.N.; Reed, M.S.; Christie, M.; Brady, E.; Bryce, R.; et al. What are shared and social values of ecosystems? *Ecol. Econ.* **2015**, *111*, 86–99.
57. Karlen, D.L.; Mausbach, M.J.; Doran, J.W.; Cline, R.G.; Harris, R.F.; Schuman, G.E. Soil quality: A concept, definition, and framework for evaluation. Soil Sci. Soc. Am. J. **1997**, 61:4-10.