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Abstract: Report on the views of stakeholders for potential for SOC management to contribute to SOC sequestration for climate change mitigation and adaptation and for the achievement of SDGs, including how these measures can be implemented, which barriers may constrain this, and which knowledge gaps need to be filled.

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DISCLAIMER OF WARRANTIES

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Table of content

FIGURES

TABLES

Glossary

Carbon sequestration	Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide in plants, soils, geologic formations, and the ocean.
SOC	Soil organic carbon (SOC) is one part in the much larger global carbon cycle that involves the cycling of carbon through soil, vegetation, oceans, and the atmosphere. SOC is the main component of soil organic matter.
SOM	Soil Organic Matter (SOM) also includes nutrients such as nitrogen, phosphorous and sulphur. It is divided into living and dead components and can range from very recent inputs such as roots and stubble to largely decayed materials that are thousands of years old.
SDGs	The Sustainable Development Goals (SDGs) are a collection of 17 global goals set by the United Nations General Assembly in 2015 for the year 2030. The SDGs are part of Resolution 70/1 of the United Nations General Assembly, the 2030 Agenda.

Executive summary

There is increased awareness of the importance of soils among policy makers, various stakeholders, research communities and the general public. The societal debate on SOC management spans multiple policy areas and a wide range of stakeholders with different, and in part converging, agendas. Most directly, soil carbon management is a key issue for climate mitigation and adaptation and for coping with increased demands on food production. However, to be able to strengthen research and policies on soils and the use of soils for carbon sequestration will require common understanding of the current status of soils and of the options for improving quality of the soils though enhanced carbon storage. The specific challenge lies in the identification, implementation, assessment and verification of arable and grassland soil management practices, which create a positive soil/ecosystem carbon budget at the farm and landscape levels, sequester carbon, improve soil structure and soil quality and provide climate change mitigation and adaptation while contributing to sustainable development. For these reasons, stakeholders' views on the role of SOC for climate mitigation, adaptation and SDGs are of great importance and a key objective of this report.

A mixed approach was applied to identify stakeholder's views on the role of SOC for climate change mitigation, adaptation and SDGs, combining quantitative and qualitative data gathering. This included workshop dialogues with key stakeholders on SOC management and two online surveys. One survey was distributed globally to a diverse group of stakeholders working or having knowledge on SOC management (the global survey), and another survey was directed specifically to farmers in Denmark (Danish farm survey). There were a total of 1369 usable answers in the global survey, of which one third was from farmers, one third from research organisations and the rest covered many other types of stakeholders. The farm survey in Denmark has a total of 1807 usable responses. To ensure that a broad range of perspectives was captured around the globe, 11 regional/national hubs were facilitated by regional/national coordinators. Each hub identified key stakeholders in their region and motivated them to participate in the global online survey and the regional workshops. The approach for interacting with stakeholders differed across the hubs, depending on the context and the resources available.

Farmers were asked in the online questionnaire on various aspects of their current knowledge on SOC. About 30% of farmers in the global survey stated that they know the SOC concentration of their soil, whereas this was only 9% for the survey among farmers in Denmark. This may reflect a bias among farmers in the global survey towards farmers that have a knowledge and interest in SOC and SOC management. The low proportion of farmers in Denmark stating knowledge on SOC most likely reflect that SOC has not been an issue for farm management decisions. Knowledge on SOC concentration increases with farm size, which may reflect a higher general knowledge level among farmers that farm greater areas. Farmers in general considered SOC of their soil to be similar or higher than those of soils in the region in general. This could indicate that respondents may have a greater focus on enhancing SOC than farmers in general and therefore believe that their soils have greater SOC. However, this also applied to the Danish survey, and responses may also reflect a general tendency of farmers to

overestimate quality of their own soils. Around half of the farmers in the global survey consider SOC of their soil to be decreasing, whereas 20% of farmers do not know the direction. For the Danish survey, 53% respond that they do not know the direction of change in SOC, but 40% estimate that it is increasing. In the global survey, 20% of farmers respond that SOC is not critically low and 23% do not know. There is a geographical pattern in responses with more farmers in Southern Europe than in Northern Europe responding that SOC is critically low. In the Danish study, only 4% responds that SOC is critically low, and 43% responds that they do not know.

In the global survey, farmers and other stakeholders asked to give their view on 17 different management options. A slightly smaller list of options was used for the Danish survey. Across management options farmers that find an option effective for SOC management also have applied or consider applying the option, whereas farmers that find the option ineffective or do not know has a lower use of the option. Therefore, the farmer responses to effectiveness should be interpreted with some care, since they may relate to how the questions was interpreted as well as to the knowledge and experiences of the farmer with the management option.

There is a considerable interest among farmers in global survey of having access to organic amendments that can increase SOC. About 80% of farmers in the global survey apply manure or compost, which is a surprisingly large proportion, given that access to organic amendments often are constrained. A large proportion of farmers were also applying residue management and measures to prevent erosion. In contrast, very few farmers apply biochar. For the Danish farm survey, the use of cover crops and manure application was the most applied management options. The response rate of don't know answers was generally considerably lower for the survey from Denmark compared to the global survey, but of similar magnitude for most management options as for the European part of the global survey. This may illustrate that farmers in Denmark are generally aware of which options are available. For several management options the application of the options increase with farm size in the Danish survey.

Farmers in the global survey considered manure and composting, zero tillage, use of cover crops and grasslands as being the most effective measures for increasing SOC. Except for the use of manure and compost and residue management, there were relatively large response rates for don't know. This was particularly large and above 50% for rewetting of organic soils and use of biochar. Danish farmers do not rank the management options as effective as the global or European farmers. There was also a substantially higher response rate of don't know for the survey from Denmark compared with the global survey.

More than 80% of respondents from all regions have a high level of confidence that SOC management will deliver ecosystem services in the form of preventing nutrient leakage, prevent soil erosion, reduce demand for fertilizer, reduce irrigation demand, improve water infiltration and drainage, improve soil water holding capacity, improve biodiversity, improve soil workability, improve soil quality, enhance yield stability. However, three aspects of crop production are considered to be less favourably affected by SOC management: product quality; reduction of crop protection needs, and yield potential. These three production services are connected to SDG2 on zero hunger, and as the contributions of SOC management may according to the respondents be challenged. In summary, it can be concluded that the respondents in the global survey are very optimistic on contributions of SOC management to

SDGs and have great confidence with that SOC management can contribute with many important ecosystem services.

1. Introduction

There is increased awareness of the importance of soils among policy makers, research communities, other stakeholders and the general public. The public profile of the issue of soil management has recently been raised by the Global Soil Partnership (GSP), the global soil week and the 4 per 1000 Initiative on Soils for Food Security and Climate (Minasny et al., 2017). The societal debate on soil management in the context of climate change spans multiple policy areas and a wide range of stakeholders with different, and in part converging, agendas. Most directly, soil management is a key issue for climate mitigation and adaptation and for coping with increased demands on food production.

Agricultural soils carry a large potential for carbon sequestration, especially in degraded soils (Paustian et al., 2016). On the one hand, world soils contain a total organic carbon stock of about 1,500±230 gigatons carbon (GtC) (up to 1 m depth) (Scharlemann et al., 2014), equivalent to twice the amount of carbon as CO_2 in the atmosphere (i.e. 829 GtC in 2015) (Quèrè et al., 2015). On the other hand, close to half of all agricultural soils are estimated to be degraded, which threatens food production, because climate change is likely to accelerate land degradation. Therefore, preserving Soil Organic Matter (SOM), restoring degraded agricultural soils and raising Soil Organic Carbon (SOC) stocks provides adaptation to climate change (less variable yields) and sustainable intensification (higher productivity). Indeed, improved efforts for SOC management are central for achieving several sustainable development goals (SDGs), and they also play an important role in meeting the objectives of the UN Framework Convention on Climate Change (UNFCCC), the UN Convention to Combat Desertification (UNCCD) as well as the Convention on Biological Diversity (CBD). These different but related foci create potentially synergistic drivers to advance societal action to enhance SOC sequestration.

Agricultural soil carbon preservation and enhancement appear as both a no-regret and an indispensable climate action. It is no-regret for its contribution to climate change adaptation, food security, and to wider ecosystem service benefits adding to overall climate resilience. It is indispensable for its climate mitigation and negative emissions characteristics, helping undo historical carbon emissions. Nonetheless, the potentials for enhancing soil carbon storage has been challenged by several studies. The arguments fall in different categories, including:

- Increased SOC through higher inputs in organic matter will enhance the SOC decomposition rate since this is roughly proportional to the amount of SOC, so that enhanced SOC needs to be sustained by continued higher carbon inputs (Smith et al., 2007).
- Global warming will increase microbial decomposition of soil organic matter resulting in a loss of soil carbon that needs to be balanced by higher carbon inputs to sustain current stocks (Crowther et al., 2016).
- The increased carbon inputs resulting from higher atmospheric CO_2 has been shown to enhance SOC content in the short term (< 1 year), but not in the longer term (1-4 years) (van Groenigen et al., 2017a).
- Enhancing SOC also requires enhanced storage of other nutrients (nitrogen, phosphorus and sulphur), and limitations in availability of these nutrients limits the potential for increasing SOC levels (Kirkby et al., 2011, van Groeningen et al., 2017b).
- There are practical and market limitations to the implementation of SOC enhancing technologies (Poulton et al., 2017), some of which are: 1) farmers not having the necessary

resources (e.g. insufficient manure). 2) some practices favouring SOC already being widely adopted, 3) practices are uneconomic for farmers—potentially overcome by changes in regulations or subsidies, 4) practices being undesirable for global food security, i.e. resulting in lower food or feed production, at least in the short term.

In this context, the specific challenge for research lies in the identification, implementation, assessment and verification of arable and grassland soil management practices, which create a positive soil/ecosystem carbon budget at the farm and landscape levels, sequester carbon, improve soil structure and soil quality and provide climate change mitigation and adaptation while contributing to sustainable development. Such improved evidence base is central to advancing effective and targeted policy action, which requires improved coordination of research and a strategic research agenda that addresses the most pressing research needs.

Taking stock of the perspectives of diverse stakeholders from different geographic and policy areas is central to assessing research needs and advancing an effective international research agenda. For these reasons, stakeholders' views on the role of SOC for climate mitigation and adaptation are of great importance and a key objective of this report.

The aim of CIRCASA WP2 was to carry out a dialogue with stakeholders across the globe on challenges and opportunities related to SOC management. This report presents the results of Task 2.1., which specifically sought to gather stakeholders' views on the potential for soil carbon management to contribute to climate change mitigation and adaptation, sustainable intensification of agriculture and Sustainable Development Goals (SDGs), as well as stakeholders' views on the degree of implementation of management measures. The role of sustainable intensification was seen in the context of how improved soil carbon could improve crop productivity and enhance resilience to climate change and extremes.

The report is structured as follows. Chapter 2 outlines the methodology used. Chapter 3 presents the findings on farmers' knowledge of SOC. Chapter 4 looks at findings on stakeholders' perceptions of management options. Chapter 5 examines the views on the contribution of SOC management to ecosystem service delivery and to SDGs, and Chapter 6 concludes with some overarching observations.

2. Method

A mixed approach was applied to identify stakeholder's views on the role of SOC for climate change mitigation, adaptation and SDGs, combining quantitative and qualitative data gathering. This included workshop dialogues with key stakeholders on SOC management and two online surveys. One survey was distributed globally to a diverse group of stakeholders working or having knowledge on SOC management (the global survey), and another survey was directed specifically to farmers in Denmark (Danish farm survey).

To ensure that a broad range of perspectives was captured around the globe, 11 regional/national hubs were facilitated by regional/national coordinators (Annex 5). Each hub identified key stakeholders in their region and motivated them to participate in the global online survey and the regional workshops. The approach for interacting with stakeholders differed across the hubs, depending on the context and the resources available.

Moreover, a Stakeholder Advisory Board (StAB) was established, consisting of 12 representatives from farmers' organizations, conservation agriculture and land conservation interests, technical, business and industry, landowners and land users, foundations, investment funds and NGOs. The StAB was involved in the piloting of the online survey, assisted by identifying and reaching stakeholders, and reflected on the results of the survey at a physical meeting in January 2019.

2.1. Online surveys

The global online survey was translated into seven languages: English, German, Danish, Portuguese, Spanish and Russian, and it was disseminated via the regional hubs. The survey consisted of both open-ended and closed-ended questions. A summary of the survey structure and the full list of questions is shown in Annex 1. In the global survey, questions were phrased around "SOC", rather than "carbon sequestration" as this can be an unfamiliar term for some stakeholders.

The survey consisted of seven main sections:

1. Background questions on SOC
2. Current management in relation to SOC
3. Barriers for implementing SOC management options
4. Solutions to address the barriers to implementation
5. Knowledge needs
6. Contribution of SOC management - sustaining and enhancing agricultural crop production and ecosystem services
7. Contribution of SOC management to climate and sustainable development.

Two versions of the global survey were prepared: one for farmers and one for other stakeholders. Many questions overlapped, but there were also some differences. For example, farmers were asked for information on their social-economic background (specify primary farming system, ownership and employment conditions) and their knowledge about the SOC (e.g. SOC concentration of their soils). Section 7, on the other hand, was only included in the questions to "other stakeholders". The questions in the survey were selected based on expert's opinions followed by a pilot test with partners and the StAB.

In this report on Task 2.1, the analysis will mainly focus around the sections 1, 2, 6 and 7. Task 2.2 focuses on sections 3 and 4 and is reported in deliverable D2.2 (Claessens et al., 2019), whereas the results on knowledge needs are reported in deliverable D2.3.

2.1.1. Global survey

The global survey was disseminated through all 11 regional HUB´s and their networks, as well as through the network of the European Soil Partnership, the EIONET NRC Soil network and the 4 per 1000 initiative. The survey was available online from July 2018 until March 2019. In total, the global survey was visited 2057 times, of which 1369 answers can be used for the analysis after data cleaning. The data cleaning excluded those responses, where no questions or only the background questions were answered.

We can observe a variable response rate from different stakeholder groups and geographic regions. One third of responses came from "Research institute or university", another third from "Farmers" followed by "Public / government authority" with 9% (see Table 3 in Annex 2). A total of 407 responses were from farmers, 451 from research institutions and 489 from other types of stakeholders.

The highest number of answers come from EU stakeholders (678), followed by Latin America (227), Africa (196) and Asia (112) and a limited number of answers for North America (76), Australia (44), Russia (16) and New Zealand (6). The answers in different regions vary with respect to different stakeholder types and specific farming system. For farmers in Europe the proportion of farms with grain and root crops were greater than for the global survey (Figure 1).

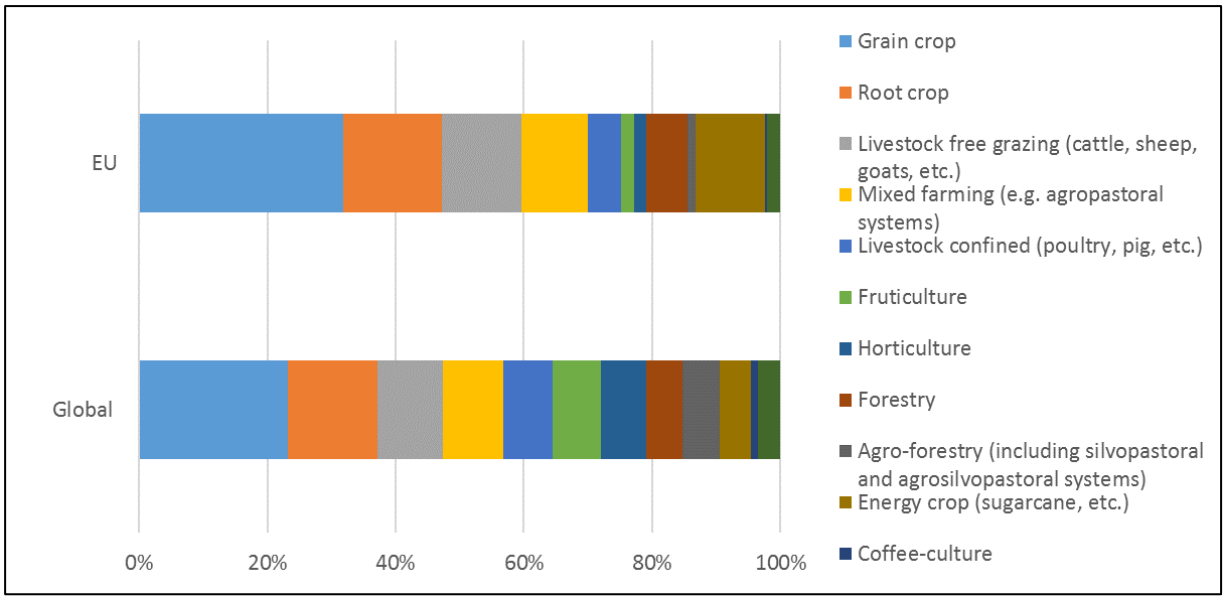

Figure 1: Overview of responses from EU and global farmers to their primary farming system

The results were analysed and visualised with the help of cross tabulations. The analysis considers differences in relation to a) geographical regions, b) stakeholder type, c) specific farming system and d) farm size. Due to the different number of responses for different regions as well as the different participation of different stakeholder types, the results are biased and have to be interpreted carefully. The results of the survey for the different regions were validated with the results of the regional workshops (see chapter 2.2).

2.1.2 Farm survey in Denmark

Danish farmers' views and perceptions on SOC management were surveyed using the same design as for the global survey. The survey was translated into Danish, with some amendments that adapted it to Danish farming and agricultural conditions. For example, the farm type coffee-culture is not a production form in Denmark so this option was excluded from the Danish farm survey.

In order to ensure that questions were comprehendible, the Danish farm survey was tested with a small group of farmers, as well as with researchers that have knowledge of farm surveys. The questions were then edited, taking into account comments from participants in the pilot group. This pilot resulted in some useful corrections for the final survey. To increase the response rate and for dissemination purposes a newspaper article was written and published in the national Danish farmers magazine (Landbrugsavisen), which introduced the project and stated that the survey would be distributed to Danish farmers (Olesen, 2018).

The survey was distributed, via email, to a representative sample of 9434 farmers across Denmark through a web-based questionnaire survey via the online platform SurveyExact. The sample were extracted randomly among farmers registered in the Danish fertilization register (Gødningsregistret) that include all Danish farms[1]. In the register-database of Danish farmers, approximately 25.000 farmers were registered with email-addresses in 2018. Therefore, our sample distribution was around 40 percent of all farms in Denmark[2]. The survey was distributed from September 2018 – December 2018 with two email-reminders. In total, 2108 respondents started the questionnaire and 1807 completed it (19 percent). This means that we have responses from a little more than 5 percent of all farmers in Denmark. The response rate of around 19 percent of the sample is normal for web-based surveys (Hansen & Pedersen, 2012).

In total, 1807 complete responses are included in this analysis. When comparing the farmer responses with national agricultural statistics from 2017 (2018 not available before summer 2019), we can see the survey was representative of Danish farms (see Table in Annex 3). The survey are representative of Danish farms, in terms of farm characteristics (farm type, farm size and agricultural practices), demographics (age and gender), and geographically distributed over the five regions in Denmark.

2.2. Workshops

Ten regional workshops were organised between July 2018 and March 2019 by Hub-Partners with a total number of 202 participants (Table 1). The overall aim of the workshops was to engage with regional stakeholders' in order to gather their perspectives on SOC management, in particular their views on SOC management options, barriers and solutions for the

[1] All Danish farmers are obliged to report fertilizer plans and accounts every year, to get payments and subsidies and for complying with Danish and European legislation.

[2] According to Danish national statistics, there were 34731 farms in total in Denmark in 2017. The number for 2018 are not officially reported yet.

implementation, as well as knowledge and research needs to increase uptake of SOC management practices in their region.

Table 1: Regional workshops and number of participants

Workshop	Number of participants
Brazil	23
Madagascar	33
Russia/Eurasia	13
South Africa	18
Colombia	16
EU	31
Australia	24
China	35
New Zealand	9

The CIRCASA WP2 team provided a guideline for the workshops and briefed the partners. The guideline included a detailed description on the aim of the workshop, who should be involved, steps to select and invite participants, guidance on selecting the timing and the venue, the role of the facilitator as well as a detailed programme for internal use and an agenda. In order to ensure the quality and consistency in reporting, a report template was provided. The workshops were organised as full-day or half-day workshops, depending on capacities and nature of the event (e.g. side-event to conference). The aim was to have at least 15–20 stakeholders present at the workshops to ensure that a range of perspectives were included. A third of the participants came from the research, followed by government representatives, whereas agricultural advisory services, international research initiatives/programs, NGO´s, farmers and farmer´s and landowner´s associations each were represented with about 5% (Figure 2).

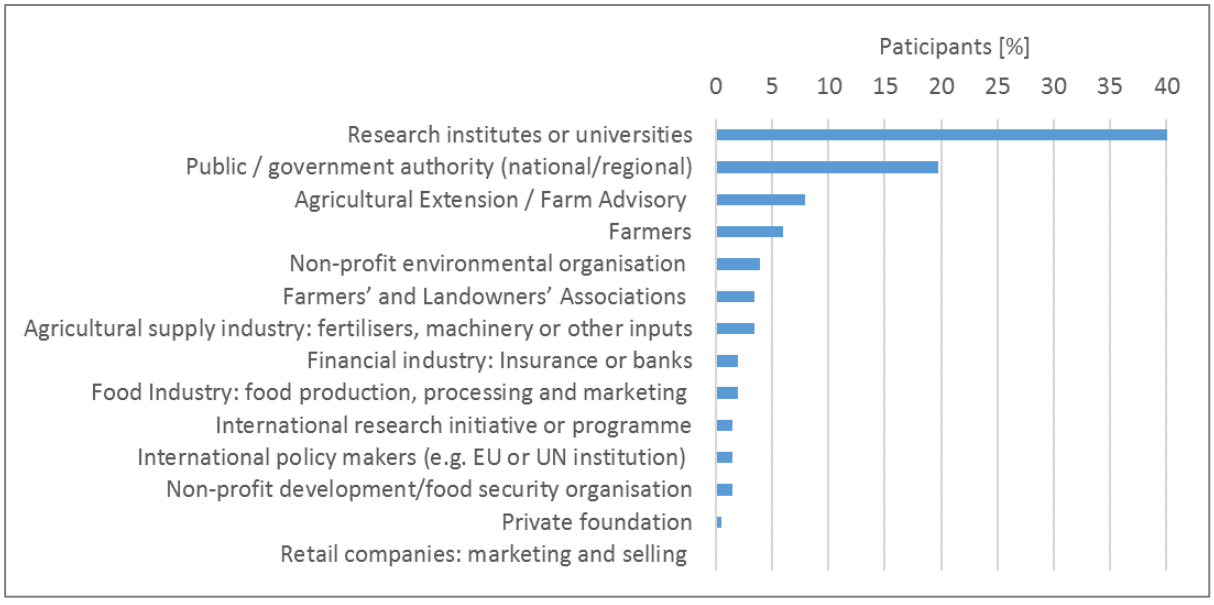

Figure 2: Stakeholder participation in the 9 regional workshops

The workshop covered two main thematic blocks with two sessions each (Table 2). The results of all workshops were summarized in a spreadsheet. In session 1 voting was applied to identify most effective, most applied and most interesting, but not well-known management options per region and global. The pros & cons were categorized and most important arguments analysed

for the most important practices. The barriers and solutions were categorized in political, economic, social, financial and knowledge issues and analysed by region. The results of the workshops complement the results of the global survey (Annex 4).

Table 2: Thematic blocks and sessions of the regional stakeholder workshop.

Block	Session	Content
Current SOC management and barriers to implementation	1	First all management options identified for the online survey were presented to the participants. Stakeholders were asked to complete the list of management options for their region. In a second step participants prioritized options according to: i) most effective, ii) most applied and iii) interesting but not implemented or not known. In smaller groups, participants discussed pros and cons of options in terms of the effect on SOC of the most relevant options identified before.
	2	After presenting the type of barriers from the survey, stakeholders discussed specific barriers to the uptake of SOC management in their region and prioritized these barriers by voting.
Solutions and knowledge needs for implementing SOC management options	3	After presenting the types of solutions identified in the online survey, stakeholders discussed which solutions for enabling the uptake of SOC management options are most important to address in the context of their region and how solutions can be effectively organized. All solutions were prioritized by voting.
	4	After presenting the types of solutions identified in the online survey, stakeholders discussed which solutions for enabling the uptake of SOC management options are most important to address in the context of their region and how solutions can be effectively organized. All solutions were prioritized by voting.

3. Farmers' knowledge on SOC

This section presents the views and basic knowledge of farmers and other stakeholders on SOC and trends in SOC. The results are presented for the global and the Danish farm survey.

3.1. Farmers' knowledge of SOC concentration

Figure 3 shows that approximately 30 percent of farmers in the global survey stated that they know the SOC concentrations of their soil or of the soils in their region, and almost 70 percent do not know the SOC concentration. Considering different regions, it can be seen that farmers in Europe, Australia, North America and New Zealand have the highest share of farmers who know of their SOC concentrations. When comparing the global results with the Danish farm survey (Figure 4), we can see that in Denmark only 9 percent of farmers indicate that they know the SOC concentration compared to 30 percent on a global level. This apparent discrepancy between the Danish study and the global study could indicate that respondents to the global study were in general more aware of the issue of SOC than farmers in general. The low proportion of farmers in Denmark stating that they know the SOC concentration most likely reflect that SOC has not been an issue for farm management decisions in this region. The considerably higher knowledge of SOC among European farmers may just reflect that respondents were more aware of SOC issues than farmers in general.

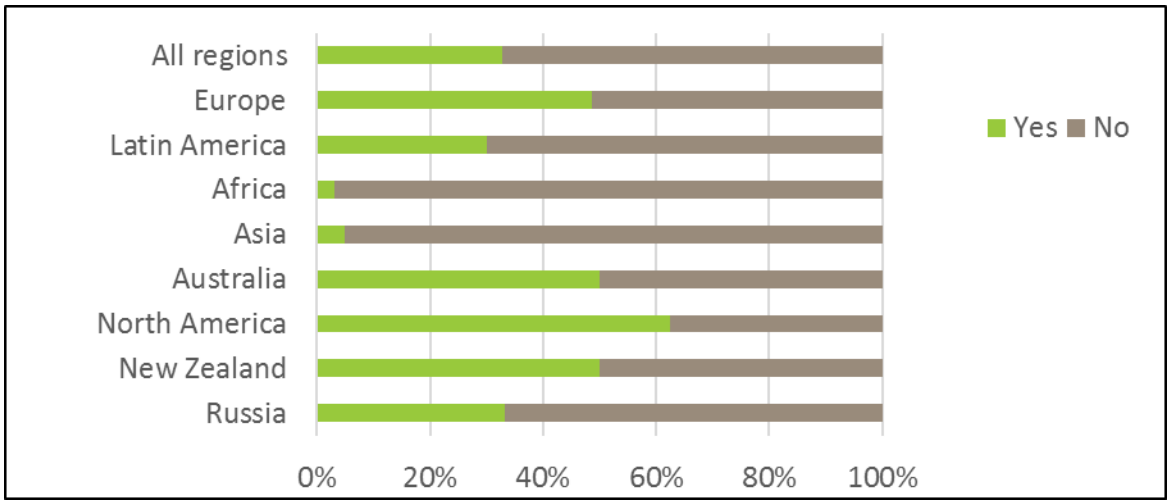

Figure 3: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" with responses from all regions.

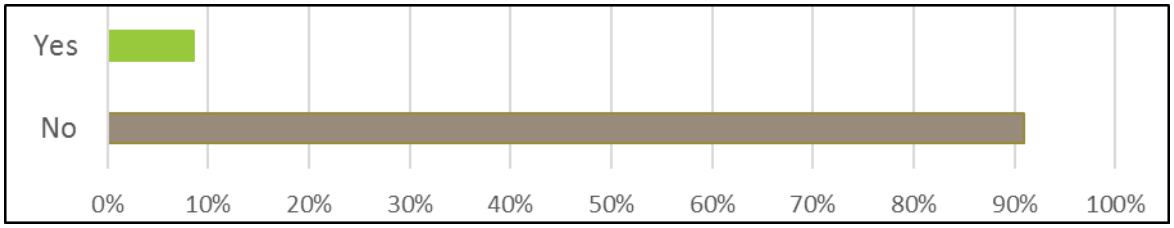

Figure 4: Answers to the question "Do you know the SOC concentration of your soil?" with responses from the survey with Danish farmers.

For farmers in Europe there was quite a diversity in response on knowledge of SOC in their soils (Figure 5). About 50% of respondents stated that they know the SOC concentration of their soils. This varied from about 25% in France to 100% in Finland, Hungary and Italy. For farmers from Denmark there were about 50% in the global survey that responded of knowledge on the SOC concentration, whereas only 9% responded positively to this question in the Danish farmer survey. This clearly points to a bias in the global survey towards farmers that have more knowledge on SOC than farmers in general. In fact, this bias may vary between countries in the survey.

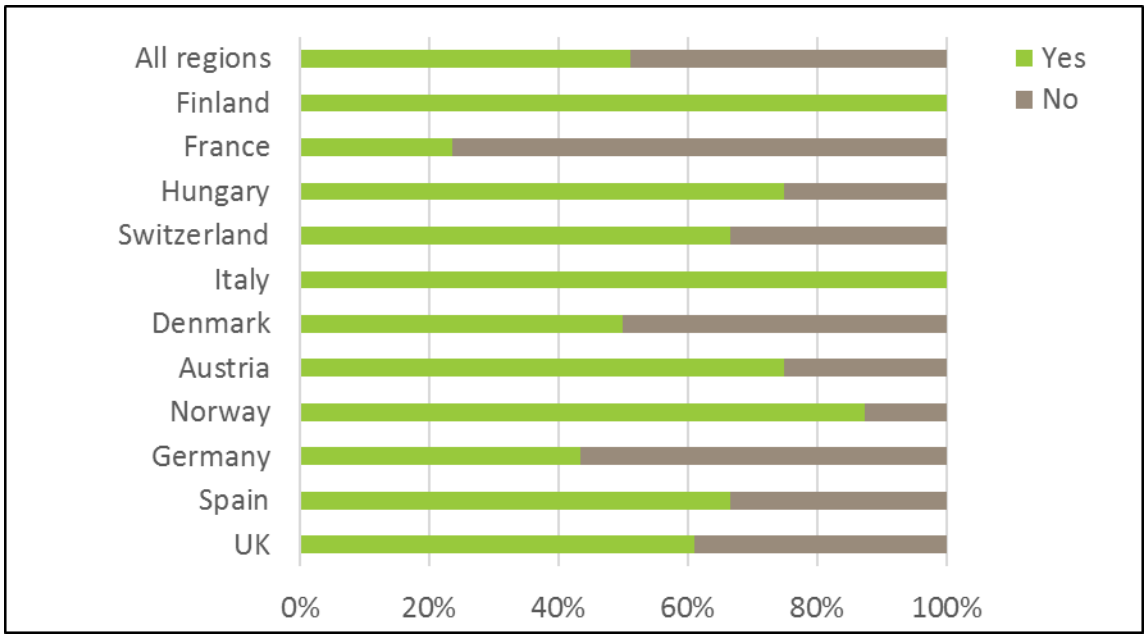

Figure 5: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" with responses from countries in EU as part of the global survey.

When we cross-tabulate the question on farmer's knowledge on SOC with farm size and farm type, we can see that knowledge on SOC concentrations increases with farm size, where farmers with between 500-1000 ha have the largest knowledge of SOC concentrations and farmers with less than 5 ha have the least knowledge on SOC concentrations (Figure 6).

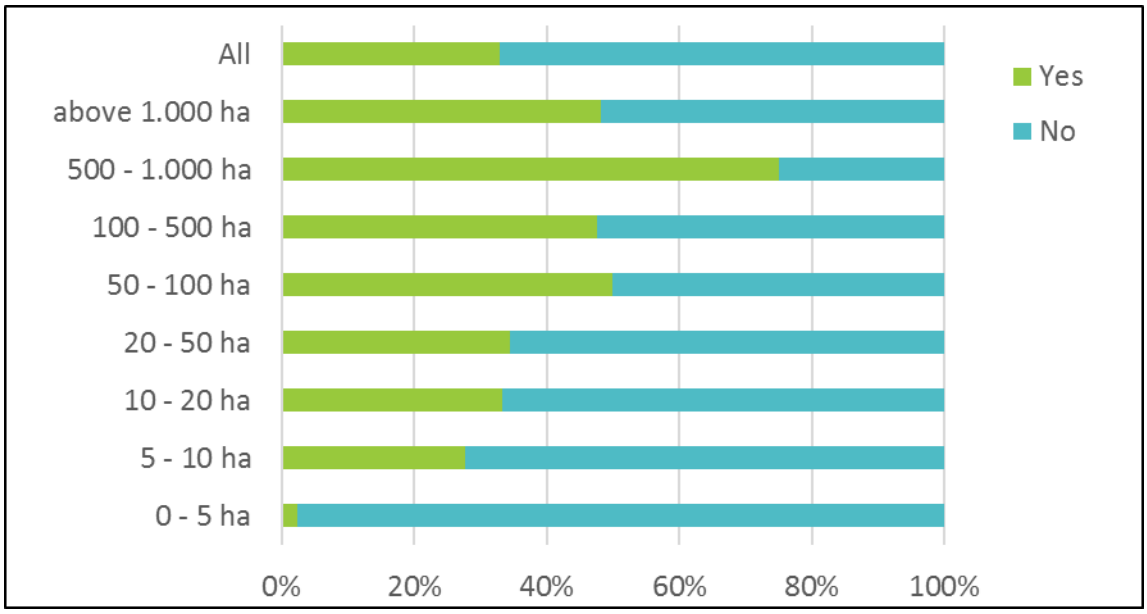

Figure 6: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" crossed with farm size in the global survey.

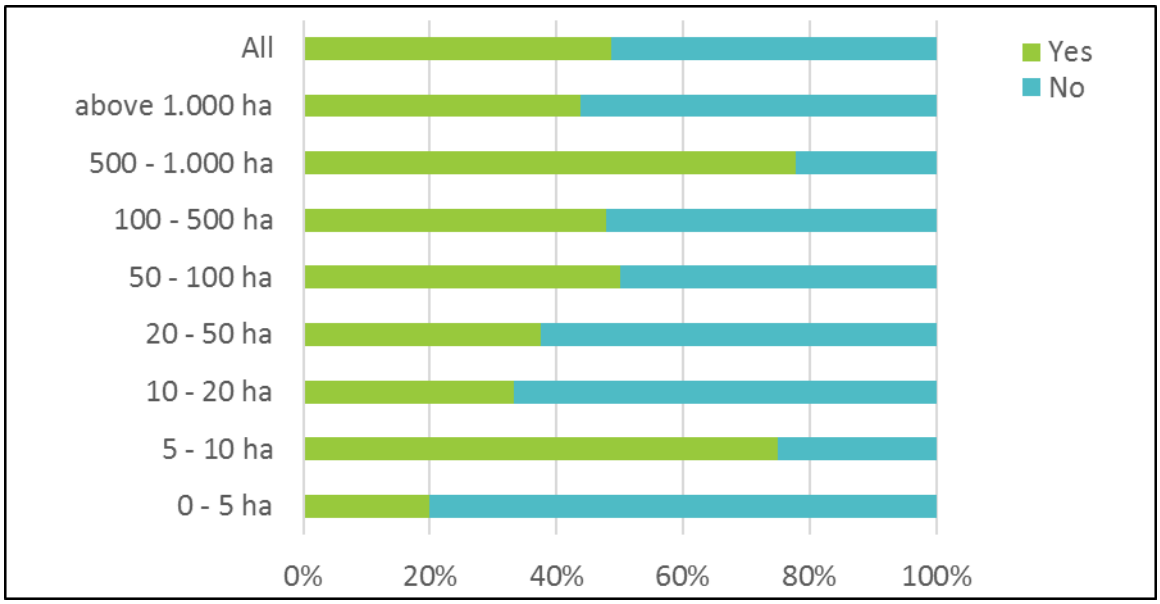

Figure 7: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" crossed with farm size for responses from Europe in the global survey.

Farms size is also correlated with least knowledge of SOC concentrations in the survey responses by European farmers: farms with less than 5 ha of land have less knowledge on SOC concentration of their soils than other farmers (Figure 7). The highest knowledge was reported by farmers with 500-1000 ha of land, which probably reflects greater knowledge levels with greater farm size as a consequence of greater capacity for investment in improved management.

The Danish farm data also shows this tendency. Farmers from 500 ha and above 1000 ha of land are the ones with the highest knowledge of SOC concentrations in Denmark (Figure 8).

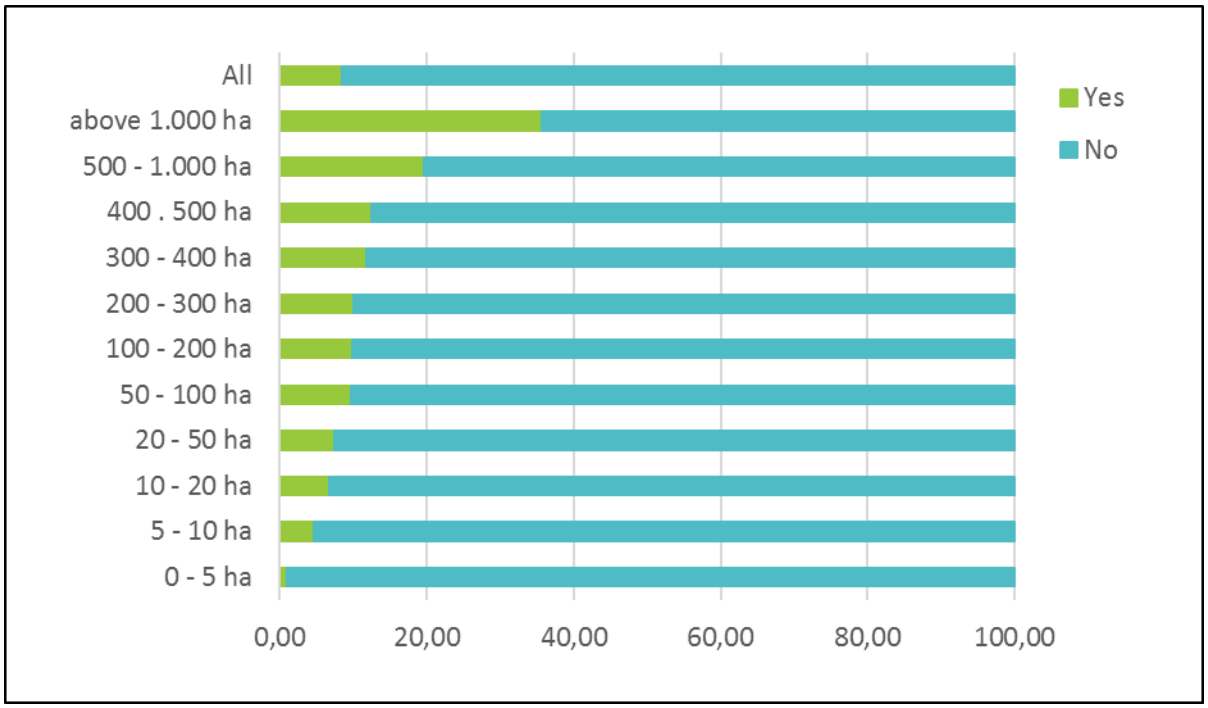

Figure 8: Farmer answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" crossed with farm size in Denmark.

The farm types with the greatest knowledge on SOC concentrations in the global survey are energy crop producers (38 percent), grain crop producers (28 percent), livestock free grazing farmers (28 percent), mixed farming (26 percent), whereas the lowest knowledge are among fruticulture, agro-forestry and coffee-culture farmers (Figure 9)

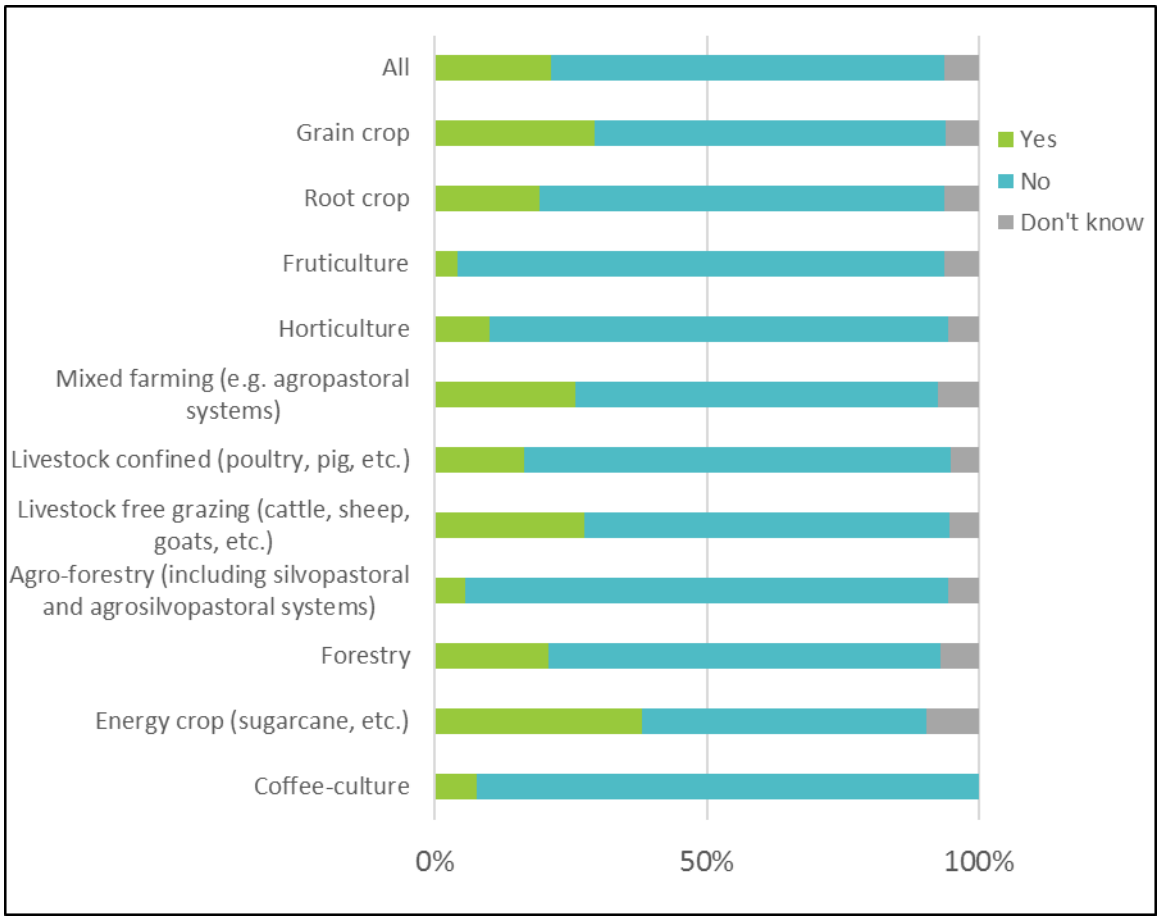

Figure 9: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" crossed with farm type globally.

There was no clear pattern among different farm types within Europe with respect to knowledge on SOC concentration (Figure 10). However, farmers in horticulture reported a greater knowledge than other farmers. This was not the case for the global regions (Figure 9) where we could see that the lowest knowledge was among fruticulture, agro-forestry and coffee-culture farmers.

In the Danish farm survey, the horticulture and fruticulture farmers also reported a higher knowledge on the SOC concentrations than other farmers (Figures 11 and 12).

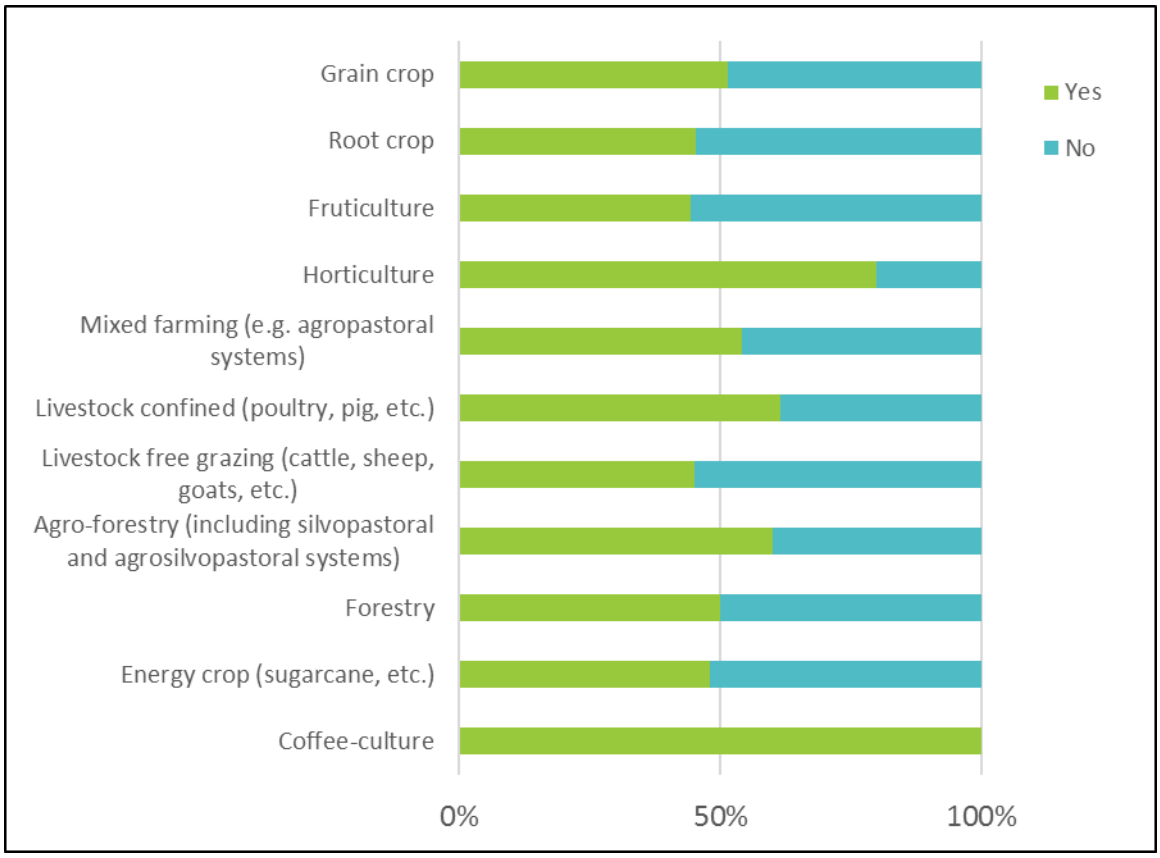

Figure 10: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" answers from Europe in the global survey crossed with farm type.

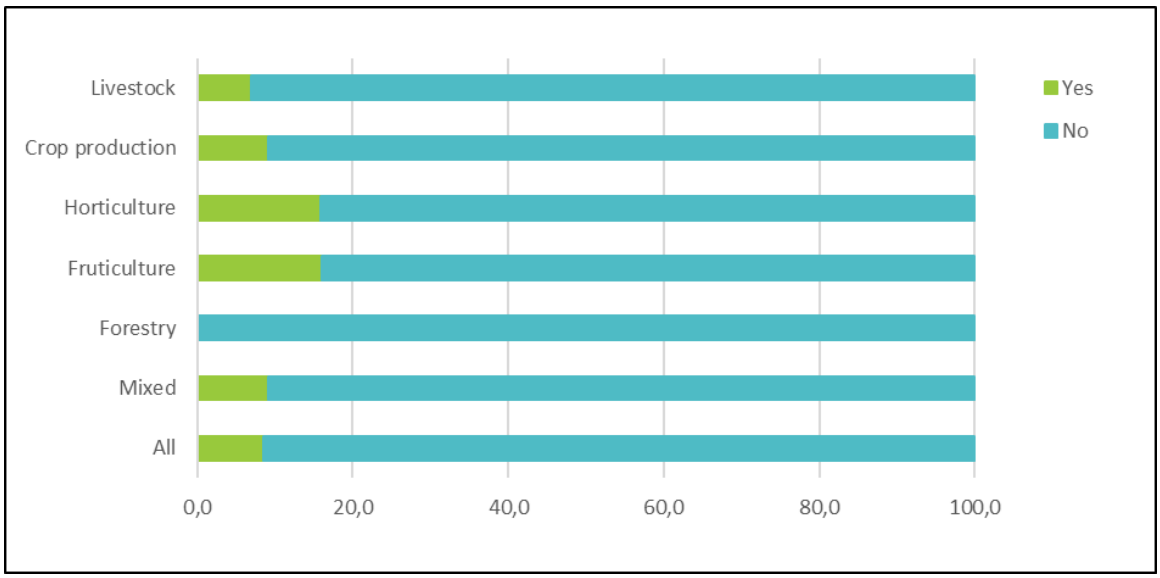

Figure 11: Farmers' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" Danish farmer answers crossed with farm type.

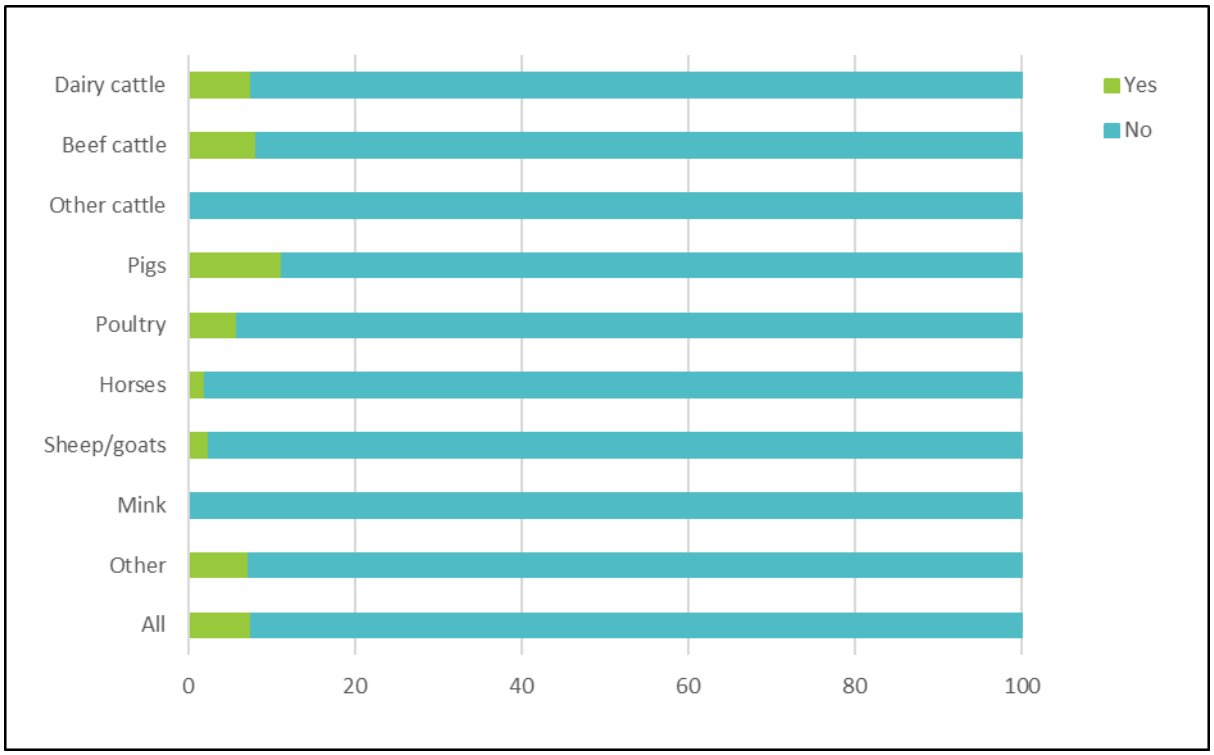

Figure 12: Farmer' answers to the question "Do you know the SOC concentration of (your) soil or of the soils in your region?" Danish farmer answers crossed with farm type (only livestock farmers).

Farmers in general considered SOC of their soils to be similar or higher than those of soils in the region in general (Figure 13). In particular, more than half of the responding farmers in North America, Australia, Russia, Latin America and Europe considered their soils to have SOC above those in the region. This indicates that respondents may have a greater focus on enhancing SOC than farmers in general.

Very few of the responding farmers in Europe considered their soils to have lower SOC than soil in the region (Figure 14). In fact, only a few farmers in Germany and UK provided this answer. The largest response in terms of don't know were in Hungary and France with 30-40% of responses. However, overall about 60% responded that they considered their soils to have higher SOC than soils in the region. As for the global survey, this may reflect a bias in farmers responding to the survey as those being more aware of SOC management.

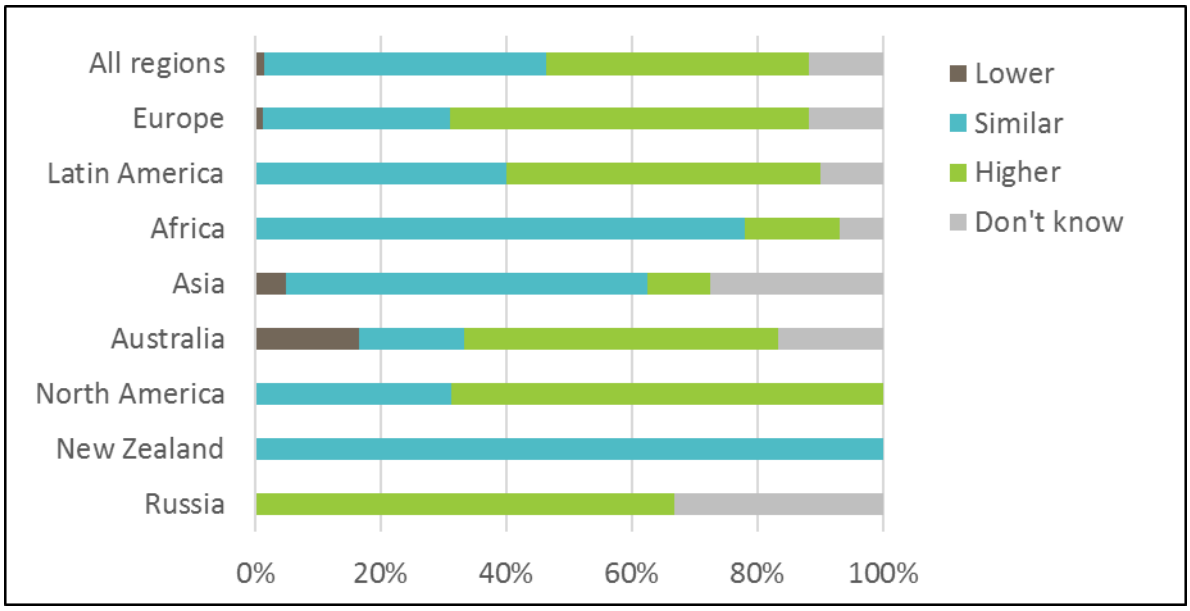

Figure 13: Farmer answers to the question "How do you view SOC of (your) soil to be different from soils in your region?" with responses from all regions.

The survey on farmers in Denmark can be considered more representative of farmers in general. Even here, very few farmers (4 %) considered their soils to have lower SOC than soils in the region (Figure 15), 31% consider the SOC to be similar and 28% higher, whereas 39% replied don't know. There may therefore be a general bias among farmers to overestimate quality of their own soils compared to that of the regions.

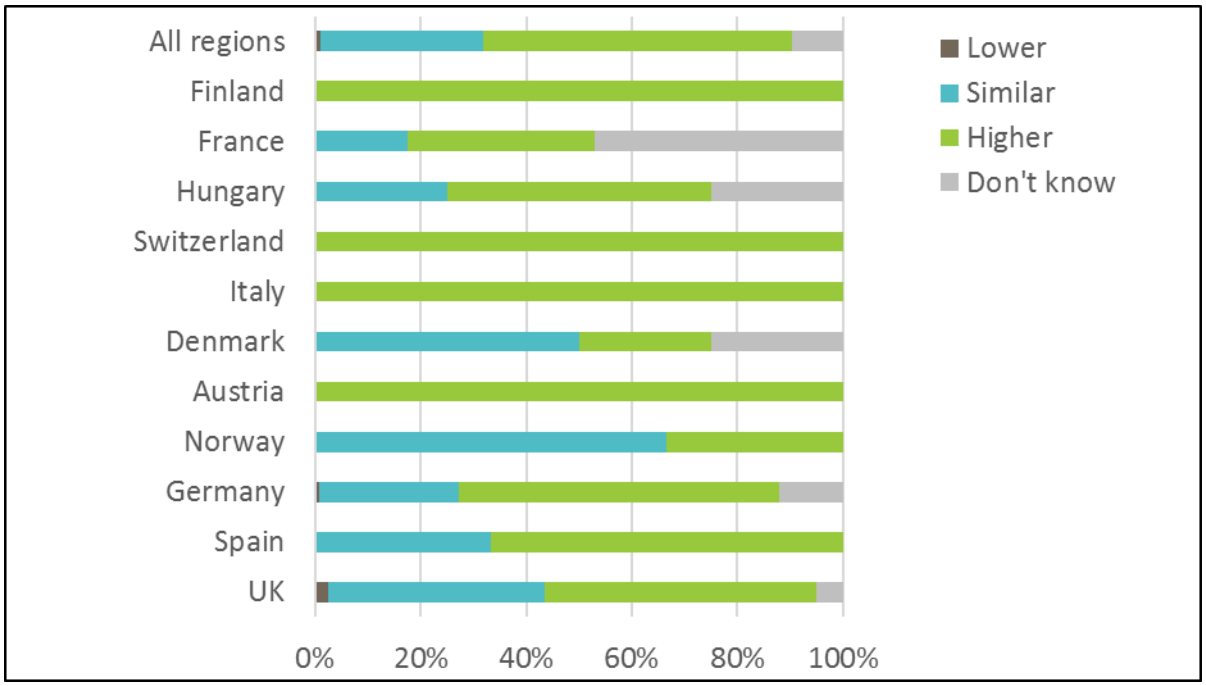

Figure 14: Farmers' answers to the question "How do you view SOC of (your) soil to be different from soils in your region?" with responses from countries in EU.

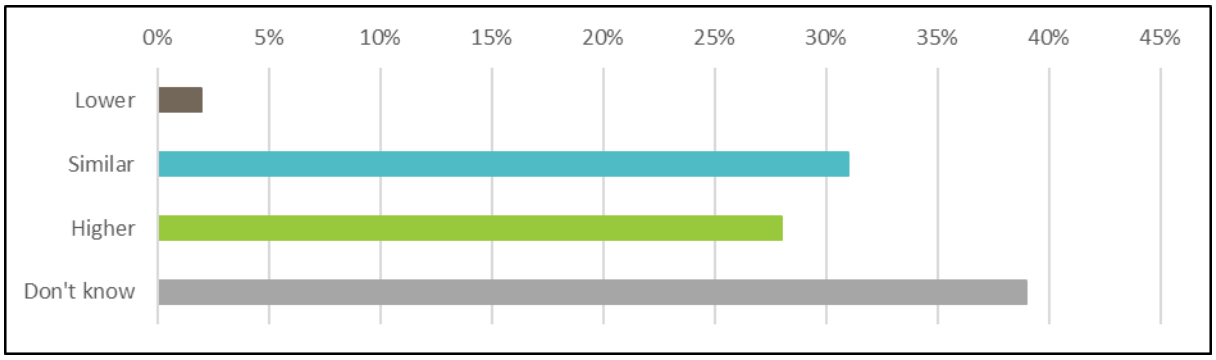

Figure 15: Farmers' answers to the question "How do you view SOC of (your) soil to be different from soils in your region?" with responses from farmers in the Danish survey.

3.2. Farmers' knowledge on change in SOC

Around half of the farmers across all regions in the global survey consider SOC of their soil to be decreasing (Figure 16). In Africa, it is the majority of farmers who consider SOC to be increasing and in Asia where 40 percent consider SOC to be decreasing, whereas farmers in Russia (only 3 responses in total), New Zealand (only 3 responses in total) and North America consider that they have an increase in SOC.

Farmers in Europe are almost equally divided on perceptions of whether SOC is increasing or decreasing (Figure 17). About 30% do not know the direction, or perhaps consider it to be stable. Farmers from France have the largest response rate on don't know.

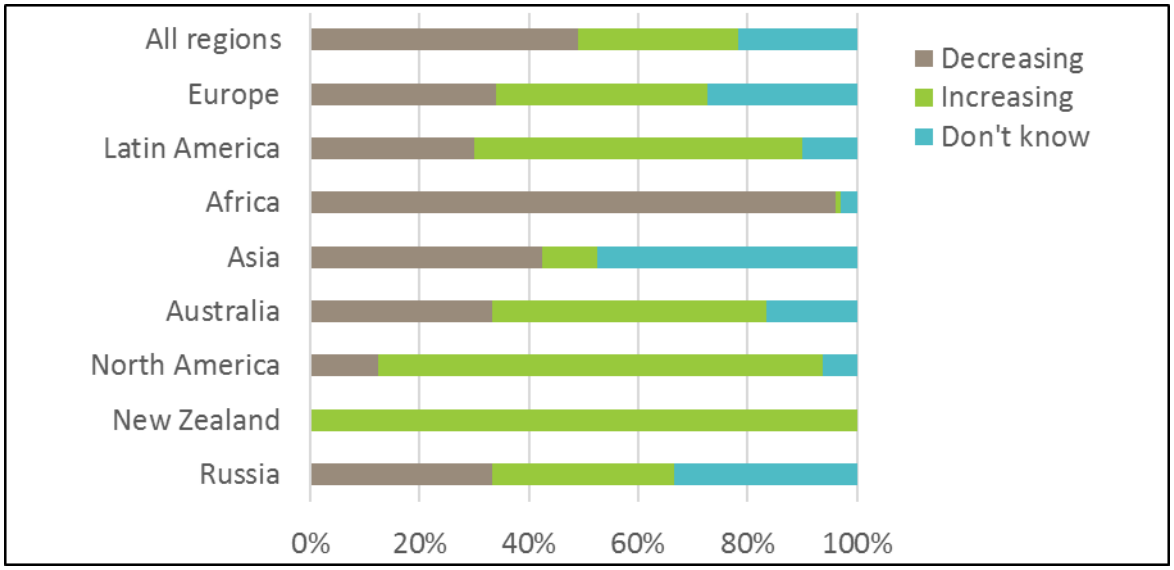

Figure 16: Farmer answers to the question "Do you consider SOC of (your) soil to be increasing or decreasing?" with responses from all regions in the global survey.

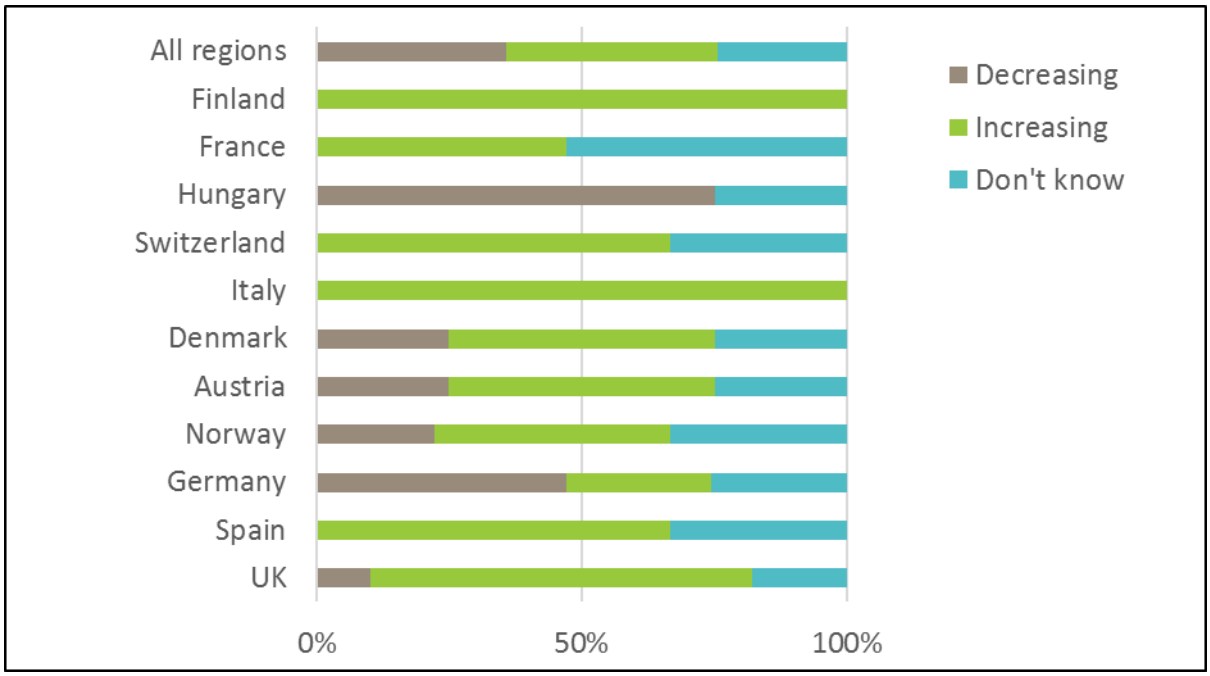

Figure 17: Farmer answers to the question "Do you consider SOC of (your) soil to be increasing or decreasing?" with responses from countries in EU.

If we compare with the survey of Danish farmers (Figure 18), 7% of the Danish farmers view that SOC is decreasing, 40% says it is increasing and 53% do not know. The larger proportion of don't know answers in the Danish survey again indicate that the global survey respondents are more familiar and have more knowledge of the SOC concept than average farmers.

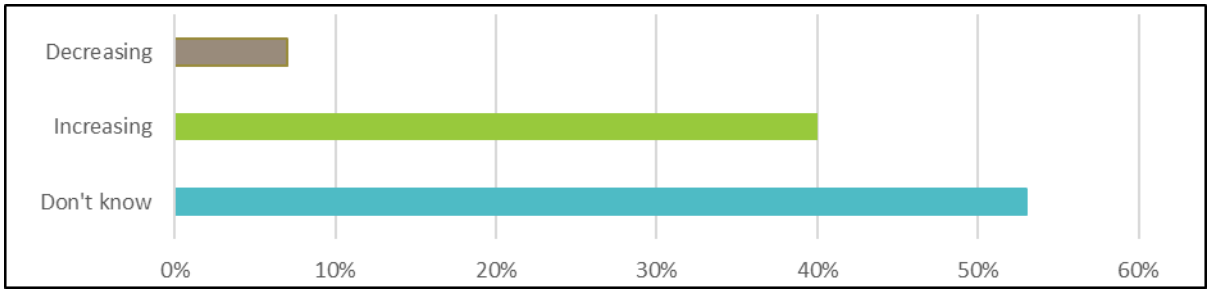

Figure 18: Farmers answers to the question "Do you consider SOC of (your) soil to be increasing or decreasing?" with responses from Danish farmers.

A majority of farmers (57 percent) across all regions consider that SOC is not critically low (Figure 19). This is particularly the case for Africa, North America and New Zealand, but less so for farmers in Latin America and Australia. Asia and Russia have a higher number of don't know answers. The responses of direction of SOC appear to have no relationship to concepts of whether SOC is critically low (compare Figures 16 and 19).

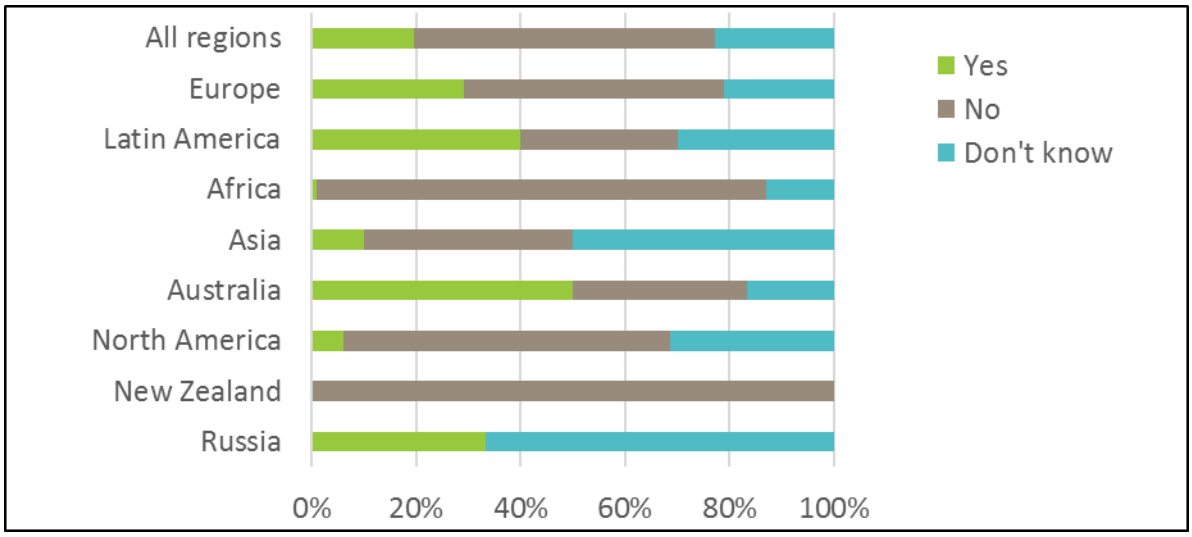

Figure 19. Farmer answers to the question "Do you consider SOC of (your) soil to be critically low?" with responses from all regions.

There appears to be a geographical pattern, in the European answers, on the response to whether SOC is critically low (Figure 20). A greater proportion of farmers in Southern Europe consider SOC to be critically low than for farmers in Northern Europe. This pattern could be related to climatic conditions such that warmer climate generally have lower SOC, and thus farmers consider the problem to be greater. This can also be seen in the Danish farmer responses where only 4% of Danish farmers consider the SOC of their soil to be critical low (Figure 21), again a high proportion of Danish farmers (43%) replies don't know.

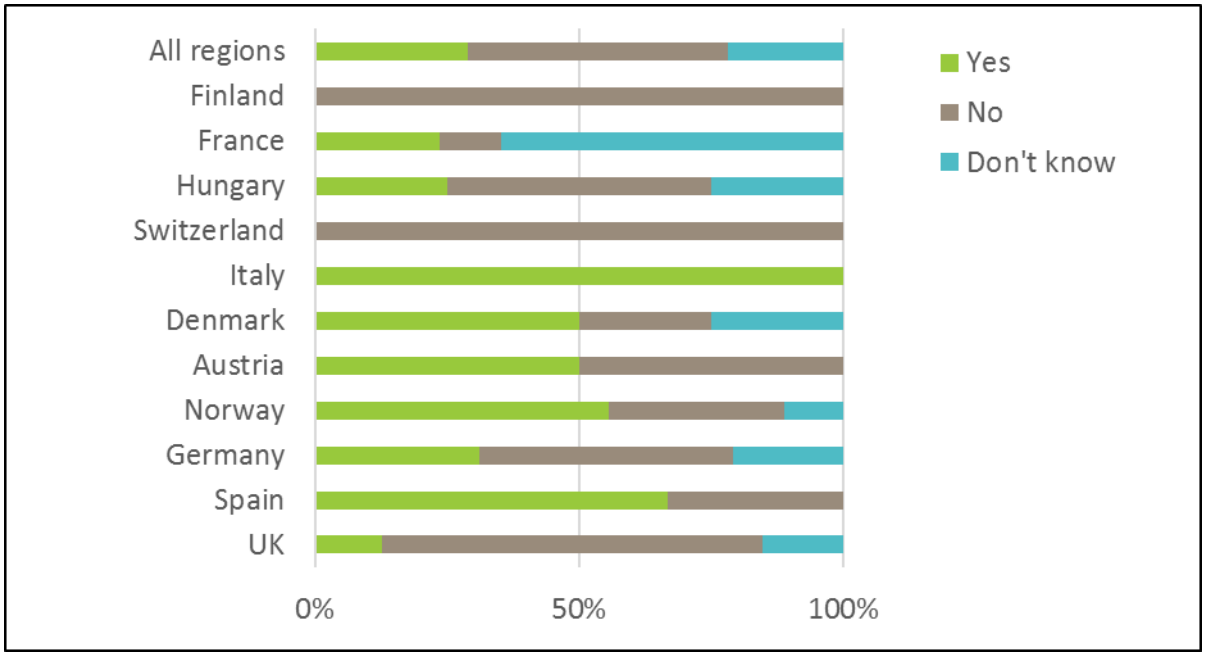

Figure 20. Farmers' answers to the question "Do you consider SOC of (your) soil to be critically low?" with responses from countries in EU.

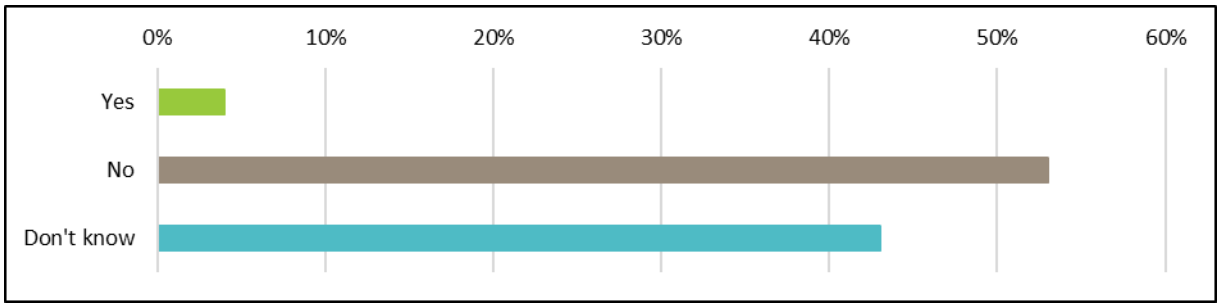

Figure 21: Farmers' answers to the question "Do you consider SOC of (your) soil to be critically low?" with responses from Danish farmers.

3.3 Summary of findings

The findings on the farmer knowledge and perceptions on SOC are briefly summarized below for each of the four questions asked.

Do you know the SOC concentration of your soil?

- About 30% of farmers in the global survey stated that they know the SOC concentration of their soil, whereas this was only 9% for the survey among farmers in Denmark. This may reflect a bias among farmers in the global survey towards farmers that have a knowledge and interest in SOC and SOC management.
- The low proportion of farmers in Denmark stating knowledge on SOC most likely reflect that SOC has not been an issue for farm management decisions.
- Knowledge on SOC concentration increases with farm size, which may reflect a higher general knowledge level among farmers that farm greater areas.

Do you consider SOC of your soil to be different from soils in the region?

- Farmers in general considered SOC of their soil to be similar or higher than those of soils in the region in general. This could indicate that respondents may have a greater focus on enhancing SOC than farmers in general and therefore believe that their soils have greater SOC.
- For the farm survey in Denmark, considered representative of farmers in general, there were very few farmers considering that SOC of their soil to be lower than soils in region in general. This may reflect a general tendency of farmers to overestimate quality of their own soils.

Do you consider SOC of your soil to be increasing or decreasing?

- Around half of the farmers in the global survey consider SOC of their soil to be decreasing. About 20% of farmers do not know the direction.
- For the survey in Denmark, which may be more representative of farmers in general, 53% respond that they do not know the direction of change in SOC, but 40% estimate that it is increasing.

Do you consider SOC of your soil to be critically low?

- A minority of 20% in the global survey estimate that SOC is not critically low, whereas 23% do not know.

- There is a geographical pattern in responses with more farmers in Southern Europe than in Northern Europe responding that SOC is critically low.
- In the Danish study only 4% responds that SOC is critically low, and 43% responds that they do not know.

4. SOC management options

This section provides an overview of stakeholder views and perceptions on SOC management options. The farmers' views and perceptions are shown for both global and European perspectives using the global survey as well as for the survey for farmers in Denmark (section 4.1). The view of other stakeholders than farmers are only handled at the global scale.

In the global survey, farmers and other stakeholders were given the option to give their view on 17 different management (agricultural practices and systems) options. The questions were centred on whether these management options were being applied and how effective these management options are in terms of enhancing and conserving SOC compared to current levels. The management options are shown in Table 3. A slightly smaller list of options was used for the Danish survey, see Annex 3. An overview of farmer responses for different regions, farm types and farm sizes is given in Annex 6.

Table 3: Overview of management options in the questionnaire.

Management options
Residue management (crop residue left in the field)
Reduced/minimum tillage
Zero tillage
Manure and composting
Grass in rotation
Use of cover crops (also called catch crops)
Use of grain legumes
Use of forage legumes
Permanent grassland management (optimised grazing)
Buffer strips and set-aside areas
Crop-livestock systems
Agro-forestry in cropland
Agro-forestry in grazing lands
Agro-forestry in mixed crop-livestock systems
Biochar
Rewetting of organic soils
Preventing erosion (e.g., contour farming, terracing, windbreaks)

4.1 SOC management options as viewed by farmers

About 80% of responding farmers in the global survey apply manure or compost, and including those that also considered this option, the rate was above 90% (Figure 22). This is surprising, given that access to these sources of organic amendments often are constrained. A large proportion of farmers were also applying residue management and measures to prevent erosion. In contrast, very few farmers apply biochar, although this was considered by almost 25% of respondents. It seems from these responses that there is a considerable interest by farmers in having or getting access to amendments that can increase SOC.

In Europe, residue management along with reduced/minimum tillage, use of cover crops and manure and composting were the management options most farmers already applied. Zero

tillage was one of the options that a large proportion (31%) of farmers considered applying (Figure 23).

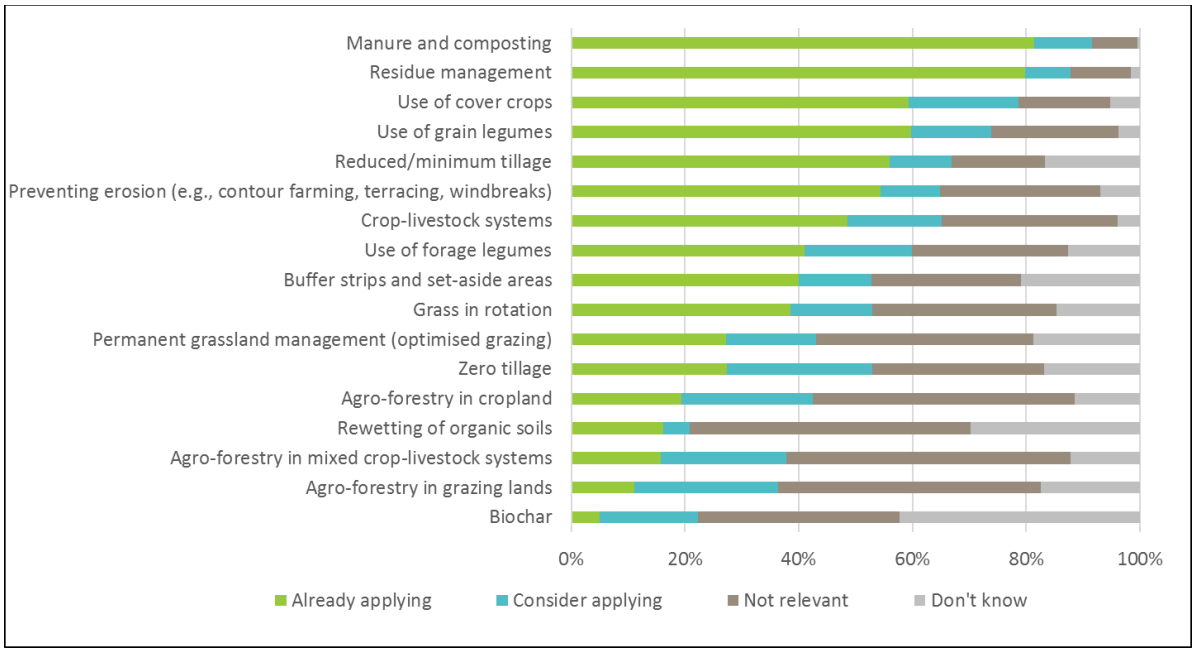

Figure 22. Farmers' answers to the question "Which management options do you apply or consider applying?" with responses from farmers from all regions.

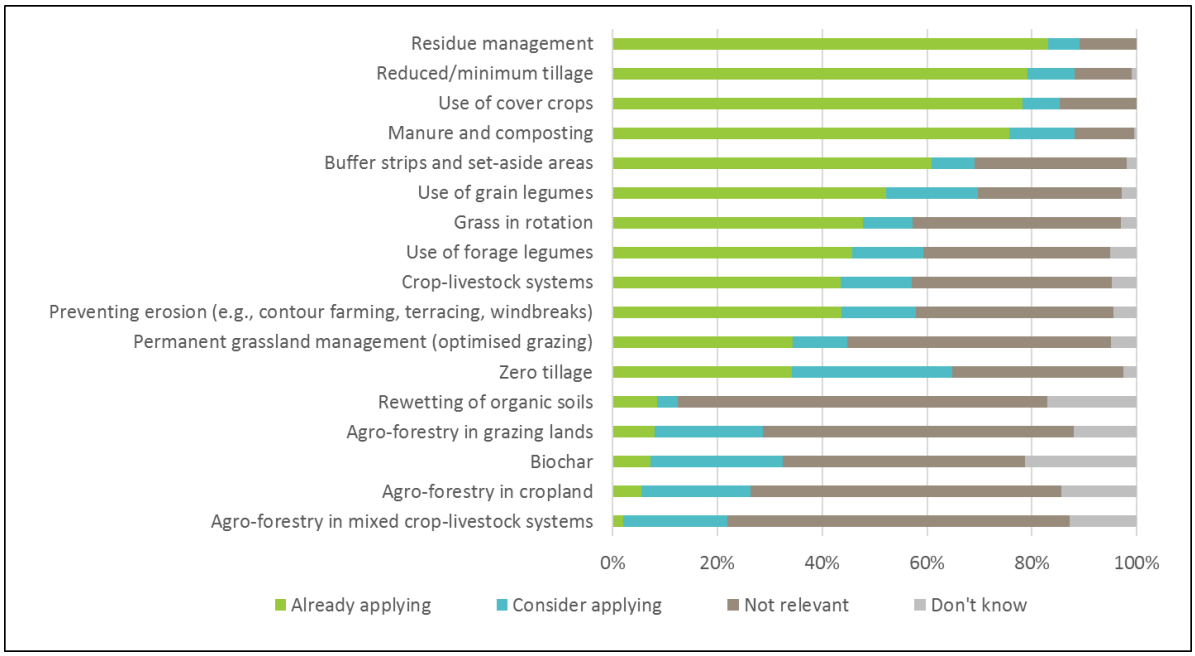

Figure 23: Farmers' answers to the question "Which management options do you apply or consider applying?" with responses from farmers in Europe in the global survey.

For the Danish farmers, the use of cover crops and manure application was the most applied management options (Figure 24). This is mainly related to legal obligations for use of these management options. Also, the use of hedgerows and residue management is management options used by Danish farmers according to the survey. The response rate of don't know answers was generally considerably lower for the survey from Denmark compared to the global survey, but of similar magnitude for most management options as for the European part of the

survey. This may illustrate that farmers in Denmark are generally aware of which options are available, except perhaps for biochar.

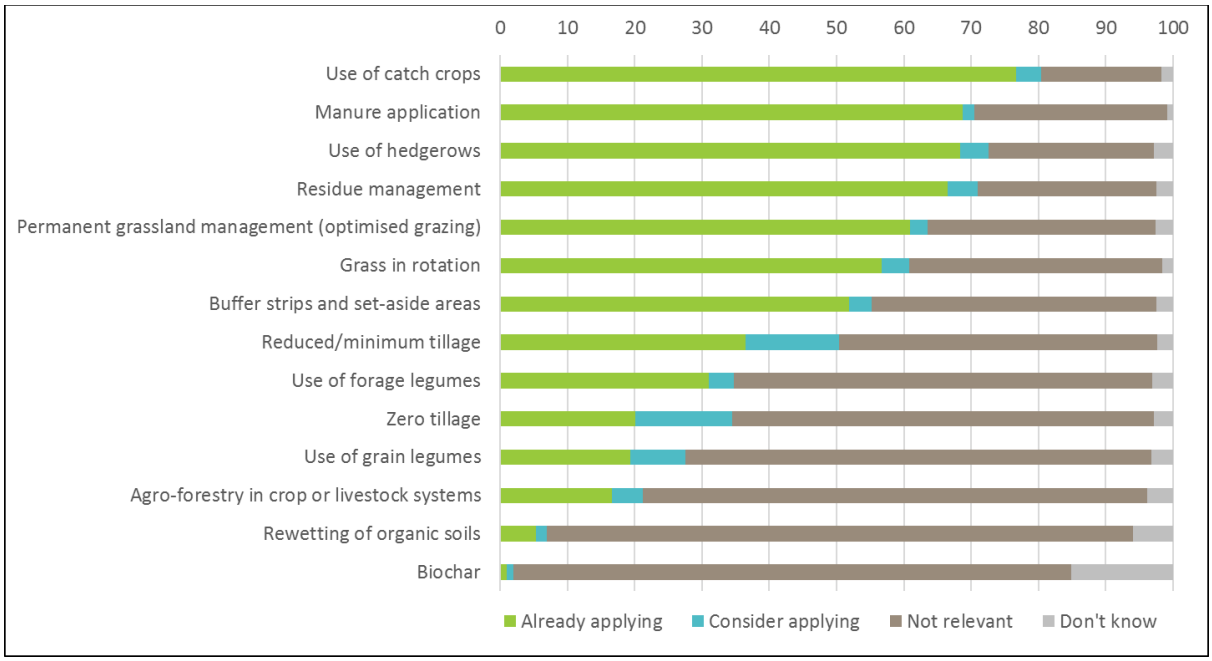

Figure 24: Farmers' answers to the question "Which management options do you apply or consider applying?" with responses from farmers in Denmark.

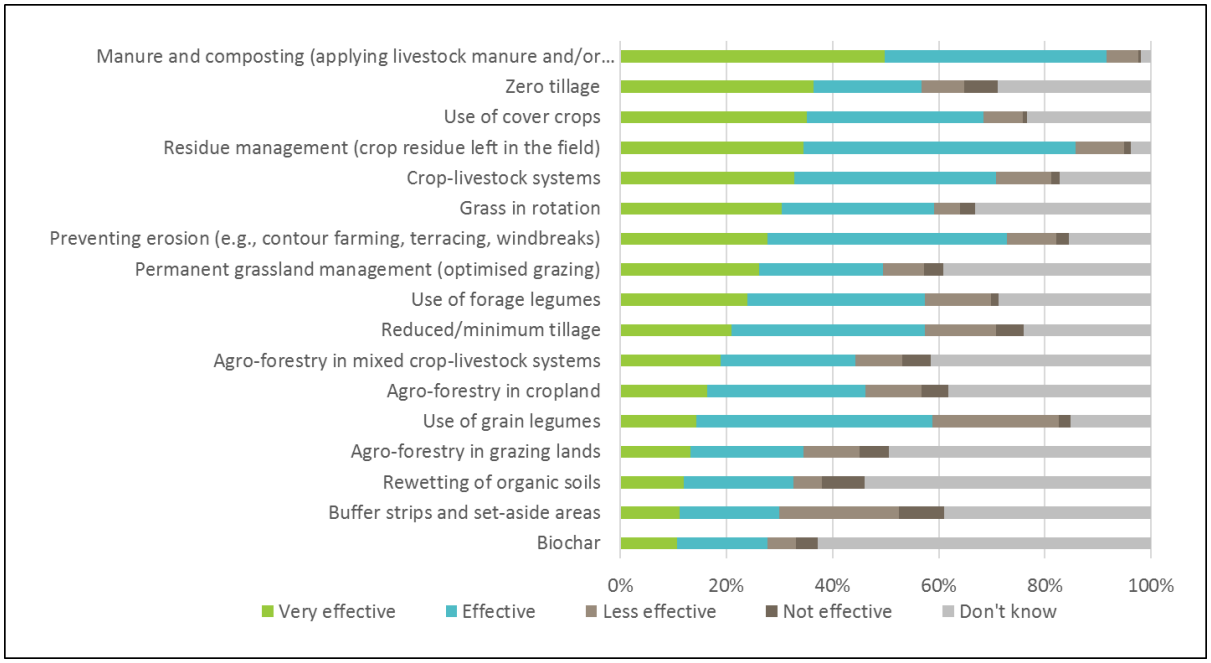

Figure 25: Farmers' answers to the question "In your opinion, how effective are the following management options for enhancing and conserving SOC compared to current levels?" with responses from farmers from all regions in the global survey.

Farmers in the global survey considered manure and composting, zero tillage, use of cover crops and grasslands (permanent or in rotation) as being the most effective measures for increasing SOC (Figure 25). Buffer strips, set-aside and use of grain legumes were considered the least effective. Except for the use of manure and compost and residue management, there

were relatively large response rates for don't know. This was particularly large and above 50% for rewetting of organic soils and use of biochar, which for organic soils probably means that the farmers are not familiar with this type of soil and for biochar that this technology generally is not available.

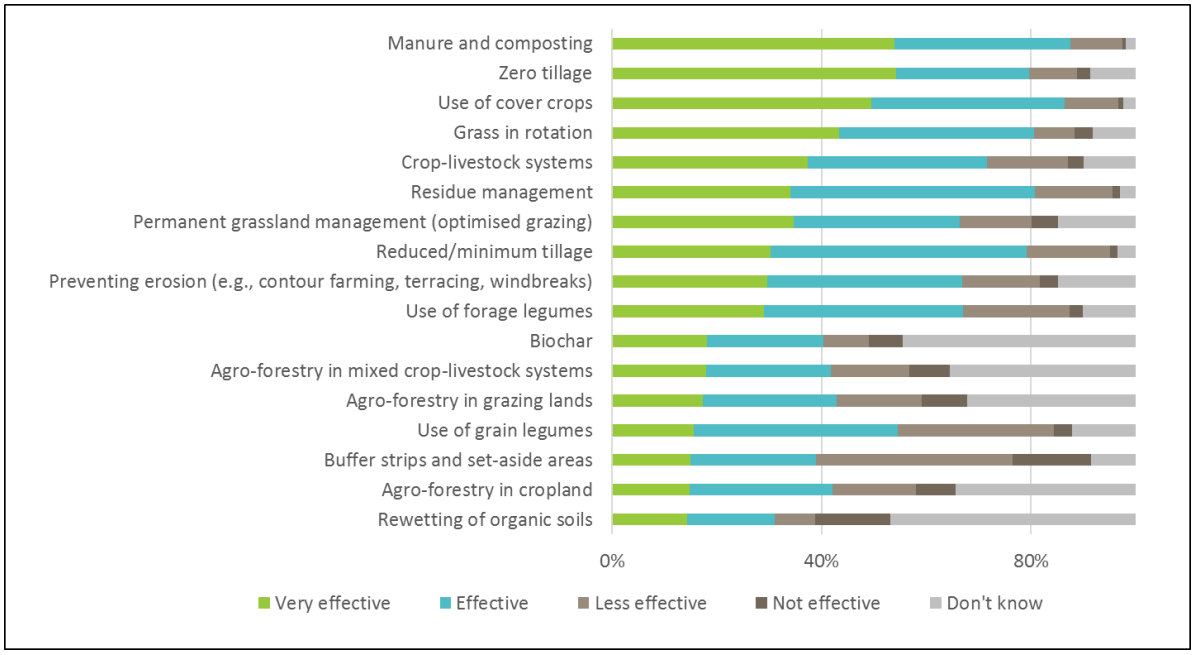

Figure 26: Farmers' answers to the question "In your opinion, how effective are the following management options for enhancing and conserving SOC compared to current levels?" with responses from farmers from Europe.

According to farmers across the European region, the most effective (very effective and effective) management options (around 80%) are manure and composting, zero tillage, use of cover crops, grass in rotation, residue management and reduced/minimum tillage (Figure 26). Whereas the least effective (not effective and least effective) are buffer strips and set-aside areas and to some degree use of grain legumes. The management options with most don't know answers are biochar, rewetting of organic soils and to some degree agro-forestry.

The most effective options in the Danish survey were grass in rotation, manure application, use of cover crops, residue management and to some degree also permanent grassland (very effective and effective) (Figure 27). Danish farmers do not rank the management options as effective as the global or European farmers. There are substantially more don't know answers for many of the management options, but as with the European survey responses, rewetting of organic soils, biochar and also agro-forestry are the ones with least knowledge on effectiveness. The higher response rate of don't know for the survey from Denmark may reflect that respondents in the survey from Denmark have less overall interest and knowledge on SOC management than respondents for the global survey.

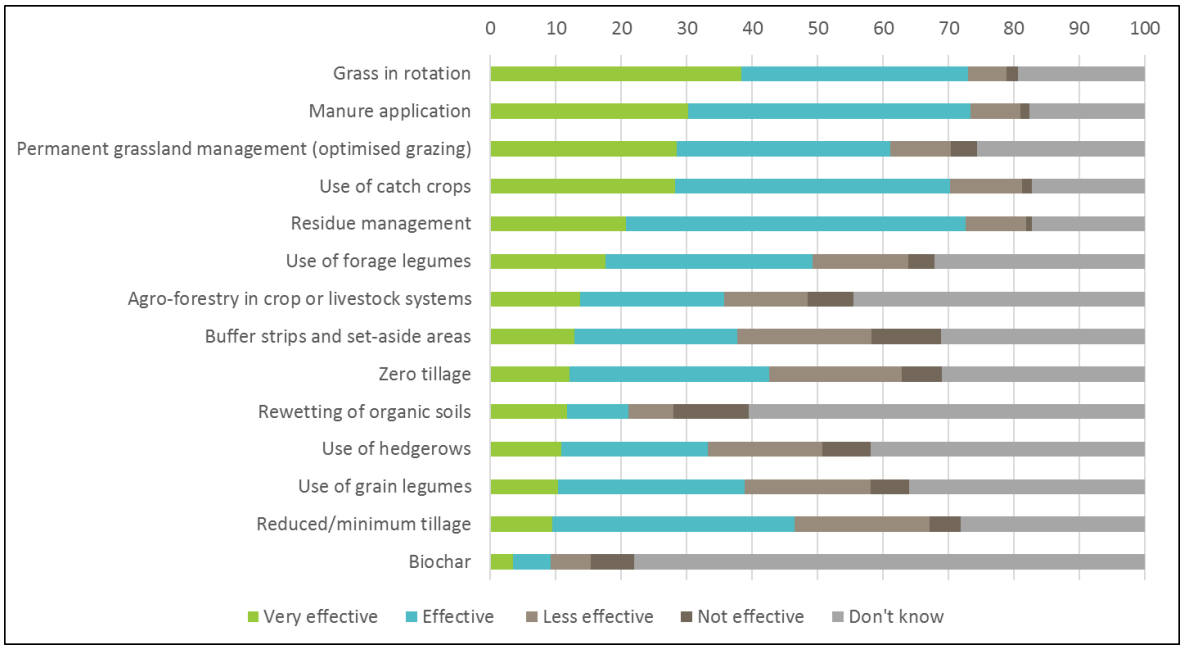

Figure 27. Farmers' answers to the question "In your opinion, how effective are the following management options for enhancing and conserving SOC compared to current levels?" with responses from farmers from Denmark.

Crop residue management involves retaining straw and other crop residues in the field on the soil surface or incorporated into the soil. It is more applied in crop production systems than livestock and mixed farming systems (Figures 34 and 35). There is also a greater use of crop residue management with increasing farm size in the Danish survey with farms under 20 ha having less use of crop residue management (Figure 36). Slightly more Danish farmers within crop production or horticulture found crop residue management effective than other farm types (Figure 38). The greatest uncertainty on crop residue management were found for farmers with forestry.

With reduced/minimum tillage there is no ploughing and with zero tillage there is no soil cultivation at all (sometimes also called direct drilling). More farmers in both the global and the Danish survey apply reduced/minimum tillage than those who apply zero tillage (compare Figures 39 and 44). Reduced and minimum tillage is most applied in North America and Australia and least in Africa and Asia (Figure 39). There is little difference among farming systems in their application of both reduced/minimum tillage and zero tillage (Figures 43 to 45). Both reduced/minimum tillage and zero tillage is applied at a greater extent on larger farms in the Danish survey, so that 80% of farms with areas above 1000 ha apply reduced/minimum tillage. The extent of application of minimum tillage in the survey exceeds the statistics on application of minimum/reduced and zero tillage in Denmark. The responses therefore likely reflect that these forms of reduced tillage is only applied on parts of the cropping area and possibly only for some crops in the rotation. There appears to be considerably disagreement among respondent in the Danish survey on the effectiveness of tillage for enhancing and conserving SOC across all types of farming systems (Figures 43 and 48).

Manure and compost involve application of manure (various types) and compost to the field. These organic amendments may in practice originate from on-farm sources or be imported from external sources. In the global survey this measure is applied to a very large extent across all farm types (Figure 49), whereas for the Danish survey it is mostly applied on livestock and

mixed farming systems (Figure 50). The Danish survey shows that this option is applied to a greater extent with increasing farm size up to 400 ha (Figure 51). About 70 percent of the livestock and crop farmers in Denmark find this option effect or very effective (Figure 53).

Grass in rotation includes the growing of grass or grass-clover crops as part of a rotation that also include other crops such as cereals, seed crops and forage crops. This option is more widely used in livestock systems than in crop production systems in both the global and Danish surveys (Figures 54 and 55). In the Danish survey about 70% of livestock and mixed farming systems use grass in rotation, which likely provide fodder for livestock. However, about 45% of crop farms in Denmark use grass in rotation. This use of grass on crop farms may have several purposes, such as grass for seed production, production of grass for nearby livestock farms and grass for green manure (in particular on organic farms). The use of grass in rotation increases slightly with increasing farm size in the Danish survey (Figure 56), which may relate to a higher probability of having grass as farm size increases simply due to a larger number of field and associated diversity of crops. In the Danish survey about 70% of farms consider this grass very effective or effective for enhancing or sustaining SOC (Figure 58). The percentage is slightly greater for livestock and mixed farming.

Cover crops include the growing of crops outside of the main crop growing season to protect the soil surface from erosion and to prevent nutrients from being lost. Cover cropping is less used in Asia and Africa than in other world regions (Figure 59). In the Danish survey cover crops are applied to a wide extent in all farming systems, except for fruticulture and forestry. The use of cover crops increases with farm size up to a size of 50 ha in the Danish farm survey (Figure 61), some of which may be due to exceptions for some of the small-scale farmers from legal requirements of having cover crops. Except for farmers within forestry there is general consensus among 70 % of farmers in the Danish survey that cover crops is a very effective or effective measure for enhancing or sustaining SOC (Figure 63).

Grain legumes are grown for providing protein-rich food or feed. There are many different types of grain legumes (e.g., soybean, pea, beans and lentils) and they are often grown in rotation with other grain crops or as intercrops. Grain legumes provide nitrogen input through biological nitrogen fixation and may thus sustain production without external nitrogen input. Grain legumes appear to be applied a considerably greater extent in the global survey than in the Danish surveys (Figures 64 and 65). In the Danish survey only about 25% apply grain legumes, whereas this is about 75% in the global survey, where even coffee culture, forestry and energy crops appear to have grain legumes to a relatively large extent. Such systems do not appear to favour growing of grain legumes, and there is therefore need to question the representativeness of the results from the global survey. In the Danish survey there is about 20% of farmers applying grain legumes in most farming systems and almost 10% of farmers considering to do so. The use of grain legumes increases considerably with farm size in the Danish survey (Figure 66). Only about 40% of the Danish farmers across all farm types consider grain legumes a very effective or effective measure of increasing or sustaining SOC, whereas about 25% do not know.

Forage legumes are grown for forage production, either as sole crops (e.g. Lucerne) or in mixture with grass (e.g. clover). Grain legumes provide nitrogen input through biological nitrogen fixation and may thus sustain production without external nitrogen input. Forage legumes are mostly applied in livestock systems or mixed systems (Figures 69 and 70). For the

Danish survey about 50% of these systems apply forage legumes, whereas this is about 60% in the global survey. Few Danish horticultural farmers apply forage legumes, but about 20% of these farmers consider to do so, which may be organic horticultural farmers considering to increase soil fertility and nitrogen supply to vegetable crops through forage legumes. There is no apparent relationship between the use of forage legumes and farm size (Figure 71). About 50% of farmers in the Danish survey across all farm types consider forage legumes effective for increasing or sustaining SOC (Figure 73).

Permanent grassland management involves management of stocking density, sward species composition and fertilisation to optimize grassland productivity. This management option is most relevant in the global survey for livestock and mixed farming systems (Figure 74). For the Danish survey, also fruticulture and forestry apply this option (Figure 75), possibly on parts of the area. There is no relationship with farm size for this option (Figure 76). About 50% of respondents in the Danish survey consider this option very effective or effective, less so by farmers in fruticulture and forestry (Figure 78).

Buffer strips and set-aside are areas that are taken out of agricultural production, and where no fertilizer is being applied. These areas regrow with natural vegetation or with a seeded mixture of perennial species, typically grass. In the global survey this option is most applied in energy crops and grain cropping systems (Figure 79). There is no difference among cropping systems in the Danish survey for this option. In the Danish survey buffer strips and set-aside is applied to a greater extent for farms with a land area greater than 50 ha (Figure 80). Only about 35% of farmers in the Danish survey consider this option very effective or effective in enhancing or sustaining SOC (Figure 82):

Crop-livestock systems entails that livestock production is integrated with the production of the feed crops and that manure is applied within the cropping system providing the feed. Since this by legislation is an integral part of farming systems in Denmark, this question was not included in the Danish survey. In the global survey this option was apparently very widely used, even in grain cropping systems, but mostly in mixed farming systems (Figure 83). The wide use of crop-livestock systems also in grain crops and horticultural systems cast some doubts on the representativeness of the survey results or how they should be interpreted.

Agroforestry involves the growing of trees as an integral component of other cropping systems (crops, grazing land and mixed-crop livestock systems). The Danish survey did not distinguish these different types of agroforestry, but asked for agroforestry in general. Agroforestry on cropland and mixed crop-livestock systems in the global survey is most wide applied in coffee-culture, agroforestry systems, fruticulture, horticulture and to some extent mixed farming (Figures 85 and 89). Agroforestry in grazing lands is less widespread in the global survey, and mostly in agroforestry systems and free grazing lands (Figure 87). In the Danish survey survey on agroforestry in general, this option was most widespread in forestry and fruticulture systems with more than 40% and least so in crop production and horticulture (Figure 90). There was a tendency for lower proportion of agroforestry with increasing farm size in the Danish survey (Figure 91). About 35 percent of farmers in the Danish survey consider this option very effective or effective for increasing or sustaining SOC (Figure 93); however, more about 45 percent state that they do not know. The highest positive response rate in terms of very effective was in fruiticulture and forestry (about 25%) and least in horticulture (5%).

Biochar is a recalcitrant product that originates from pyrolysis of biomass. It can come in many different types and qualities, but it is generally considered to be very stable when incorporated into the soil. Biochar is very little applied in both the global and Danish survey (Figures 94 and 95). In the Danish survey, this option was only applied on about 3 percent of the livestock farms, and with a few percent of the cropland and fruticulture farmers considering to apply the option. In the global survey, 50 to 90 % of farmers, depending on farm type, responded that they did not know of this option. For the Danish survey only about 20% of respondents did not know of biochar, but the large majority considered this option irrelevant. About 35% of the Danish farmers considered biochar very effective or effective at increasing or sustaining SOC, whereas more than 40 percent did not know (Figure 93).

Rewetting of organic soils involved stopping drainage of cultivated peatlands and other organic soils. This will typically mean that these soils are no longer applicable for agricultural production, although various forms of paludiculture have been proposed. A surprisingly large proportion of farms in the global survey (more than 20%) stated that they already apply this measure (Figure 99), which seems unlikely, given the extent of organic soils globally and the general application of rewetting of organic soils. About half of the respondents in the global survey do not know of this measure, and many of the farmers responding that they are applying the measure may have misinterpreted the question. The application of this measure is considerably lower (about 6 percent) in the Danish survey, which appears more realistic (Figure 100). Only about 10 percent of respondents in the Danish survey do not know of the measure, but for a large majority this is not relevant, because their farms do not have organic soils. There is a slight increase in the application and consideration of application of rewetting of organic soils with farm size in the Danish survey (Figure 101). This is probably related to a higher chance for farmers having organic soils as part of their farmland with increasing farm size. About 20% of farmers in Denmark consider this an effective option (Figure 103). Since rewetting is a very effective option for reducing GHG emissions, farmers may have interpreted the question in terms of whether this option would be effective on his/her own farm.

Measures for preventing soil erosion involves soil cover, terracing, hedge rows and buffer strips among others. This measure is being well applied across different farm types (Figure 104), with slightly less application in grain crops and energy crops.

In general, across management options farmers that find an option effective for SOC management also have applied or consider applying the option, whereas farmers that find the option ineffective or do not know has a lower use of the option (e.g. Figures 37, 42 and 47). There may be several reasons for this relationship: 1) the farm structure may not allow the application of a particular management option and thus this is considered ineffective by the farmer, 2) the farmer may have inadequate or bad experiences with the management option and thus considers it ineffective, and 3) the farmer has interpreted the question on effectiveness as effectiveness on his/her own specific farm.

4.2 Other stakeholders' views and perceptions on farm management options

Other stakeholders than farmers responded to the global survey, and they were asked which management options they thought farmers are using for SOC management in their region.

Figure 28 shows some variation in how other stakeholders than farmers consider options applied in different parts of the world. Across all continents, residue management, reduced/minimum tillage, manure/composting and use of cover crops comes out as the most applied measures. However, for example residue management is widely used in Asia, but less in North America. In contrast, cover cropping is hardly used in Russia, but to a greater extent in many other regions, including Europe.

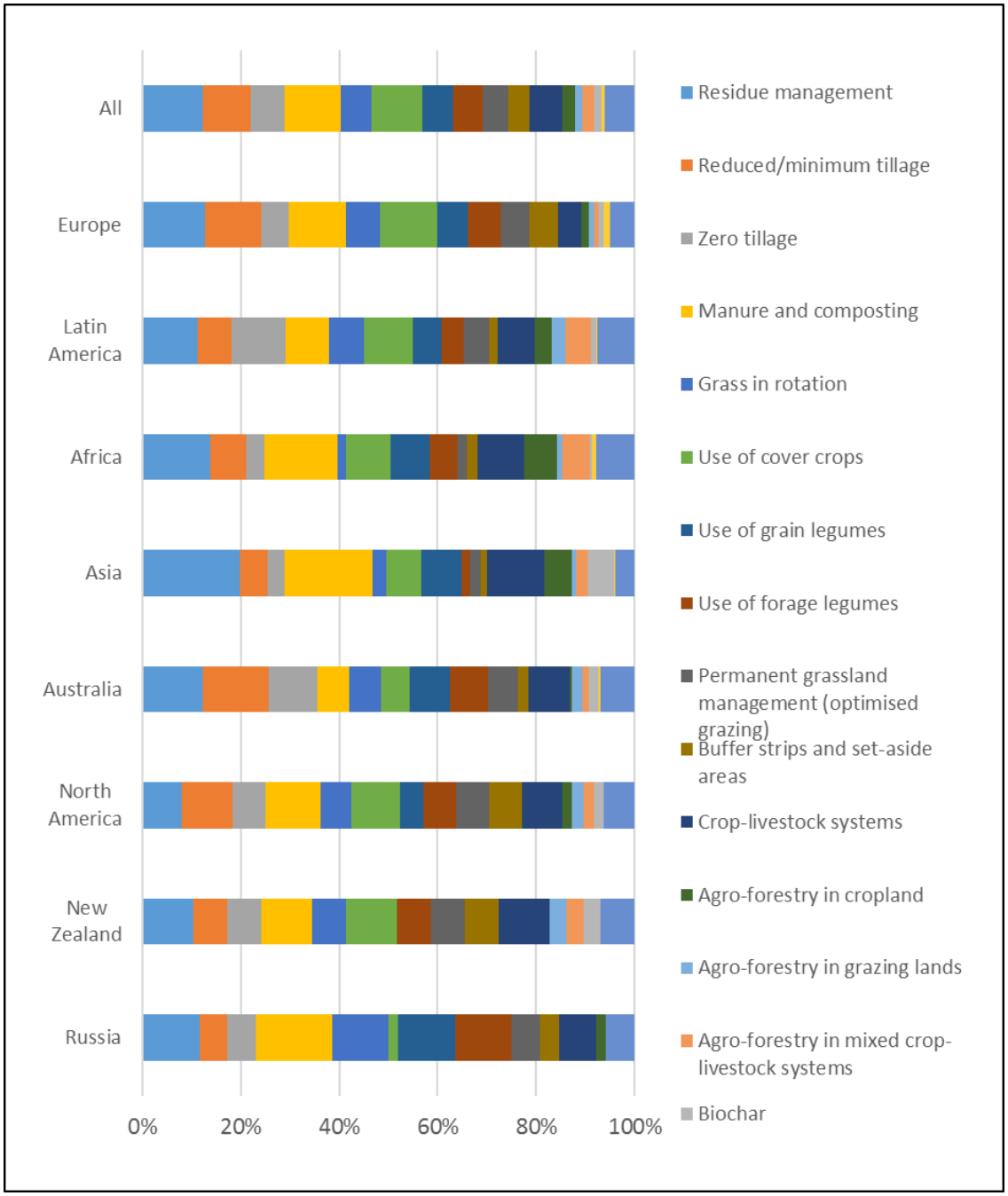

Figure 28: Other stakeholders answers to the question "Which options do you think farmers are using for SOC management in your region at present?" with responses from all regions. The percentage shows how frequent specific management options were identified as present.

Figure 29 shows the variation in response among different stakeholder groups. There is in general little variation among stakeholder groups in their view on management options applied, showing that there is a general consensus among stakeholders on what farmers are applying.

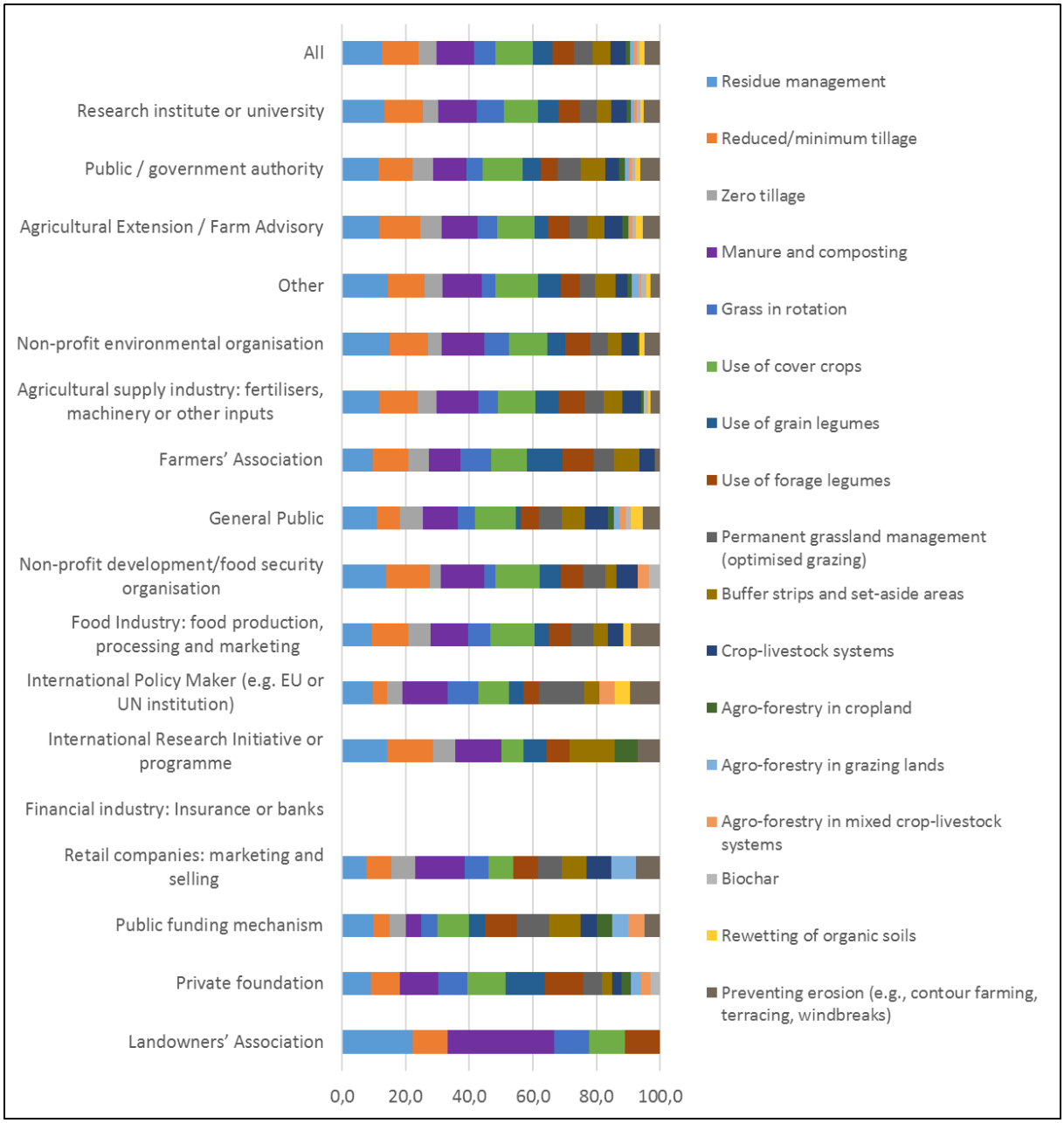

Figure 29: Other stakeholders answers to the question "Which options do you think farmers are using for SOC management in your region at present?" with which stakeholder group describes you best. The percentage shows how frequent specific management options were identified as present.

4.3 Results from workshops

The results from the regional workshops are summarized in Annex 5. Workshop participants were asked to reflect on management practices that they see as most effective in their region, practices that are most applied by farmers, and practices, which are interesting for SOC management in the region (have potential), but have not yet been applied at all or have not been

applied to a significant degree. Stakeholders were offered the list of practices that were included in the survey as the basis for discussion, but could extend this list or also remove practices as not applicable to the region.

The following observations were made on the ranking from the workshop reports:

- The ranking of options ranged widely among the regions. There are some commonalities, i.e. some practices are more frequently named as top 3 – 5 practices. However, there is also a lot of variation between the regions. Stakeholders also stressed the context specificity within their regions, with applicability and effectiveness depending on biophysical / climate conditions (in particular amount of rainfall and soil type) and farming systems.
- As most effective the following SOC management practices were identified: agroforestry (on cropland, grazing land or in mixed-crop livestock systems), cover crops and residue management, preventing erosion, reduced and zero tillage, manure and composting. The following were cited less frequently as most effective: grain and forage legumes, permanent pasture management, grass in rotation. The least frequently cited were biochar, buffer strips and others.
- Most frequently mentioned as top 3 most used practices: manure and composting, reduced tillage and zero tillage, residue management. Less frequent options are agroforestry, grain legumes and cover crops. Least frequent are forage legumes
- Biochar and rewetting of organic soils were mentioned in five regions as top three practices that are little know but potentially interesting for SOC management
- A large number of other practices were mentioned by at least two regions as top three. Some practices are widely applied in some regions, but hardly applied in other regions. This again is not surprising given the diversity of biophysical conditions.
- Some stakeholders also stressed that the effectiveness of management practices will depend on how the practices are implemented, including management choices that farmers make (in terms of timing of operations, for example).
- Several less known practices were identified by stakeholders, such as for example, soil engineering in Australia, where subsoil clay is mixed with top soil sand. This may enhance crop productivity as well as carbon inputs and SOC retention.
- Stakeholders in workshops stressed the need to apply multiple practices, as well as the value of systemic approaches. Different terms are used for these, and the understandings of what these systems contain also vary. The terms used: conservation agriculture (in South Africa, for example, this refers to soil conservation more broadly not just focus on reduced or zero tillage), regenerative agriculture, low carbon, climate smart agriculture.

4.4 Summary of findings

In the global survey, farmers and other stakeholders asked to give their view on 17 different management options. A slightly smaller list of options was used for the Danish survey. The questions were centred on whether these management options were being applied and how effective these management options are in terms of enhancing and conserving SOC compared to current levels.

Across management options farmers that find an option effective for SOC management also have applied or consider applying the option, whereas farmers that find the option ineffective or do not know has a lower use of the option. There may be several reasons for this relationship: 1) the farm structure may not allow the application of a particular management option and thus this is considered ineffective by the farmer, 2) the farmer may have inadequate or bad experiences with the management option and thus considers it ineffective, and 3) the farmer has interpreted the question on effectiveness as effectiveness on his/her own specific farm.

There is a considerable interest among farmers in global survey of having access to organic amendments that can increase SOC. About 80% of farmers in the global survey apply manure or compost, which is a surprisingly large proportion, given that access to organic amendments often are constrained. A large proportion of farmers were also applying residue management and measures to prevent erosion. In contrast, very few farmers apply biochar, although this was considered by almost 25% of respondents. In Europe, residue management along with reduced/minimum tillage, use of cover crops and manure and composting were the management options most farmers already applied. Zero tillage was one of the options that a large proportion of farmers considered applying. Several management options appear to be less relevant in Asia, including grass in rotation, cover crops, forage legumes, permanent grassland and buffer strips, which may reflect which parts of Asia respondents represented. For options that is not well know this is particularly the case for biochar and rewetting of organic soils as well as reduced tillage and zero tillage in Asia and Africa.

For the Danish farm survey, the use of cover crops and manure application was the most applied management options. This is mainly related to legal obligations for use of these management options. Also, the use of hedgerows and residue management is management options used by Danish farmers according to the survey. The response rate of don't know answers was generally considerably lower for the survey from Denmark compared to the global survey, but of similar magnitude for most management options as for the European part of the survey. This may illustrate that farmers in Denmark are generally aware of which options are available, except perhaps for biochar. For several management options the application of the options increase with farm size in the Danish survey. This was particularly the case for residue management, reduced and zero tillage, manure and compost, cover crops, grain legumes, buffer strips, and to a lesser extent for grass in rotation, forage legumes, and biochar and rewetting of organic soils, whereas agroforestry showed the opposite trend.

Farmers in the global survey considered manure and composting, zero tillage, use of cover crops and grasslands as being the most effective measures for increasing SOC. Buffer strips, set-aside and use of grain legumes were considered the least effective. Except for the use of manure and compost and residue management, there were relatively large response rates for don't know. This was particularly large and above 50% for rewetting of organic soils and use of biochar. The most effective options in the Danish survey were grass in rotation, manure application, use of cover crops, residue management and to some degree also permanent grassland. Danish farmers do not rank the management options as effective as the global or European farmers. There was a substantially higher response rate of don't know for the survey from Denmark compared with the global survey, which may reflect that respondents in the survey from Denmark have less overall interest and knowledge on SOC management than respondents for the global survey.

5. The contribution of SOC management to ecosystem services and SDGs

This section provides an overview of stakeholder views and perceptions on the contribution of SOC management to ecosystem services and selected SDGs. Table 4 shows the questions and related SDG or ecosystem services. The farmers' views and perceptions are shown for both global and European perspectives using the global survey as well as for the survey for farmers in Denmark. The view of other stakeholders than farmers are handled at the global and EU scale.

Table 4: Overview of questions on SOC management related to SDGs and ecosystem services.

SDG and ecosystem services	**Question**
SDG2: Zero hunger	To what extent does SOC enhance yield potential To what extent does SOC enhance yield stability To what extent does SOC enhance product quality To what extent does SOC reduce crop protection needs Does higher SOC protect against soil degradation under climate change Is SOC management relevant to climate change mitigation Is SOC management relevant to food security
SDG6: Clean water and sanitation	To what extent does SOC reduce irrigation demand To what extent does SOC reduce demand for fertilizer To what extent does SOC prevent nutrient leakage
SDG13: Climate action	Does SOC management affect GHG emissions from soils Should GHG emissions be a concern for SOC management Does SOC management compensate for other agricultural GHG emissions Does SOC management compensate emissions from fossil fuels
SDG15: Life on land	To what extent does SOC improve soil quality To what extent does SOC improve soil workability To what extent does SOC improve soil biodiversity To what extent does SOC improve soil water holding capacity To what extent does SOC improve water infiltration and drainage To what extent does SOC prevent soil erosion

The overview graphics, at the global level, shows that both 'other stakeholders' and farmers think that SOC management improves soil quality to a large extent (Figure 30). Other stakeholders are generally slightly more optimistic than farmers on a global level regarding SOC management for improving soil water holding capacity, water infiltration and drainage and biodiversity. Around 70% of farmers state that SOC management enhance yield stability to a large extent (Figure 30).

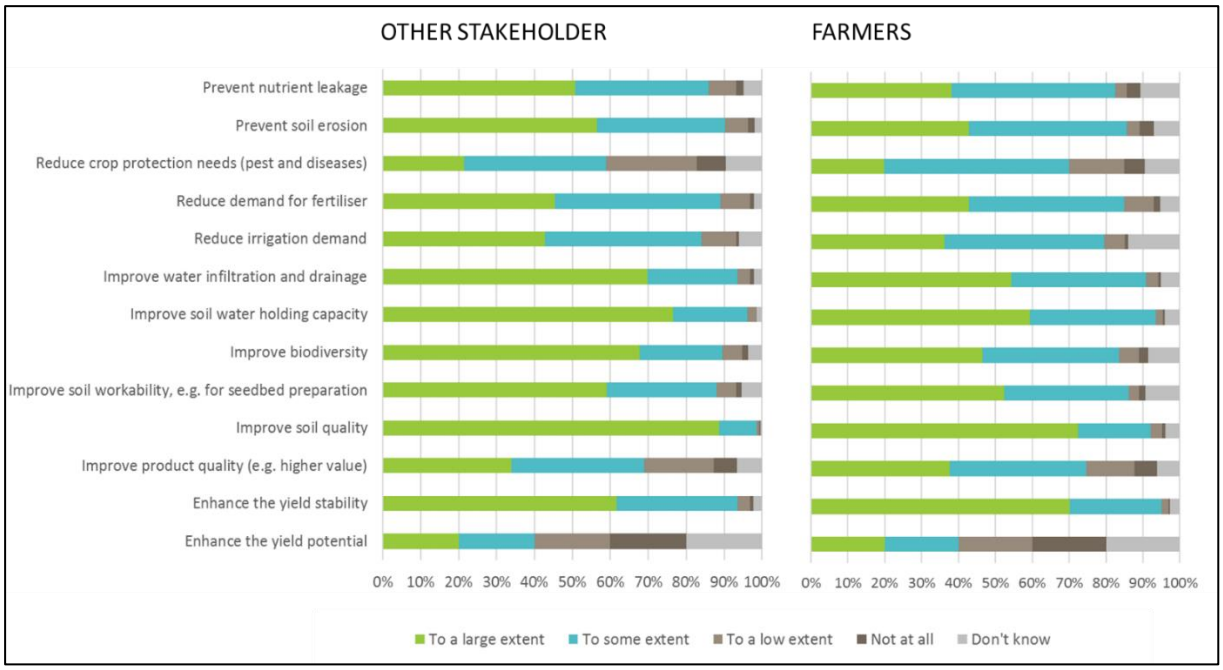

Figure 30: Overview of answers from "other stakeholder" and "farmers" on the question: "To what extent does SOC management contribute to ecosystem services?" – Global.

The results from European farmers and other stakeholders are similar to the global responses; however, there is a slightly difference between the European farmers and global farmers. The European farmers are generally a bit more positive regarding SOC management in terms of providing the described ecosystem services (Figure 31).

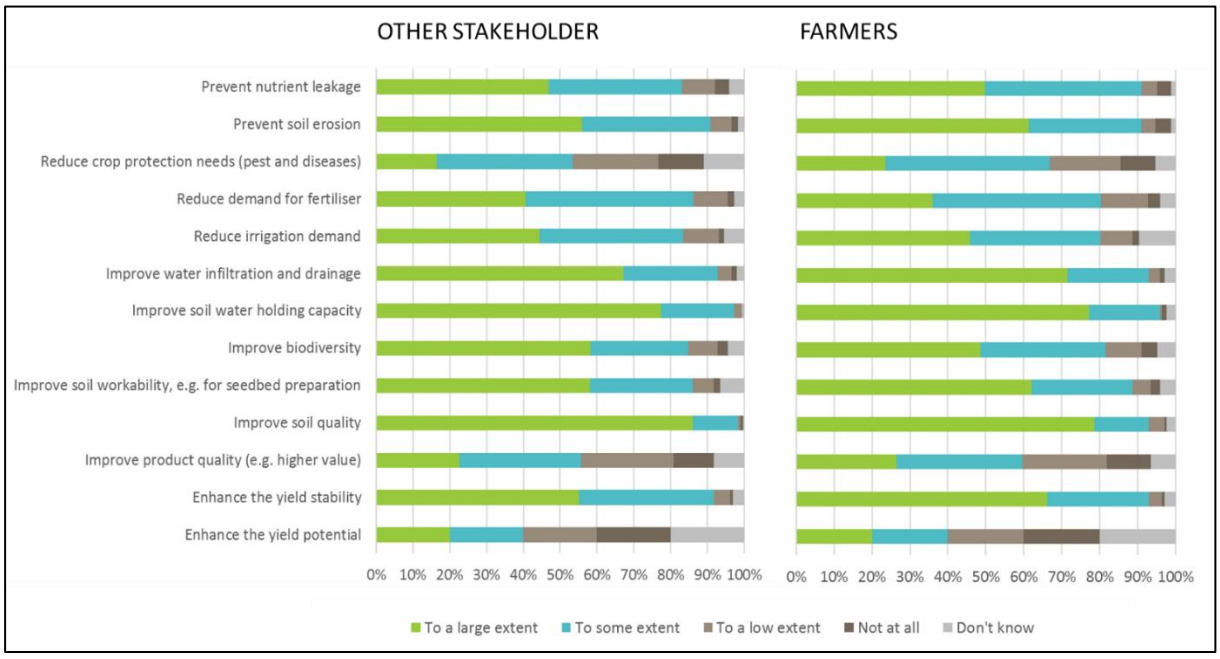

Figure 31: Overview of answers from "other stakeholder" and "farmers" on the question: "To what extent does SOC management contribute to ecosystem services?" – EU.

The Danish farmers respond in the same pattern as the European farmers, with improving soil quality being the option receiving the greatest emphasis (Figure 32). However, it can be seen

that the Danish farmers to a higher degree have answered don't know to the answers compared with the global survey.

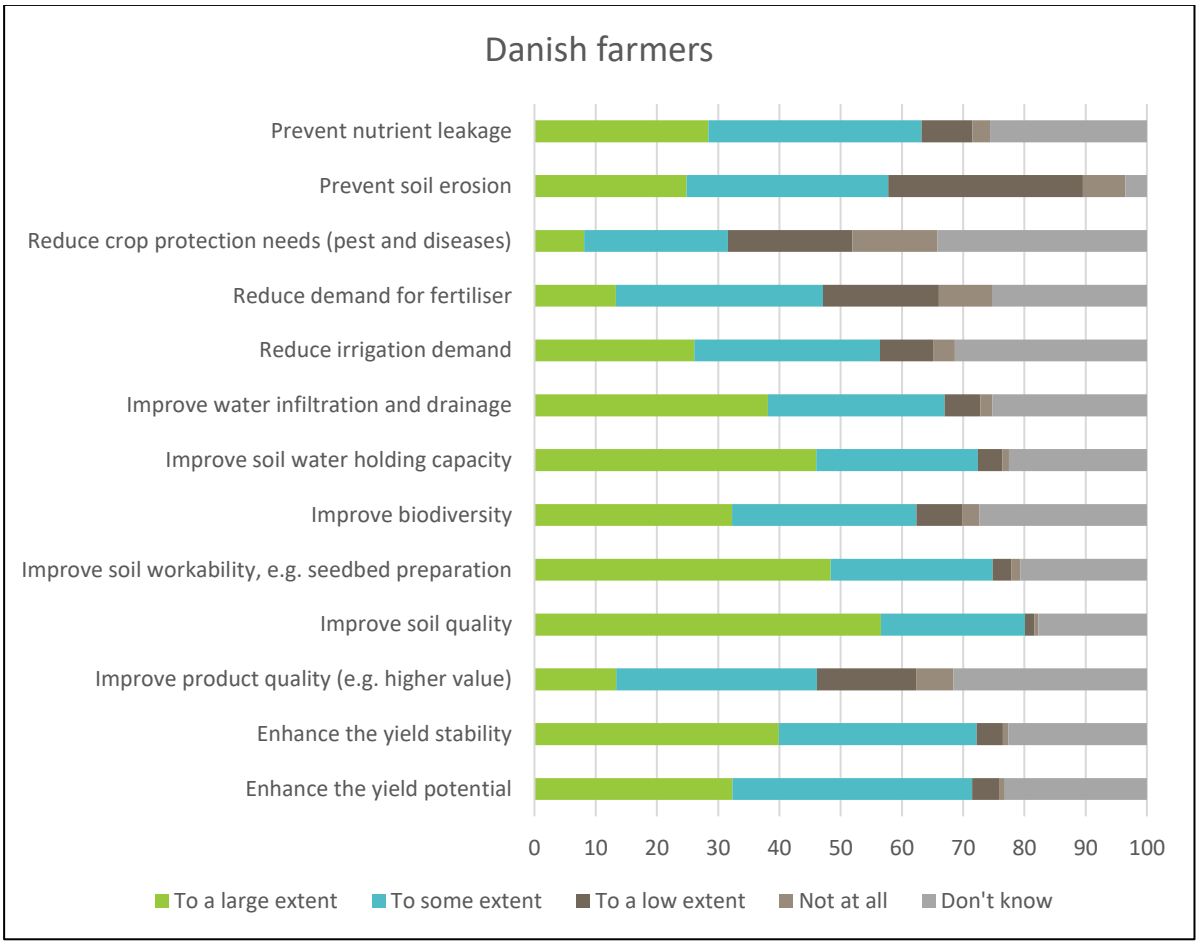

Figure 32: Overview of answers from "Danish farmers" on the question: "To what extent does SOC management contribute to ecosystem services?".

Both the global and European respondents have replied very similar to the statements asked in Figure 33. The statements where the respondents agree most on are that SOC management is relevant to food security, with more than 60% and that SOC management affects GHG emissions from soils. The statements that the respondents disagree the most with are that SOC management compensates emissions from fossil fuels and that SOC management compensates other agricultural GHG emissions (Figure 33).

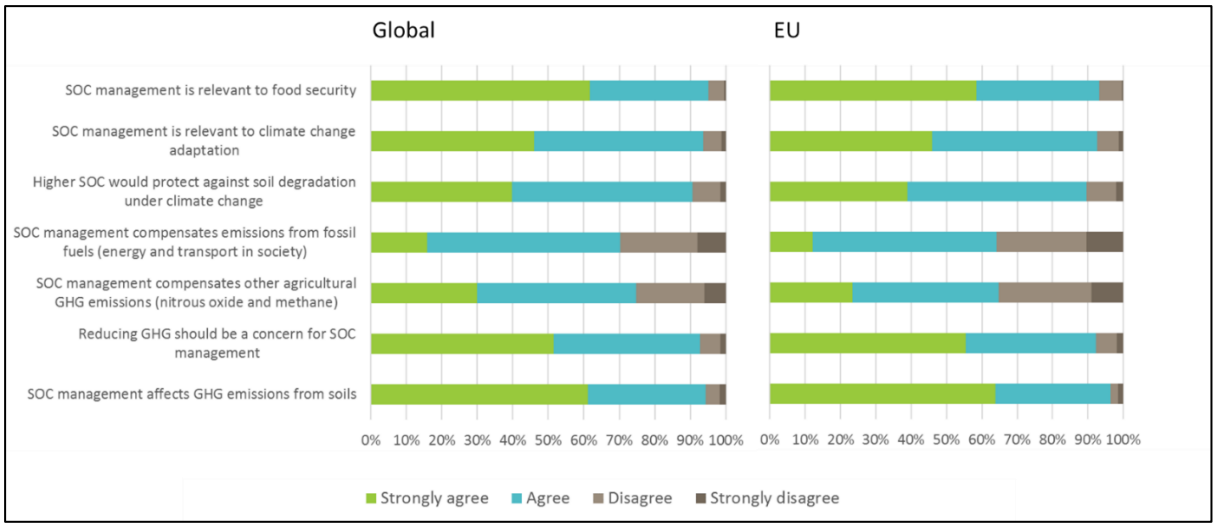

Figure 33: Overview of answers to the question: "To what extent do you agree with the following? –Global and EU. These questions was only given to 'other stakeholders'.

5.1 Zero hunger (SDG2)

One of the core SDGs that are related to SOC management is SDG2 on Zero hunger. Table 4 shows the four questions asked in connected to the potential of achieving zero hunger:

- To what extent does SOC enhance yield potential
- To what extent does SOC enhance yield stability
- To what extent does SOC enhance product quality
- To what extent does SOC reduce crop protection needs
- Does higher SOC protect against soil degradation under climate change
- Is SOC management relevant to climate change mitigation
- Is SOC management relevant to food security

Globally more that 50 % of all respondents from New Zealand, Africa, North America and Latin America state that SOC management enhance the yield potential (Figure 106 in Annex 7). In Europe, it is less than 50% that state that SOC management enhance the yield potential and it its mainly respondents from Norway and UK that state this (Figure 107). Less than 10% answer that yield potential is enhanced to a low extent or not at all.

In Denmark, 30% of the farmers state that SOC management enhances the yield potential and approximately (23%) states that they don't know if SOC management enhances the yield potential (Figure 108).

When asked about yield stability, it can be seen that about 60 % globally state that SOC management increases yield stability, especially the respondents from Africa and Latin America state this (Figure 109). Less than 10% answer that SOC does not improve yield stability. European respondents show similar results, with a little less than 60% answering that SOC management enhance the yield stability. In Europe, it is especially stakeholders from Norway, Denmark, Hungary, UK and Switzerland that state this to a large extent (Figure 110). When asking Danish farmers, it is 40% that thinks that SOC management enhances yield

stability, only around 5% state to a low extent or not at all, and more than 20% responds don't know (Figure 111).

The respondents were also asked to what extent SOC management enhances product quality. Globally less than 40 % state this, with stakeholders from Africa having the highest share of respondents thinking SOC management will enhance product quality to a large extent (Figure 112). In Europe, it is less than 25%, and in Denmark it is less than 15% of farmers who think that SOC management enhances product quality (Figures 113 and 114).

Regarding SOC management and its abilities to reduce crop protection needs. It can be seen that globally and in Europe that less than 25% thinks SOC management can deliver this service to a large extent (Figure 115). With only New Zealand respondents having more than 50% stating that SOC management can reduce crop protection needs (Figure 116). In Denmark, it is less than 10% of the farmers that think SOC management, to a large extent, can reduce crop protection needs and more than 40% that say don't know (Figure 117).

Globally and in Europe more than 50% strongly agree that SOC would protect against soil degradation under climate change. Less than 10% disagree or strongly disagree (Figures 118 and 119).

More than 55% of the respondents both globally and in Europe strongly agree that SOC management is relevant to climate change adaptation and only a few percentages disagree or strongly disagree (Figures 120 and 121).

The last question asked in relation to SDG2 was if respondents agreed or disagreed that SOC management is relevant to food security. Globally more than 55% agree that SOC management is relevant to food security and only a few percentages disagree or strongly disagree (Figures 122 and 123).

5.2 Clean water and sanitation (SDG6)

Stakeholders and farmers were asked questions related to the SDG6 on SOC managements ability to achieve clean water and sanitation:

- To what extent does SOC reduce irrigation demand
- To what extent does SOC reduce demand for fertilizer
- To what extent does SOC prevent nutrient leakage

Globally, around 40% of the respondent's state that SOC management to a large extent reduces irrigation demand; this is mainly stakeholders from Russia and North America who replies this with more than 50%. Around 10% state that SOC management to a low extent or not at all reduces irrigation demand. The most uncertain and with the highest share of don't know answers are from Russia (Figure 124). The same picture can be seen in Europe with around 40% of respondents stating that SOC management to a large extent reduces irrigation demand. In Europe it is mainly from Norway, Switzerland and UK the highest share of to a large extent answers come from (Figure 125). The Danish farmers have less confidence in SOC management being able to reduce irrigation demand. Here around 25% state that SOC

management to a large extent reduces irrigation demand and around 30% don't know (Figure 126).

Globally, around 40% of stakeholders respond that they think that SOC management to a large extent reduces demand for fertilizer, more than 50% from Africa and North America (Figure 127). In Europe the same level of responses are shown, with 40% of the stakeholders responding that they think that SOC management to a large extent reduces demand for fertilizer, mainly responses from Norway and Belgium (Figure 128). In Denmark, it is less than 15% that say that SOC management to a large extent reduce demand for fertilizer and more than 25 % state the opposite, and around 25% say that they don't know (Figure 129).

50% of the stakeholders globally and from Europe state that SOC prevent nutrient leakage to a large extent (Figure 130). A little less than 30% of the Danish farmers reply that SOC prevent nutrient leakage to a large extent and around 25% states don't know (Figures 131 and 132).

5.3 Climate action (SDG13)

Four questions were asked in relation to SDG13 on climate action:

- Does SOC management affect GHG emissions from soils
- Should GHG emissions be a concern for SOC management
- Does SOC management compensate for other agricultural GHG emissions
- Does SOC management compensate emissions from fossil fuels

Globally, around 60% strongly agree that SOC management affects GHG emissions from soils, only in Africa and Asia do less than 50% strongly agree on this statement (Figure 133).

In Europe, it is also around 60% that strongly agree that SOC management affects soil GHG emissions, only stakeholders from Ukraine and Hungary are below 50% (Figure 134). Both globally and in Europe it is very few who disagree or strongly disagree that SOC management affects GHG emissions from soils.

Around 50% of the stakeholders globally and in Europe strongly agree that GHG emissions should be a concern for SOC management, around 10% disagree (Figures 135 and 136).

When the stakeholders are asked if they agree with that SOC management compensates other agricultural GHG emissions (nitrous oxide and methane), only a little more than 25% strongly agrees with this statement globally (Figure 137), and less than 20% at the European level (Figure 138). A much higher proportion of the respondents strongly disagree or disagree to the statement that SOC management compensates other agricultural GHG emissions (nitrous oxide and methane).

The same picture can be seen with the statement that SOC management compensates emissions from fossil fuels (energy and transport in society). Only a little more than 25% strongly agrees with this statement globally (Figure 139), and less than 20% at the European level (Figure 130). A much higher proportion of the respondents strongly disagrees or disagree to the statement that SOC management compensates emissions from fossil fuels (energy and transport in society).

5.4 Life on land (SDG15)

SOC management is also related to SDG15 Life on land. Six questions was developed to analyse stakeholders views and perceptions on SOC management in relation to Life on land:

- To what extent does SOC improve soil quality
- To what extent does SOC improve soil workability
- To what extent does SOC improve soil biodiversity
- To what extent does SOC improve soil water holding capacity
- To what extent does SOC improve water infiltration and drainage
- To what extent does SOC prevent soil erosion

Both globally and in Europe a very high number of respondents (more than 80%) answer that SOC management to a large extent improve soil quality (Figures 141 and 142). Around 55% of the Danish farmers answers that they to a large extent think that SOC improve soil quality and around 20% don't know (Figure 143).

55% of the global and European respondents think that SOC improve soil workability to a large extent (figure 144 and 145 in Annex 7). Around 50% of the farmers in the Danish survey answer that they to a large extent think that SOC improve soil quality and around 20% don't know (figure 146 in Annex 7).

Around 60% of the global and 55% of the European respondents think that SOC improve soil biodiversity to a large extent (Figures 147 and 148). 32% of the farmers in the Danish survey answer that they to a large extent think that SOC improve soil biodiversity and around 27% don't know (Figure 149).

70% of the global and European respondents state that SOC improve soil water holding capacity to a large extent (Figures 150 and 151). Whereas around 45% of the Danish farmers state that SOC improve soil water holding capacity to a large extent (Figure 152).

Both global and European respondents answer with around 60% that SOC, to a large extent, improves water infiltration and drainage (Figure 153 and 154). In the Danish survey, around 37% of farmers answer that SOC improve water infiltration and drainage to a large extent and 25% don't know (Figure 155).

Around 50% of the global stakeholders, 55% of the European and 32% of the Danish farmers think that SOC prevent soil erosion to a large extent (Figures 156, 157 and 158).

5.5 Summary of findings

The findings on stakeholders and farmer knowledge and perceptions on the contribution of SOC management to ecosystem services and SDGs are briefly summarized below.

More than 80% of "other stakeholders" and farmers from all regions have a high level of confidence that SOC management will deliver ecosystem services that prevent nutrient leakage, prevent soil erosion, reduce demand for fertilizer, reduce irrigation demand, improve water infiltration and drainage, improve soil water holding capacity, improve biodiversity, improve soil workability, improve soil quality, enhance yield stability to a large or to some extent.

However, three aspects of crop production is considered to be less favourably affected by SOC management. This is improved product quality where less than 70% answer to a large extent or to some extent, reduction of crop protection needs (60% with positive answers), and less than 40% answer that SOC management to a large or to some extent will improve yield potential. These three production services are connected to SDG2 on zero hunger, which makes this SDG the most challenging to achieve with SOC management according to the respondents in this study.

From the Danish farm survey, it can be seen that the respondents are confident that SOC management can contribute to all of the ecosystems services are much lower, which again can be explained with the bias in the global survey. However, the same tendencies are shown in the Danish farm survey, as in the global survey. But, as explained, the numbers are lower and there are considerable more don't know answers in the Danish survey.

In summary, it can be concluded that the respondents in the global survey are very optimistic on contributions of SOC management to SDGs and have great confidence with that SOC management can contribute with many important ecosystem services.

6. Discussion and conclusions

6.1 Representativeness

Taking study aimed to take stock of the perspectives of diverse stakeholders from different geographic and policy areas on the role of SOC for climate mitigation and adaptation as well as which SOC management options are applied and considered effective for increasing and sustaining SOC. We applied two online surveys as well as stakeholder workshops for exploring the perspectives among stakeholder. For all types of stakeholder queries, there is a concern on how the responses obtained in the surveys represent the broader stakeholder groups, from which they should ideally be a random sample. In reality, there may be smaller or larger biases in the representativeness of stakeholders, partly originating from which stakeholders were approached and partly which stakeholders responded.

The online surveys included a global survey and a survey only for Danish farmers. The global survey was distributed through e-mail list held by partners in the different world regions as well as by organisations such as the European Soil Partnership, the EIONET NRC Soil network and the 4 per 1000 initiative. In contrast, the Danish farmer survey was distributed to a random selection of famers in Denmark. There was a good response rate of 19% for the Danish survey, and an analysis shows that it can be considered representative of Danish farms, in terms of farm characteristics (farm type, farm size and agricultural practices), demographics (age and gender), and geographically distributed over the five regions in Denmark. A similar representativeness cannot be assumed for the global survey, mainly because this survey was distributed among farmers, researchers and other stakeholders that had already shown an interest in SOC and soil management, and which may also have greater insights or particular stakes in the SOC issue. It is also likely that individuals have a strong interest in the subject would tend to have a greater response rate to the global survey. Therefore, the Danish survey may be considered to be representative of Danish farmers, whereas the global survey represents stakeholders (including farmers) with knowledge and interest in SOC. Similar aspects should also be considered, when evaluating the feedback from the stakeholder workshops, which probably also reflect the views of informed stakeholders.

This difference in representativeness is reflected in some of the answers of the two questionnaire. Examples of likely effects of differences in representativeness are:

- About 30% of farmers in the global survey stated that they know the SOC concentration of their soil, whereas this was only 9% for the survey among farmers in Denmark.
- About 20% of farmers in the global survey don’t know the direction of SOC change of their soil, whereas this is 53% for the Danish survey.
- In the Danish survey only about 25% apply grain legumes, whereas this is about 75% in the global survey, where even coffee-culture, forestry and energy crops appear to have grain legumes to a relatively large extent.
- The wide use of crop-livestock systems also in grain crops and horticultural systems cast some doubts on the interpretation of the global survey results.
- The responses in the global survey are more positive on the contribution of SOC to ecosystem services and societal goals than the Danish survey.

- There are in general more don't know answers in the Danish survey than in the global survey.

6.2 Knowledge on SOC

The low proportion of farmers in Denmark stating knowledge on SOC (about 9%) most likely reflect that SOC has not so far been an issue for farm management decisions. There are thus very few, if any, current crop management systems in Denmark that include soil organic matter or SOC as a component in the decision making. This also applies at the European and global level, where SOC is mostly an indirect measure for farm management. However, there are regions, such as Germany (Brock et al. 2012), where soil fertility and SOC has been a focus area for farm management with calculations schemes for addressing changes in SOC. There are thus likely regional and country differences in the focus and knowledge by farmers on SOC.

In the Danish survey knowledge on SOC concentration increases with farm size, which may reflect a higher general knowledge level among farmers that farm greater areas, likely because these farmers in many cases are also better educated and have more management resources available.

Farmers in general considered SOC of their soil to be similar or higher than those of soils in the region in general. This could indicate that respondents may have a greater focus on enhancing SOC than farmers in general and therefore believe that their soils have greater SOC. However, this pattern was also present in the survey from Denmark, where farmers may be considered representative of farmers in general. The bias towards believing that the farmer's own soils have greater SOC may therefore rather reflect a general human tendency to overestimate a person's own ability and resources.

For the survey in Denmark 40% of farmers estimate that their SOC is increasing and only 7% that it is decreasing. A monitoring programme of SOC in Danish soils have shown regional differences in the trend of SOC, but overall there is no trend in SOC for mineral soils in Denmark (Taghizadeh-Toosi et al., 2014). This may therefore again reflect tendency by respondents to overestimate own performance.

There was a clear geographical pattern in responses by farmers to the question on whether SOC can be considered critically low. Thus, more farmers in Southern Europe than Northern Europe responded that SOC is critically low. This aligns well with assessments of SOC and its functions across Europe (Merante et al., 2017). However, it should also be noted that 23% of in the global survey and 43% in the Danish survey responded that they do not know if the SOC is critically low, which clearly shows the need for improved information and tools to determine the status of SOC and on its functions in a local context.

6.3 Considerations of management options

In the global survey, farmers and other stakeholders asked to give their view on 17 different management options. A slightly smaller list of options was used for the Danish survey. It should be noted that farmers were asked whether they were applying or considering to apply certain

management practices, not the extent to which it is applied. The responses therefore do not reflect the proportion of the farmed area under certain management practices.

Across management options farmers that find an option effective for SOC management also have applied or consider applying the option, whereas farmers that find the option ineffective or do not know has a lower use of the option. There may be several reasons for this relationship: 1) the farm structure may not allow the application of a particular management option and thus this is considered ineffective by the farmer, 2) the farmer may have inadequate or bad experiences with the management option and thus considers it ineffective, and 3) the farmer has interpreted the question on effectiveness as effectiveness on his/her own specific farm. Therefore, the farmer responses to effectiveness should be interpreted with some care, since they may relate to how the questions was interpreted as well as to the knowledge and experiences of the farmer with the management option.

There is a considerable interest among farmers in global survey of having access to organic amendments that can increase SOC. About 80% of farmers in the global survey apply manure or compost, which is a surprisingly large proportion, given that access to organic amendments often are constrained. It should also be noted as mentioned by one of the respondents that application of manure and compost in reality represents a horizontal transfer of carbon, and as such it cannot be considered to provide additional carbon sequestration (Powlson et al., 2011). However, such transfer may help to improve soils with low carbon content, and this could also be achieved by better integration of livestock in cropping systems and through application of a range of changes in cropping systems (legumes, cover crops etc.) that increase organic matter inputs. This was also mentioned in several of the questionnaire comments.

It should be noted that several of the management options are linked to specific farming systems, and some are promoted in some cropping systems concepts, such as no-tillage and cover crops in conservation agriculture. Some management options is also influence by market forces, like residue management is linked to a market for the straw, e.g. for bioenergy.

There were suggestions for additional options to enhance and sustain SOC in the questionnaire responses:

- Specific farming practices, such as permaculture, ecological agriculture or permanent vegetation cover
- Specific amendments, e.g. compost extract (compost tea), effective microbes, plant ash, trace elements
- Deep tillage
- Adding clay to the topsoil, e.g. through deep ploughing or as amendment
- Application of sewage sludge (or urban sludge)
- Avoidance of grassland conversion
- Grazing practices, such as mob grazing, rotational grazing and holistic grazing

Additional comments on the management options by the respondent that have general value include:

- SOC management should always be understood as part of holistic soil organic matter management, including: 1) Carbon through soil cover, 2) Nutrients through balanced fertilization and avoid losing nutrients, 3) Biology through permanent cover, organic

amendments and reduced tillage intensity, and 4) Physical through avoiding soil erosion and compaction.

- The effectiveness of SOC management depend not only on carbon inputs, but on the nitrogen balance
- All grazing based livestock systems needs to have a grazing plan (e.g. planned grazing, holistic grazing). Without clarification on the plan for grazing, there is risk of losing carbon and building SOC becomes very difficult.

6.4 Contributions to sustainability targets

The responses show that a high level of confidence that SOC management will deliver ecosystem services that prevent nutrient leakage, prevent soil erosion, reduce demand for fertilizer, reduce irrigation demand, improve water infiltration and drainage, improve soil water holding capacity, improve biodiversity, improve soil workability, improve soil quality, enhance yield stability to a large or to some extent. All of these aspects have clear links to sustainability aspects, although many of them may not directly influence farm economic performance, at least not in the short term. This is further stressed by the fact that less respondents considered that SOC management would improve yield potential and yield quality or assist in reducing need for crop protection. This indicates a greater comparative interest by the society in general for SOC management than by individual land holders.

6.5 Perspectives

The responses from both questionnaires and workshops illustrate that SOC management issues are highly context specific. The effectiveness of management options depends on the local soil and climatic conditions, but also by the effectiveness of the manager and of the farming and cropping system in which it is incorporated. One of the particular constraints mentioned by the respondents is the availability of water, which is critical to grow crops and produce biomass in dry regions, and this also constrains the use of some SOC options such as cover crops. Another constraint is the availability of nutrients, including nitrogen for ensuring that plants grow and that soil microorganisms can form stable soil organic matter. This may be at least partly overcome through the use of legumes in rotations and in cover crops.

Sustainable SOC management as seen from many of the respondents does not depend on a single or few management options. It needs to be seen from a holistic farm and cropping systems perspective. With soils that are highly depleted in SOC additional measures will likely need to be put into place for a substantial period of time, such as including legume-based rotational grass into crop rotations and/or reducing tillage operations and ensuring a permanent vegetation cover.

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Annex 1: Questions of the global survey

1. Background questions

Are you female/male?

What is your age?

Which stakeholder group describes you best?

Background questions - Farmer

Specify primary farming system

Which soil type categorizes your soils?

Do you own the land that you farm?

How much land do you own?

How much land do you farm?

Please specify the type of labour used on your farm

How much labour do you hire?

Where do you live?

Background questions on SOC - Farmer

Do you know the SOC concentration of (your) soil or of the soils in your region?

Do you consider SOC of (your) soil to be increasing or decreasing?

Do you consider SOC of (your) soil to be critically low?

How do you view SOC of (your) soil to be different from soils in your region?

2. Current management in relation to SOC

Which management options do you apply or consider applying? – Farmer

Which options do you think farmers are using for SOC management in your region at present?

In your opinion, how effective are the following management options for enhancing and conserving SOC compared to current levels?

3. Barriers for implementing SOC management options

Which are the most important barriers to the uptake of SOC management options?

For highly important and important, please give specific examples.

4. Solutions to address the barriers to implementation

Which solutions are most important for increasing the adoption of SOC management options?

For highly important and important, please give specific examples.

5. Knowledge needs

What additional information (knowledge) do you think farmers need to increase adoption of management options that conserve or enhance SOC?

6. Contribution of SOC management - agricultural crop production and ecosystem services

To what extent does SOC?

- Enhance the yield potential
- Enhance the yield stability
- Improve product quality (e.g. higher value)
- Improve soil quality
- Improve soil workability, e.g. for seedbed preparation
- Improve biodiversity
- Improve soil water holding capacity
- Improve water infiltration and drainage
- Reduce irrigation demand
- Reduce demand for fertiliser
- Reduce crop protection needs (pest and diseases)
- Prevent soil erosion
- Prevent nutrient leakage

7. Contribution of SOC management - climate and sustainable development

To what extent do you agree with the following?

- SOC management affects GHG emissions from soils
- Reducing GHG should be a concern for SOC management
- SOC management compensates other agricultural GHG emissions (nitrous oxide and methane)
- SOC management compensates emissions from fossil fuels (energy and transport in society)
- Higher SOC would protect against soil degradation under climate change
- SOC management is relevant to climate change adaptation
- SOC management is relevant to food security

Annex 2: Representation of respondents to the global survey

Table 5: Answers of the global survey by stakeholder for all countries (global) and for the EU in percentage.

STAKEHOLDER TYPE	ANSWERS - GLOBAL [%]	ANSWERS - EU [%]
RESEARCH INSTITUTE OR UNIVERSITY	33,5	25,3
FARMER	30,1	34,0
PUBLIC / GOVERNMENT AUTHORITY	9,1	11,6
AGRICULTURAL EXTENSION / FARM ADVISORY	5,9	6,7
OTHER	5,3	6,8
NON-PROFIT ENVIRONMENTAL ORGANISATION	4,1	4,5
AGRICULTURAL SUPPLY INDUSTRY: FERTILISERS, MACHINERY OR OTHER INPUTS	2,8	3,1
NON-PROFIT DEVELOPMENT/FOOD SECURITY ORGANISATION	2,0	1,0
FARMERS' ASSOCIATION	1,8	1,3
GENERAL PUBLIC	1,7	1,6
FOOD INDUSTRY: FOOD PRODUCTION, PROCESSING AND MARKETING	0,8	0,9
INTERNATIONAL RESEARCH INITIATIVE OR PROGRAMME	0,7	0,6
PRIVATE FOUNDATION	0,5	0,6
INTERNATIONAL POLICY MAKER (E.G. EU OR UN INSTITUTION)	0,5	0,7
RETAIL COMPANIES: MARKETING AND SELLING	0,4	0,3
FINANCIAL INDUSTRY: INSURANCE OR BANKS	0,4	0,0
LANDOWNERS' ASSOCIATION	0,2	0,4
PUBLIC FUNDING MECHANISM	0,2	0,4

Annex 3: Questions of the Danish farm survey

Baggrundsspørgsmål

Er du?

(1) ❑ Kvinde
(2) ❑ Mand

Hvad er din alder?

(1) ❑ Under 18 år
(2) ❑ 18-39 år
(3) ❑ 40-54 år
(4) ❑ 55-74 år
(5) ❑ Over 74 år

Er du landmand/ansvarlig for bedriften på et landbrug?

(1) ❑ Ja
(2) ❑ Nej

Angiv overordnet bedriftstype:

(1) ❑ Husdyr
(2) ❑ Planteavl
(3) ❑ Grøntsager
(4) ❑ Frugt-/vinavl
(5) ❑ Blandet
(6) ❑ Skov

Hvilke dyr har du på bedriften
Vælg primær produktionsgren:

(1) ❑ Malkekvæg
(2) ❑ Kødkvæg
(3) ❑ Svin
(4) ❑ Fjerkræ
(5) ❑ Andet, venligst udspecificer _____
(6) ❑ Heste
(7) ❑ Får/geder

(8) ❑ Mink
(9) ❑ Slagte/tyre/fedekalve

Hvor intensivt er din husdyrproduktion i forhold til belastning med husdyrgødning?

(1) ❑ Over 0,8 DE/ha
(2) ❑ Under 0,8 DE/ha

Angiv den mest anvendte landbrugspraksis:

(1) ❑ Konventionelt
(2) ❑ Økologisk
(3) ❑ Conservation agriculture
(4) ❑ Skovlandbrug
(5) ❑ Andet, vær venlig at udspecificer _____
(6) ❑ Biodynamisk
(7) ❑ Pløjefri dyrkning
(8) ❑ Ekstensivt

Hvilken jordtype er fremherskende på din bedrift?

(1) ❑ JB1: Grovsandet jord; <5% ler
(2) ❑ JB2: Finsandet jord; <5% ler
(3) ❑ JB3: Grov lerblandet sandjord; 5-10% ler
(4) ❑ JB4: Fin lerblandet sandjord; 5-10% ler
(5) ❑ JB5: Grov sandblandet lerjord; 10-15% ler
(6) ❑ JB6: Fin sandblandet lerjord; 10-15% ler
(7) ❑ JB7: Lerjord; 15-25% ler
(8) ❑ JB8: Svær lerjord; 25-45% ler
(9) ❑ JB9: Meget svær lerjord; >45% ler
(10) ❑ JB10: Siltjord, 0-50 % ler
(11) ❑ JB11: Humus-jord (>10% organisk stof)
(12) ❑ Ved ikke

Ejer du jorden på din bedrift?

(1) ❑ Ja
(2) ❑ Nej
(3) ❑ Delvist

Hvor stor en andel af jorden på din bedrift ejer du selv?

(1) ❑ 0 - 30% selvejet
(2) ❑ 30 - 60% selvejet
(3) ❑ 60 - 80% selvejet
(4) ❑ > 80% selvejet

Hvor stort areal drives som en del af bedriften?

(1) ❑ 0 - 5 ha
(2) ❑ 5 - 10 ha
(3) ❑ 10 - 20 ha
(4) ❑ 20 - 50 ha
(5) ❑ 50 - 100 ha
(6) ❑ 100 - 200 ha
(7) ❑ 200- 300 ha
(8) ❑ 300 - 400 ha
(9) ❑ 400- 500 ha
(10) ❑ 500 - 1000 ha
(11) ❑ over 1000 ha

Angiv venligst hvilken type arbejdskraft der anvendes på din bedrift

(1) ❑ Kun familie foretagende
(2) ❑ Kun lønnet arbejdskraft uden for familien
(3) ❑ Delvist lønnet arbejdskraft uden for familien

Hvor stor en andel af arbejdskraften er uden for familien eller outsourcet?

(1) ❑ Mindre end 50% af arbejdskraften er uden for familien eller outsourcet
(2) ❑ Ca. 50-80% af arbejdskraften er uden for familien eller outsourcet
(3) ❑ Mere end 80% af arbejdskraften er uden for familien eller outsourcet

I hvilken region ligger hovedparten af din bedrift?

(1) ❑ Nordjylland
(2) ❑ Midtjylland
(3) ❑ Syddanmark
(4) ❑ Sjælland
(5) ❑ Hovedstaden

Baggrundsspørgsmål om jordens indhold af organisk kulstof

Kender du til indholdet af kulstof i jorden på din bedrift?

(1) ❑ Ja
(2) ❑ Nej

Mener du, at kulstofindholdet i jorden på din bedrift er faldende eller stigende?

(1) ❑ Faldende
(2) ❑ Stigende
(3) ❑ Ved ikke

Mener du, at kulstofindholdet i jorden på din bedrift er kritisk lavt?

(1) ❑ Ja
(2) ❑ Nej
(3) ❑ Ved ikke

Hvorfor tror du, at indholdet af kulstof i jorden på din bedrift er kritisk lavt?

_____
_____
_____
_____
_____
_____

Baggrundsspørgsmål om jordens indhold af organisk kulstof

Hvordan vil du vurdere kulstofindholdet i jorden på din bedrift, sammenlignet med kulstofindholdet i din region som helhed?

Kulstofindholdet på min bedrift er:

(1) ❑ Lavere
(2) ❑ Lignende
(3) ❑ Højere
(4) ❑ Ved ikke

Din nuværende håndtering af jordens indhold af kulstof

Hvilke af nedenstående dyrkningspraksis og arealanvendelsestiltag bruger du eller overvejer du at anvende?

	Anvender ikke	Overvejer at anvende	Anvender allerede	Ved ikke
Halmnedmuldning (afgrøderester efterladt på marken)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Reduceret jordbearbejdning	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Direkte såning	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Tilførsel af husdyrgødning	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Græs i sædskiftet	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Efterafgrøder	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Bælgsæd (fx hestebønne eller ært)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Foderbælgplanter (fx kløver)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Permanente græsarealer (græspleje, fx gødning)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Randzoner og braklægning	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Skovlandbrug (træer sammen med afgrøder/husdyr)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Biochar (biokoks)	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Udtagning af tørvejord	(1) ❑	(2) ❑	(3) ❑	(4) ❑
Læhegn	(1) ❑	(2) ❑	(3) ❑	(4) ❑

Angiv venligst anden dyrkningspraksis og arealanvendelsestiltag som du anvender eller overvejer at anvende, hvis de ikke er nævnt i ovenstående spørgsmål:

_____

_____

_____

_____

_____

_____

Håndtering af jordens indhold af kulstof

Efter din mening, hvor effektive er de følgende dyrkningspraksis og arealanvendelsestiltag generelt til at lagre kulstof i jorden sammenlignet med det nuværende niveau?

	Ikke effektivt	Mindre effektivt	Effektivt	Meget effektivt	Ved ikke
Halmnedmuldning (afgrøderester efterladt på marken)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Reduceret jordbearbejdning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Ikke effektivt	Mindre effektivt	Effektivt	Meget effektivt	Ved ikke
Direkte såning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Tilførsel af husdyrgødning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Græs i sædskiftet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Efterafgrøder	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Bælgsæd (fx hestebønne eller ært)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Foderbælgplanter (fx kløver)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Permanente græsarealer (græspleje, fx gødning)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Randzoner og braklægning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Skovlandbrug (træer sammen med afgrøder/husdyr)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Biochar (biokoks)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Udtagning af tørvejord	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Læhegn	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Angiv venligst anden dyrkningspraksis og arealanvendelsestiltag, hvis de ikke er nævnt i ovenstående og kommenter på effektiviteten herunder:

_____

_____

_____

_____

_____

_____

Tilføj venligst yderligere kommentarer om effektiviteten af dyrkningspraksis og arealanvendelsestiltag her:

_____

_____

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_____

_____

_____

Barrierer for implementering af dyrkningspraksis og arealanvendelsestiltag til håndtering af kulstoflagring

Hvilke er de vigtigste barrierer for implementeringen af dyrkningspraksis og arealanvendelsestiltag som lagrer kulstof i jorden?

	Ikke vigtigt	Mindre vigtigt	Vigtigt	Mest vigtigt	Ved ikke
Manglende finansieringsmuligheder for teknologi eller maskiner	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Manglende finansieringsmuligheder for input (fx gødning)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Yderligere omkostninger er for høje	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
De rigtige maskiner er ikke tilgængelige (fx leverandører eller maskinstationer har ikke udstyr)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Manglende incitament til medium / langsigtet investering på grund af manglende efterfølger til overtagelse af bedriften	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Jorden er forpagtet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Ikke overbevist om produktivitet og økonomiske fordele (fx bekymring om udbytter)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Kulstoflagring belønnes ikke økonomisk (fx ingen tilskud eller kulstofkreditter)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Tekniske løsninger er ikke modne (yderligere forskning er påkrævet)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Information og viden er ikke tilgængelig	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Landbrugskonsulenter og rådgivere har ikke viden og kapacitet til at oplære landmænd omkring tekniske løsninger	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Biofysiske faktorer (uegnet klima eller jord)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Kulstoflagring er ikke en politisk prioritet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Ikke vigtigt	Mindre vigtigt	Vigtigt	Mest vigtigt	Ved ikke
Andet (venligst rangorden her og angiv i tekstboksen nedenfor)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Andet (angiv venligst her):

_____
_____
_____
_____
_____
_____

For mest vigtigt og vigtigt, angiv venligst specifikke eksempler her:

_____
_____
_____
_____
_____
_____

Løsninger til at løse barrierer for implementering

Hvilke løsninger er mest vigtige at styrke, for at forøge muligheden for implementering af dyrkningspraksis og arealanvendelsestiltag for kulstoflagring?

	Ikke vigtigt	Mindre vigtigt	Vigtigt	Mest vigtigt	Ved ikke
Vejledning og rådgivning til landmænd om hvordan man kan øge jordens indhold af organisk kulstof	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Styrke landbrugsrådgivning og vidensudveksling (fx ved workshops, demonstrationer)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Betaling for økosystemtjenester (normalt offentlige tilskud)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Øvrig økonomisk støtte til overgang til	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Ikke vigtigt	Mindre vigtigt	Vigtigt	Mest vigtigt	Ved ikke
kulstoflagringspraksis (fx lån eller tilskud til investeringer)					
CO2 certificeringsordninger (produktmærker)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Obligatoriske standarder fastsat af fødevarevirksomheder	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Udvikling af betalingsordninger for kulstoflagring	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedre infrastrukturen for adgang til input og teknologier	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Fastlæggelse af obligatoriske mål og regulative krav til kulstoflagring i jorden	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Information til beslutningstagere om hvor og hvordan man skal målrette politik om kulstoflagring	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Indikatorer og værktøjer til landmænd til måling af ændring i jordens kulstoflager	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedret bevidsthed blandt offentligheden	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

For mest vigtigt og vigtigt, angiv venligst specifikke eksempler her:

_____

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Vidensbehov

Hvilke yderligere oplysninger tror du, at landmænd har brug for, for at øge muligheden for anvendelse af dyrkningspraksis og arealanvendelsestiltag, der forbedrer kulstoflagring?

	Viden eksisterer, men skal kommunikeres til landmændene	**Yderligere forskning er nødvendig, herunder forskning der inkluderer landmænd**
Viden på bedriftsniveau (fx valg af efterafgrøder og maskiner)	(1) ❑	(2) ❑
Oplysninger om økonomi (fx indvirkning på udbytter eller indkomst)	(1) ❑	(2) ❑
Oplysninger om muligheder for finansiel eller teknisk support (fx hvor man kan få adgang til lån eller tilskud)	(1) ❑	(2) ❑
Viden om og brug af beslutningsstøtteværktøjer (fx næringsstofplaner og markplaner)	(1) ❑	(2) ❑
Andet	(1) ❑	(2) ❑

Indtast yderligere kommentarer omkring vidensbehov her:

_____
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Bidrag ved kulstoflagring

I hvilken grad gør kulstoflagring følgende?

	Slet ikke	**I lav grad**	**Til en vis grad**	**I høj grad**	**Ved ikke**
Forbedrer udbyttepotentialet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer udbyttestabiliteten	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer produkternes kvalitet (for eksempel højere værdi)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer jordkvaliteten	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer jordens bearbejdbarhed, fx til klargøring af såbed	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Slet ikke	I lav grad	Til en vis grad	I høj grad	Ved ikke
Forbedrer biodiversiteten	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer jordens vandholdende evne	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forbedrer vandinfiltration og dræning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Reducer vandingsbehov	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Reducer behov for gødning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Reducer behov for beskyttelse af afgrøder (skadedyr og sygdomme)	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forebygger jorderosion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Forhindrer næringsstofudvaskning	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Hvis du har yderligere kommentarer til undersøgelsen og emnet, er du velkommen til at beskrive dem her:

_____

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Angiv venligst, om du vil være villig til at deltage i en kort opfølgning eller workshop, og / eller hvis du vil modtage yderligere oplysninger om CIRCASA-projektet

	Ja	Nej
Jeg er enig i, at CIRCASA-holdet kan kontakte mig for yderligere information om mine svar	(1) ❑	(2) ❑
Jeg er enig i, at CIRCASA-holdet kan sende en invitation til at deltage i en workshop om kulstoflagring	(1) ❑	(2) ❑
Jeg ønsker at modtage yderligere oplysninger om CIRCASA projektet	(1) ❑	(2) ❑

Skriv venligst din e-mail adresse her, hvis du siger ja til nogle af de ovenstående muligheder:

_____
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Annex 4: Representation of Danish farm survey responses

Table 6: Characteristics from the Danish farm survey compared with the national statistics regarding farm type, farm size, agricultural practice and farmer demographics.

FARM CHARACTERISTICS (YEAR OF STATISTICS)	CHARACTERISTIC RESPONSE	SURVEY (% OF RESPONDENTS)	NATIONAL STATISTICS (% OF GROUP)
PRIMARY FARM ACTIVITY (2017)	Livestock[3]	37%	40%
	Cattle	20%	29%
	Dairy	8%	8%
	Pigs	8%	6%
	Poultry	1%	1%
	Mink	1%	4%
	Arable[4]	59%	48%
	Horticulture	1%	2%
	Fruit- and viticulture	1%	1%
AGRICULTURAL PRACTICES (2017)	Conventional	80%	90%
	Organic	14%	10%
	Biodynamic (2016)	0,2%	0,1%
	Conservation agriculture	2%	NA
	No till	1%	NA
FARM SIZE (2017)	0-5 ha	6%	6%
	5-10 ha	11%	21%
	10-20 ha	13%	17%
	20-50 ha	21%	20%
	50-100 ha	19%	13%
	100-200 ha	15%	11%

[3] Other livestock types reported from the survey include Mink, horses, sheep/goats. Information on cattle types is also available in the dataset.

[4] Respondents also reported on other land use types in the survey including; forestry, mixed farming, which is also available in the dataset.

	200-300 ha	7%	5%
	300-400 ha	3%	2%
	Over 400 ha	6%	3%
REGIONAL DISTRIBUTION (2017)	North Denmark Region	14%	19%
	Central Denmark Region	36%	31%
	Region of Southern Denmark	26%	27%
	Region Zealand	20%	17%
	Capital Region of Denmark	4%	6%
AGE (2017)[5]	18-39	6%	6%
	40-54	29%	33%
	55-74	56%	47%
	over 75	9%	7%
GENDER (2013)[6]	Female	6%	8%
	Male	94%	92%

[5] The official statistics have a category with undisclosed age, in 2017 it was 7% of farms that was in this category.

[6] Eurostat statistics: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Annex 5: Comments from workshops

Table A6.1 gives a summary of pros and cons as reported in the workshops. The numbers in square brackets indicate how many regions listed the option, or how many times a specific pro / con was mentioned.

Table 7: Pros and cons identified during the stakeholder workshops for the various SOC management options. The number in square brackets show the number of regions where these were identified.

Management option	Pros	Cons
Agro-forestry in cropland [5]	• Improves soil C sequestration +N input and improved production due to tree and pasture root systems [3] • Enhance ecosystem and production stability [3] • Reduces erosion due to soil cover throughout the year [2] • Improves ambience (reduces mean temperature due to shading) [2] • Higher financial return from these systems [2] • Diversification [2] • interesting new business model • Long term benefits • water purification	• Conflicts with mechanization [2] • Competition for water, nutrients and solar radiation [2] • few/insufficient studies exploring management practices [2] • lack of advice • high investment cost and it requires commitment • Uncertain long-term economics • Difficult selling of forest products on a large scale • Income forgone; reduce crop yield near trees [2] • Possible damage to crops for tree management • Hosts of possible pests affecting crops • Adoption is a complex problem • Limited arable
Agro-forestry in grazing lands [3]	• Improves soil C sequestration +N input and improved production due to tree and pasture root systems [3] • Enhance ecosystem and production stability [3] • Reduces erosion due to soil cover throughout the year [2] • Improves ambience (reduces mean temperature due to shading); climate change adaptation [3] • Higher financial return from these systems [2] • Diversification [2] • interesting new business model • Long term benefits • water purification	• Competition of water and nutrients; water is limited for tree growth in grazing area [2] • few/insufficient studies exploring management practices [2] • lack of advice • Difficult selling of forest products on a large scale • Income forgone • high investment cost and it requires commitment • Conflicts with mechanization • Adoption is a complex problem

Agro-forestry in mixed crop-livestock systems [4]	• Improves soil C sequestration +N input and improved production due to tree and pasture root systems [2] • Continuous production of biomass and nutrients • Improves Ecosystem (reduces mean temperature due to shading); climate change adaptation [4] • Higher financial return from these systems • Reduces erosion due to soil cover throughout the year [2] • Long term benefits • interesting new business model • Diversification • water purification • Enhance circular and low carbon agriculture	• Conflicts with mechanization [2] • Competition for water, nutrients and solar radiation • few/insufficient studies exploring management practices [2] • Lack of information on cost and benefit of the complex systems [2] • lack of advice • high investment cost and it requires commitment • Income forgone; reduce crop yield near trees [2] • Difficult selling of forest products on a large scale • It requires a particular design depending on the area (adapt the system to the characteristics of the location • Adoption is a complex problem • Limited arable
Biochar [3]	• Increase SOC content; “long”-term storage [2] • Benefit for degraded soils • Reduce the pest and disease caused by the direct returning pf stalk to soil • Reduce air pollution caused by biomass burning on site • Reported effects are good	• Uncertainty of the effects and tradeoffs [2] • What is the carbon footprint of biochar as a management option, this depends on the origin of the source (waste) • Pollution caused by producing biochar (tar) • High cost • Additional energy consumption for collection and transportation of stalk and producing biochar
Buffer strips and set-aside areas [1]	• Reduce non-point pollution • Improve biodiversity	• No land for buffer strips and set-aside areas due to the limited arable land and cropland use rights policy in China

Crop-livestock systems [3]	• Gain on the complementarity of production (livestock and agriculture): a) livestock :manure for soil fertility and meat, egg, milk (for human being) and b) agriculture: food from crops, the residue is not lost and will serve as animal food (economy savings practices) • Improve soil fertility with manure and residue of culture [3] • Increase yield and production • Reduce soil erosion • Livestock feed – improves food security [2] • Economic added-value: Increasing income, decreasing cost of work, Low external input, Reduce the cost for manure treatment [3] • Low risk • Enhance circular and low carbon agriculture • Reduce non-point pollution • Increase biodiversity • Possibility of large scale transfer	• Need to integrate livestock in the farm otherwise the system is not profitable it will Increasing exploitation expense • The quantities of manure expected are not always sufficient for exploitation • Susceptible to mismanagement • Need buy-in from community in the case of communal land • Field fires is a risk • Risk of bush encroachment • Alien invaders constant threat • Capacity problems on management level • Lack of information on cost and benefit of crop-livestock systems • Difficult to adjust agricultural structure • Limited arable land
Grass in rotation [2]	• Increase soil biodiversity • More sequestration than in arable land [2] • Easy to implement • Increase grass productivity • Control sand and dust storm, and improve air quality	• Increase methane emission • Reduce livestock stock and income in short term • Difficult for supervision • Farmers lack knowledge on the benefit to keep a balance of grass production and carrying capacity

Manure and composting (applying livestock manure and/or compost on fields) [3]	• Increase yield and production • Improve product quality: keep the products in the standards of organic farming • Increase soil fertility [3] • Improve soil biological properties :Increase worms and other soil microorganisms [2] • Improves chemical and physical properties [2] • Practical aspect of implementation :technique already known by farmers, easy to use and produce, raw materials are locally available, make easier the application of Crop-livestock systems • Replace mineral fertilizer to some extent • Reduce non-point pollution • Economic aspect: affordable price, make easy and cheap as well the management of residue	• Possibility of biological and chemical contamination (e.g. heavy metal and antibiotic) [3] • Higher NH3 emission from compost • Lack of service for transport and application of organic fertilizer • Labour consuming [2] • Problems of access and availability of raw material: not available for all farmers, shortage and difficulty to find raw material especially for the compost manufacture, Manure becomes more and more limited, the number of livestock decreases consequently because of thieves • Insufficient volumes, Difficulty in terms of scaling: it may be Insufficient in large scale [2] • "High cost: expensive distribution channel If farmers do not have it locally, the purchases are very expensive" • "lack of awareness or popularization of their positive effect and benefits: Lack of vulgarization, marketing and communication " • Need of perfect understanding and handling techniques : may not be efficient when misunderstood or uncontrolled • Expensive manipulation process • Phytosanitary issues and weed outbreak: may proliferate macro and micro plant pests, may as well bring back weeds when the manure or compost are not well mature
Permanent grassland management (optimised grazing) [2]	• Higher root production, soil C source [2] • Soil correction and fertilization for biomass production • Benefit to ecosystem	• High initial implementation cost • Reduce livestock stock and income in short term • Difficult for supervision • farmers lack of knowledge on the benefit to keep balance of grass production and carrying capacity

Preventing erosion (e.g., contour farming, terracing, windbreaks) [4]	• Reduce erosion; Prevent nutrients loss / prevent fertility loss [4] • Improves soil quality and structure [2] • Increase water infiltration and soil water; decrease run-off [2] • Improves water quality of the catchment, less flooding, less erosion, better quality water • Improve water management: Better management of irrigation,enhance water reserve, increase moisture content in soil • Restore biodiversity • Regenerates landscape • Increase yield and production: guarantor ofyield rate • Practical aspect of implementation: can be done continuously, easy to do, no need for a big investment, reduces fertilizer transport work, technique already known by many farmers • Alternative practice to bushfire, to avoid roaming crops • Homogenization of the landscape • "Maintaining surface / soil depth available and usable by crops: • Increase, protect and preserve topsoil layers, increases the availability of cultivate land"	• High adoption/implementation cost; Expenditure on the installation and maintenance, work more hard, need for capital [4] • Labour and time consuming [3] e.g. requiring more time however farmer have to find what they would eat each very single day. The management can't be done in proper time :for example construction of irrigation canals in dry season and planting trees in rainy season, it represents a lot of and additionnal work for farmers as they have to find what to eat each day • If done incorrectly, it could lead to more damage (such as incorrect gabions) • Need specialised skills to identify the problem early • To some extent, dependant on government intervention • Lack of interdisciplinary consultation – only focus on 1 aspect of a problem • Constant monitoring and maintenance
Reduced / minimum tillage [1]	• Reduce the interference to soil • Reduce energy consumption and related CO2 emission from tillage • Easy to implement • Benefit to the soil recovery	• Soil compaction • Reduce production • Affect sowing

Zero tillage [3]	• Cost effective (Reduce use of fuel, labour and machinery) [3] • Physically almost undisturbed soil / soil conservation • Permanent soil cover • Reduce erosion (from keeping in stubble) [2] • Improves land use efficiency • Improves soil structure; chemical and physical properties [2] • Simplifies mechanical operations • Reduces costs • Accumulates C [2] • improve soil biodiversity • very helpful in dry conditions • Less mineral fertilizer use (medium/long-term) • Easy to implement • Increase soil water content and reduce SOC decomposition	• In certain cases (paddy rice) leaves residue in excess • Compaction in the long-term [2] • Missing adequate knowledge for effective/correct uptake of the technology / difficulties in uptake of the technology by farmers [2] • Difficulty in reducing/controlling sub-superficial acidity • Costs (new, specific machinery needed) • Not effective on his own, must practice in combination with other measures • Herbicide dependence • Difficult for organic cultivation • Lack of information about economies (Invest, Risks, transition time) • Affect sowing and reduce production • Not suitable for multiple cropping system • Weed spread • Reduce the SOC content in deep soil layer

Residue management (crop residue left in the field) [3]	• Increase soil organic matter :naturally turns into humus, restores carbon in the soil, turned into organic fertilizer [3] • Improve physical and chemical soil properties and soil structure [2] • Protect soils • Regulate soil temperature :Protects heat in hot weather and protects from cold in cold weather • Keeps humidity in the soil [2] • Control weed: avoid weed • Replace mineral fertilizer to some extent [2] • Improve air quality through reduced biomass burning on site • Improve biodiversity [2] • Practical aspect of implementation : technique easy to use and produce by Farmers, Farmers does not need external raw materials anymore, they just use what is already available on their site, reduces fertilizer transport work	• Increase the risk of pest and disease when it is uncontrolled: Vector of fungal diseases, insects,harmful mites [3] • Competition with livestock :social conflicts between landowners with plots under crop residues management and livestock owners, insufficient food for livestock • Difficult decomposition in cold climate region and affect crop emergence • Difficult in a hilly area for straw returning using the machine • Required quantity of residues not enough :need of large quantity of residue • Negative impact on landscape management (upsurge of bushfires) : may increase bushfires and disturb soil structure • It makes difficult the ploughing and weeding
Rewetting of organic soils [2]	• Reduce SOC decomposition • Easy to apply	• Consume water • Increase CH4 emission • Not suitable for soils in this region; reduces financial return from dried peats
Use of cover crops [3]	• Builds up soil fertility; Continously using of sun energy to store C (in depth) [3] • C cycling • Improves soil physical, chemical and biological properties • Controls nematoids • Reduces erosion [3] • Reduce nitrate leaching • Improve biodiversity [2] • Landscape value for society • Protection of water resources enhance nutrient retention	• Lower cropping index • No direct economic benefit. Reduce farmers income in short-term [2] • Competition with next crop for nutrient and water [2] • Addition input for seed, labour and machinery [2] • Not reality in China with high population and limited arable land • Little spread knowledge about this practice • Chemical destruction of crops • Nitrate regulation • Time window • More Snails, Disease • More use of fertilizer

Use of forage legumes [1]	• Increase N fixation	• Limited applicable area • Low income if use of grain legumes to replace staple crops
Use of grain legumes [1]	• Increase N fixation • Reduce fertilizer application	• Lower income if use of grain legumes to replace maize
*Crop rotation	• Economical and simple practice • Different kinds of roots • Nitrogen fixation • Control of weeds, pests and diseases	• Tillage machinery has to be changed depending on the crop • Difficulty in commercialization
*Associated, interspersed and relay crops (permanent and semi-annual arrangements) [1]	• Diversification • Better cash flow • Improved soil fertility • Traditional practice	• Possible management difficulties • Competition for water, nutrients and solar radiation

Annex 6: Views and perceptions on individual management options

RESIDUE MANAGEMENT

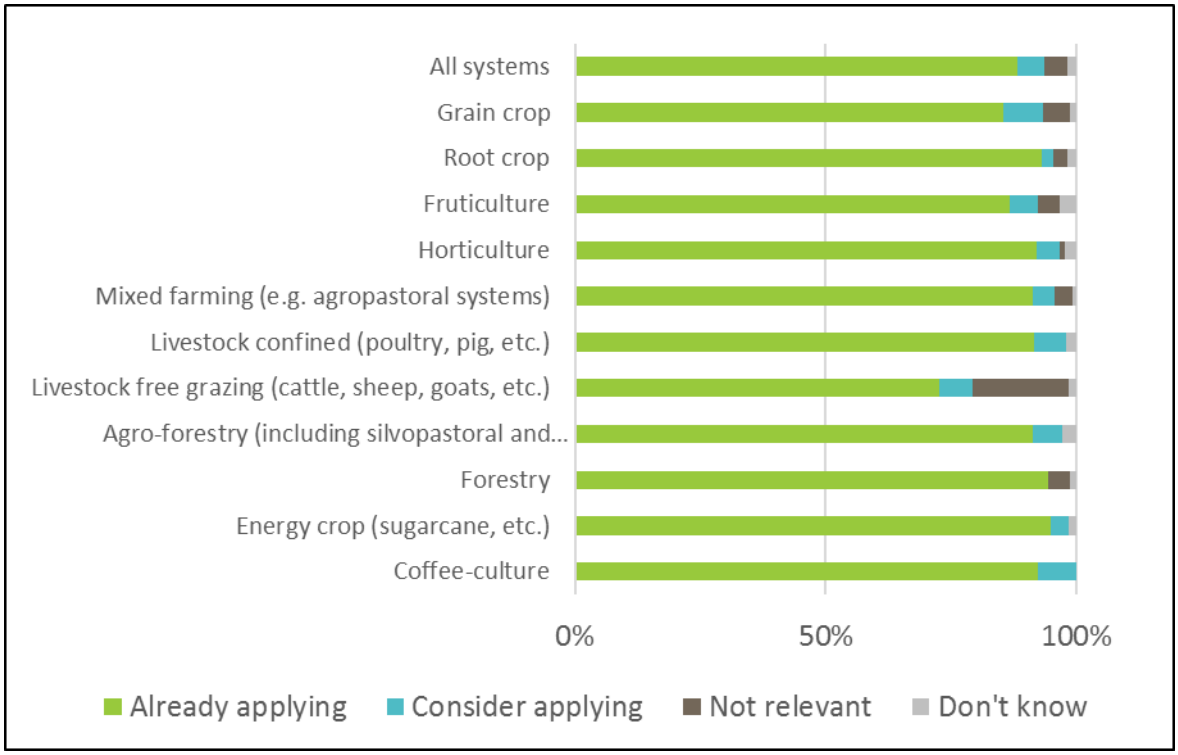


Figure 34: Farmers' answers to the question "Which management options do you apply or consider applying? - Residue management" crossed with farming system with responses from farmers from all regions.

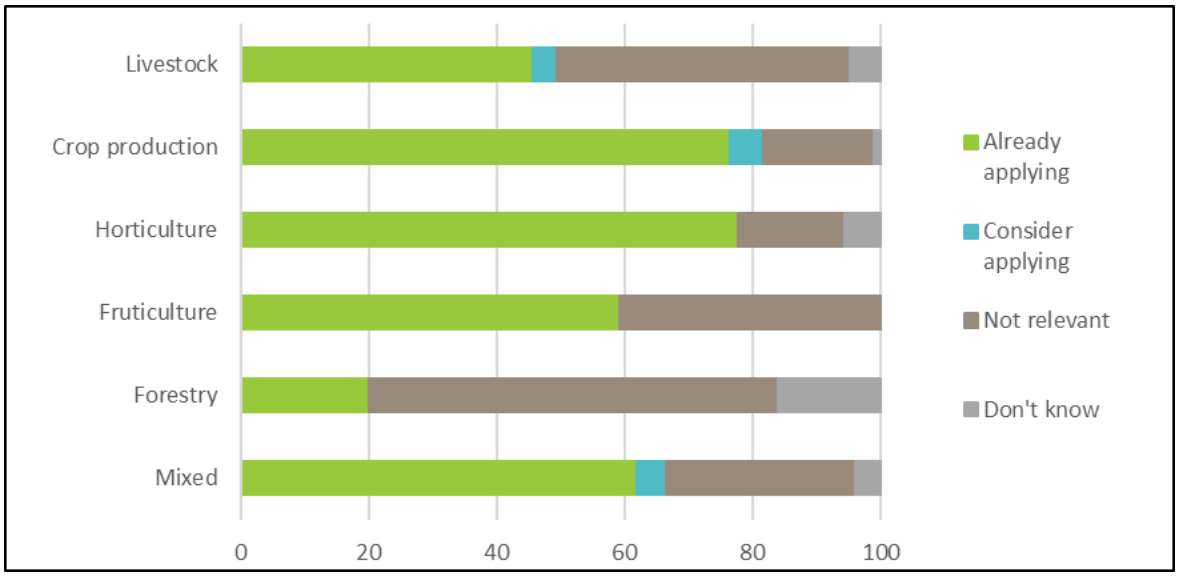


Figure 35: Farmers' answers to the question "Which management options do you apply or consider applying? - Residue management" crossed with farming system with responses from Danish farmers.

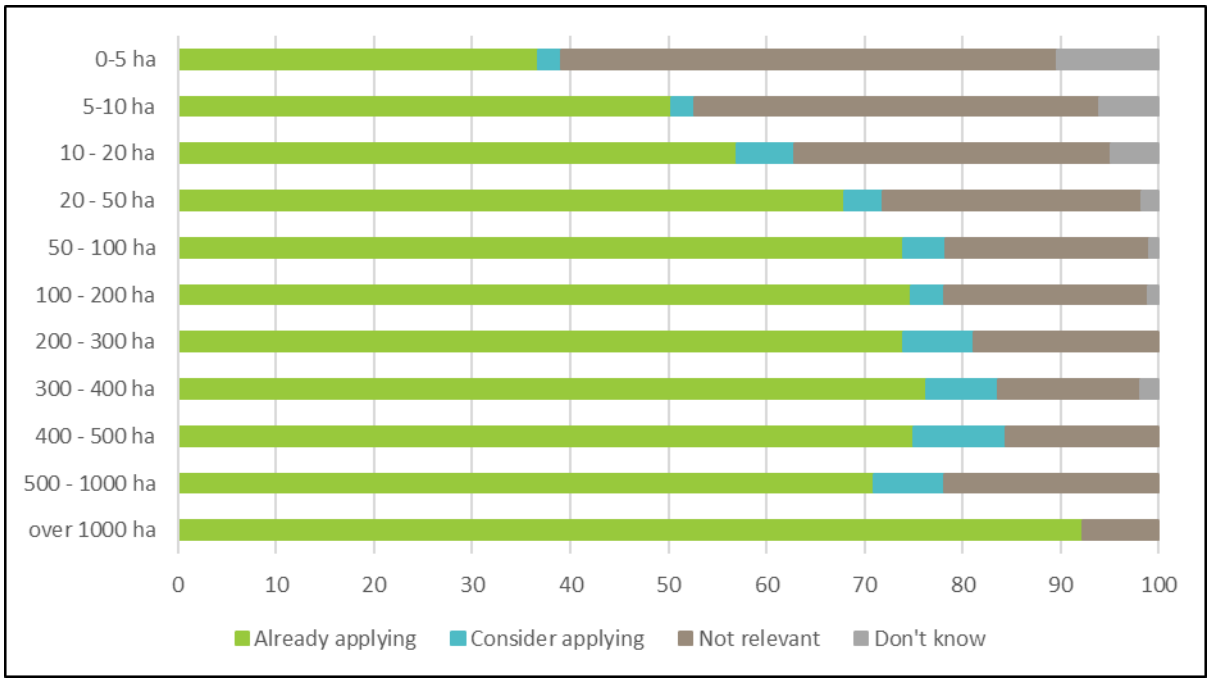


Figure 36. Farmers' answers to the question "Which management options do you apply or consider applying? - Residue management" crossed with farm size with responses from Danish farmers.

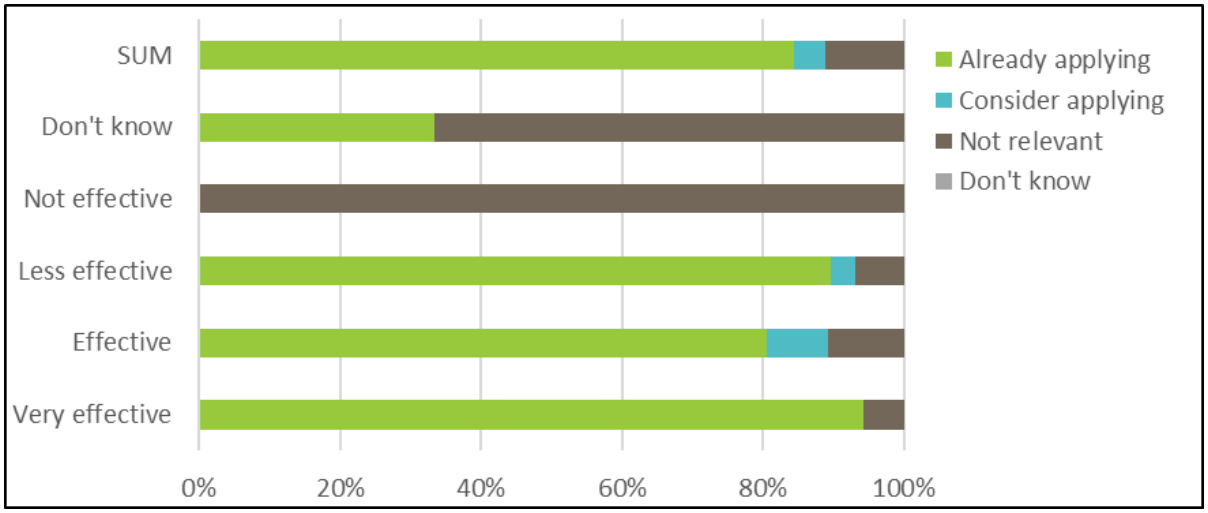


Figure 37: European farmers' answers to the question "In your opinion, how effective are residue management for enhancing and conserving SOC compared to current levels?" crossed with if they apply residue management.

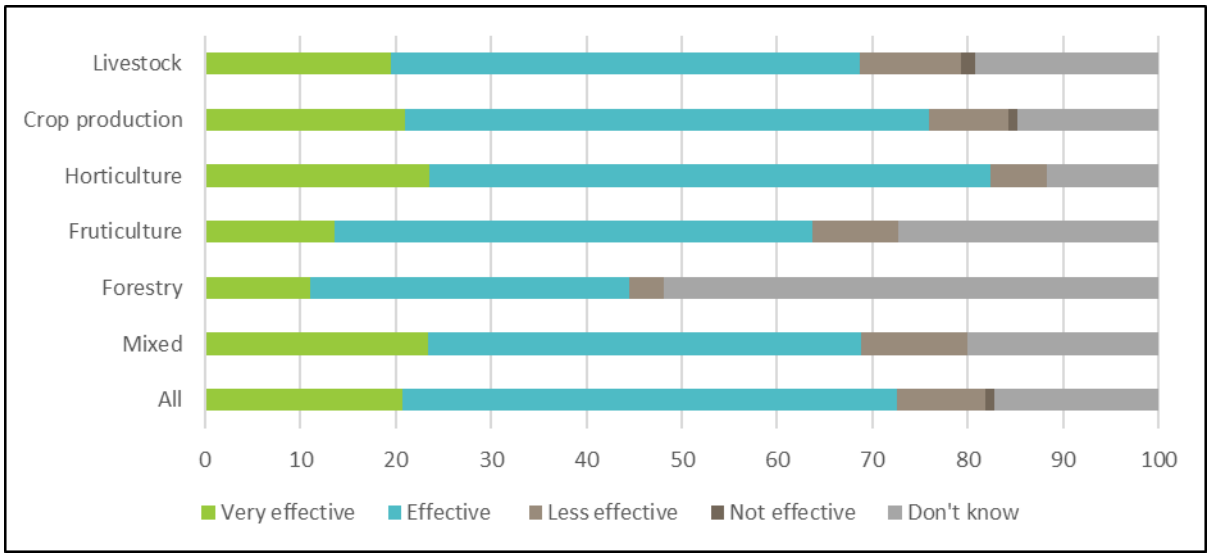


Figure 38: Danish farmers' answers to the question "In your opinion, how effective are residue management for enhancing and conserving SOC compared to current levels?" crossed with farm type.

REDUCED/MINIMUM TILLAGE

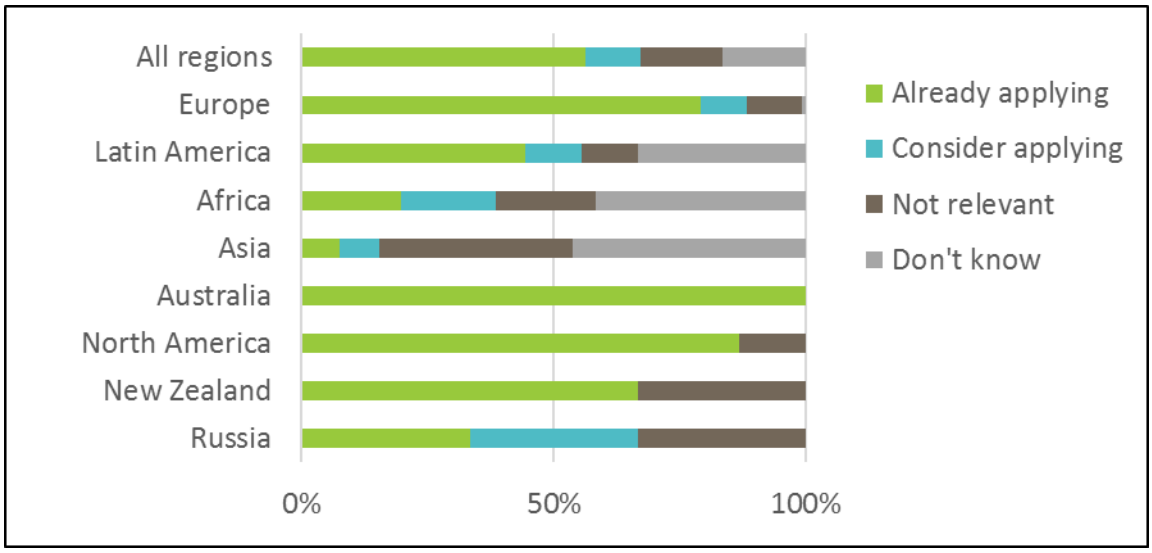


Figure 39: Farmers' answers to the question "Which management options do you apply or consider applying? – Reduced/minimum tillage" crossed with farming system with responses from farmers from all regions.

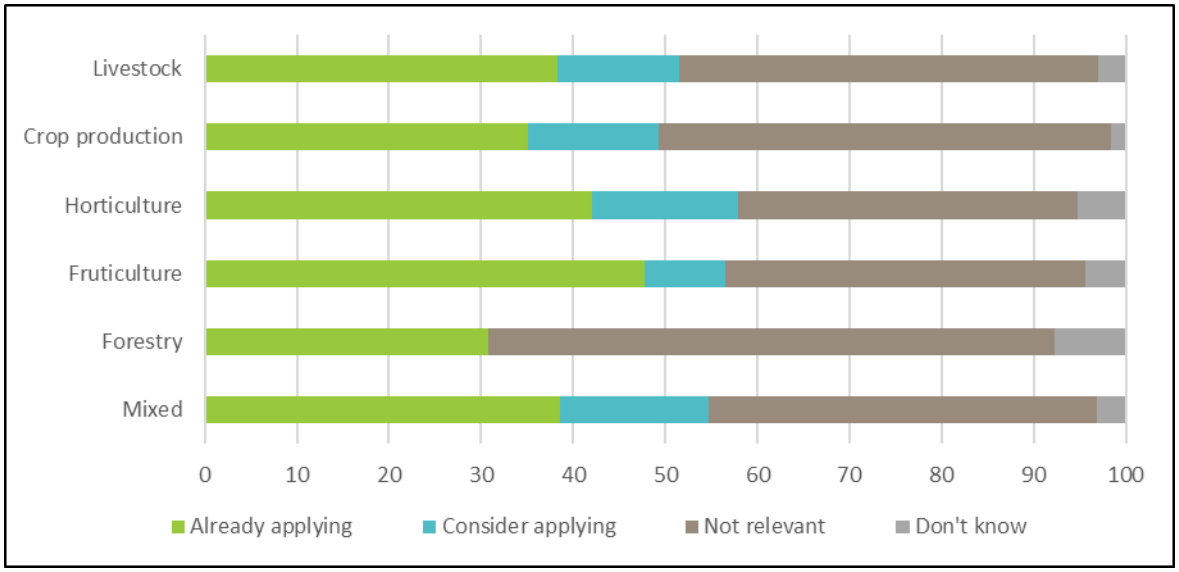


Figure 40: Farmers' answers to the question "Which management options do you apply or consider applying? – Reduced/minimum tillage" crossed with farming system with responses from Danish farmers.

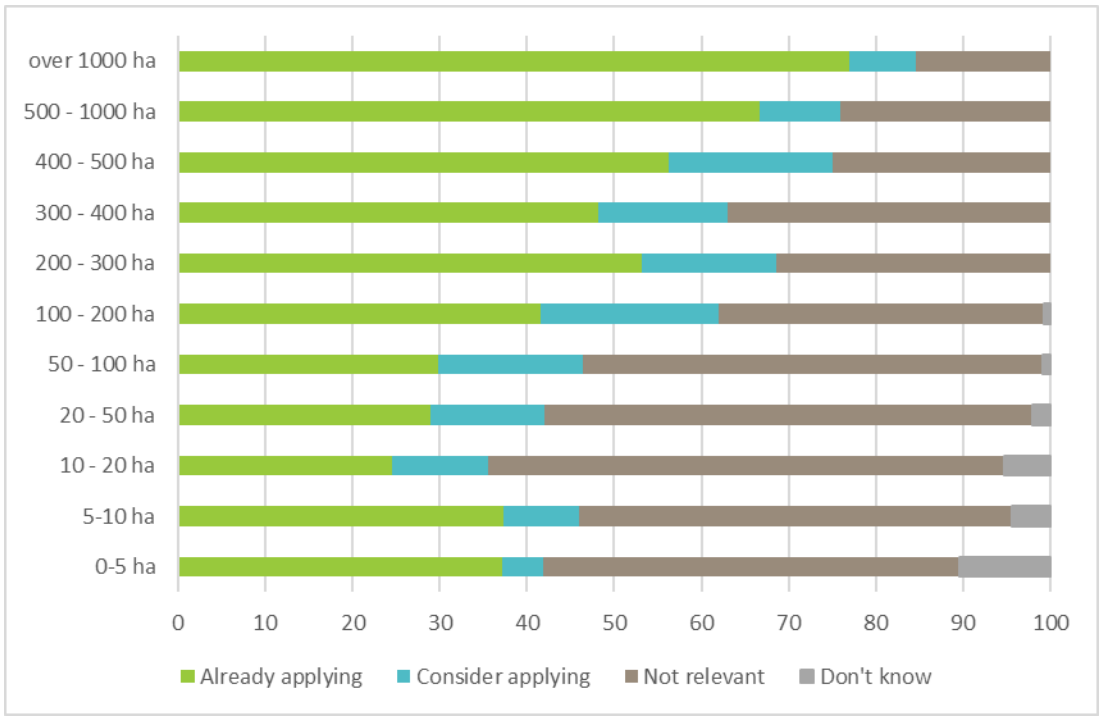


Figure 41: Farmers' answers to the question "Which management options do you apply or consider applying? - Reduced/minimum tillage" crossed with farm size with responses from Danish farmers.

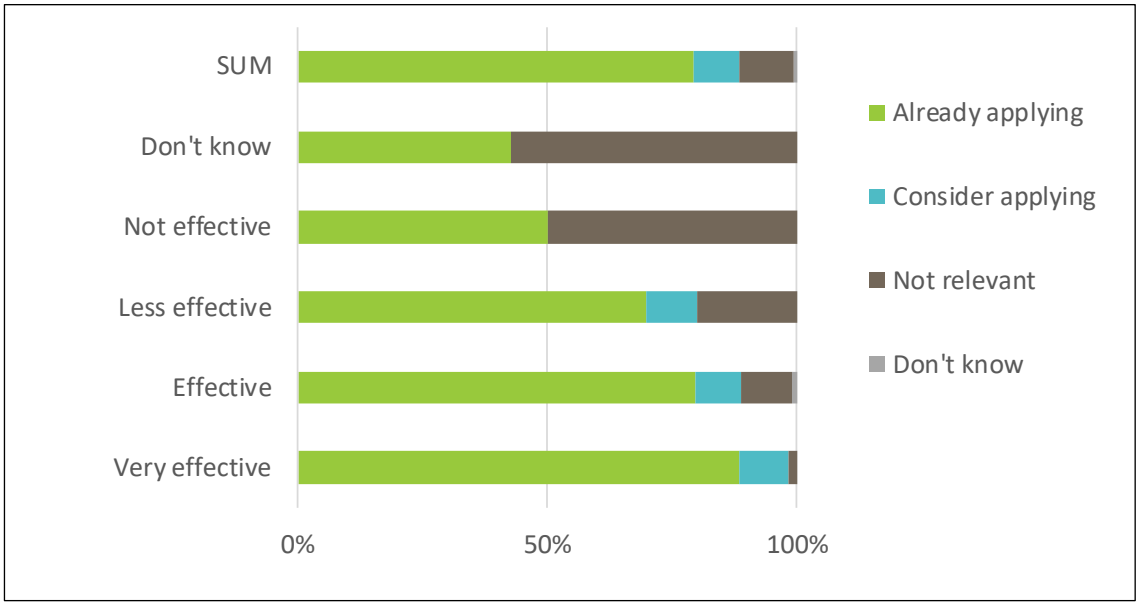


Figure 42: European farmers' answers to the question "In your opinion, how effective are reduced/minimum tillage for enhancing and conserving SOC compared to current levels?" crossed with if they apply reduced/minimum tillage.

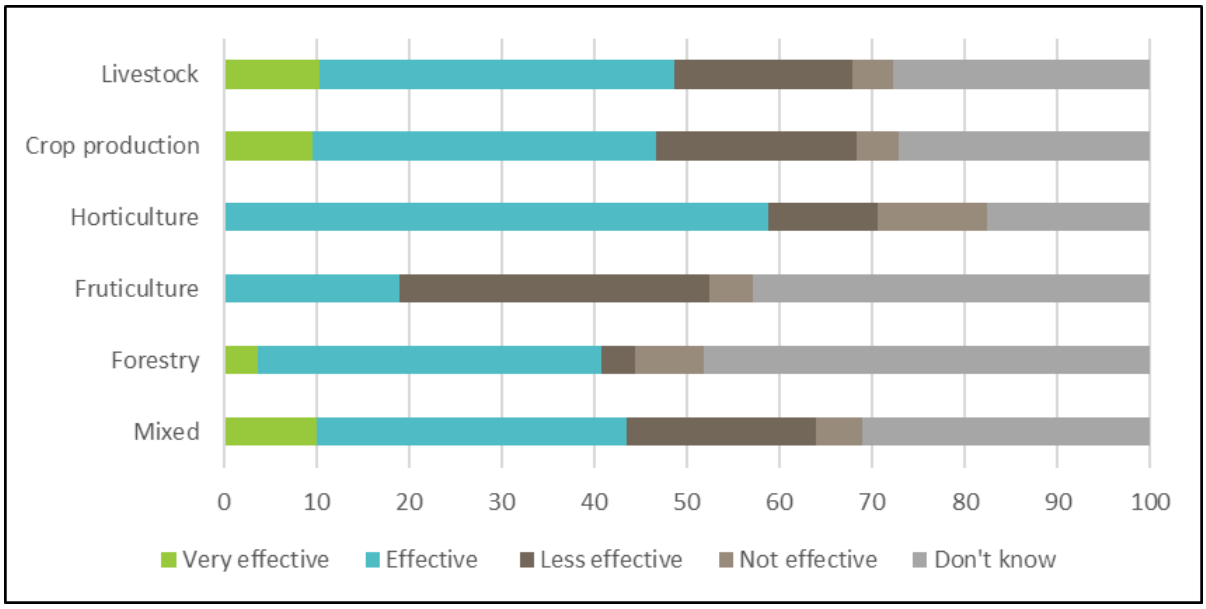


Figure 43: Danish farmers' answers to the question "In your opinion, how effective are reduced/minimum tillage for enhancing and conserving SOC compared to current levels?" crossed with farm type.

ZERO TILLAGE

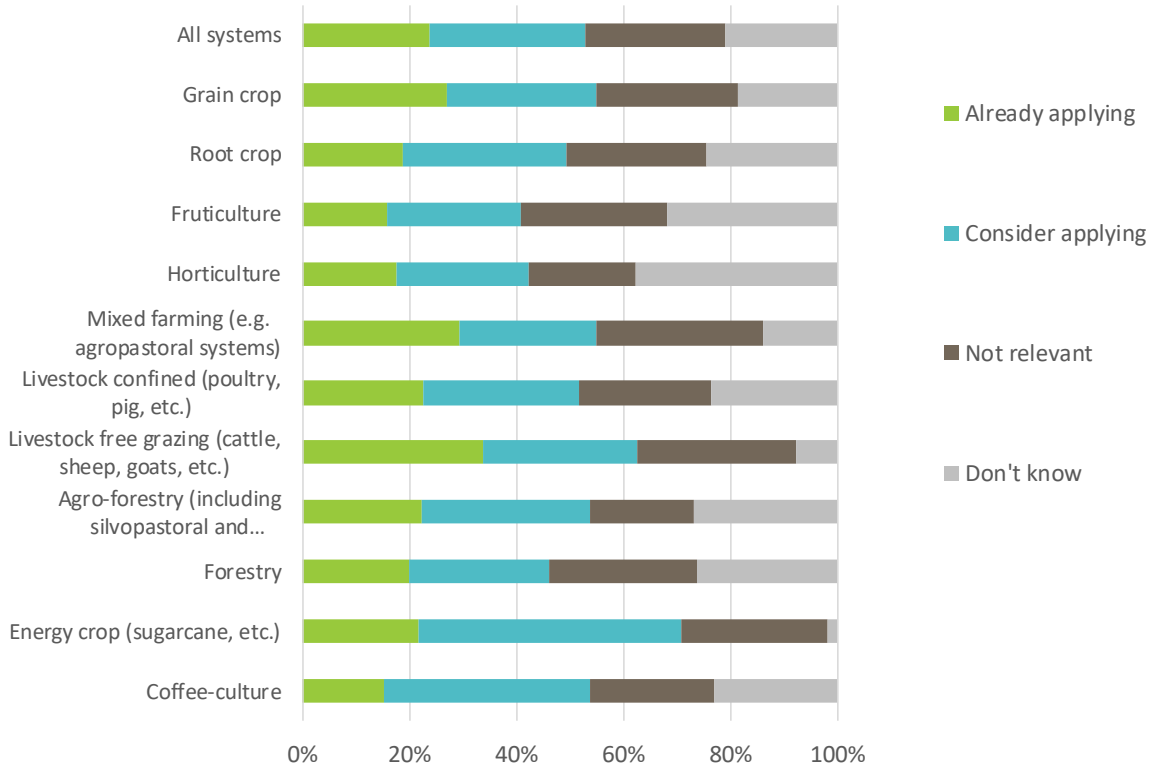


Figure 44: Farmers' answers to the question "Which management options do you apply or consider applying? – Zero tillage" crossed with farming system with responses from farmers from all regions.

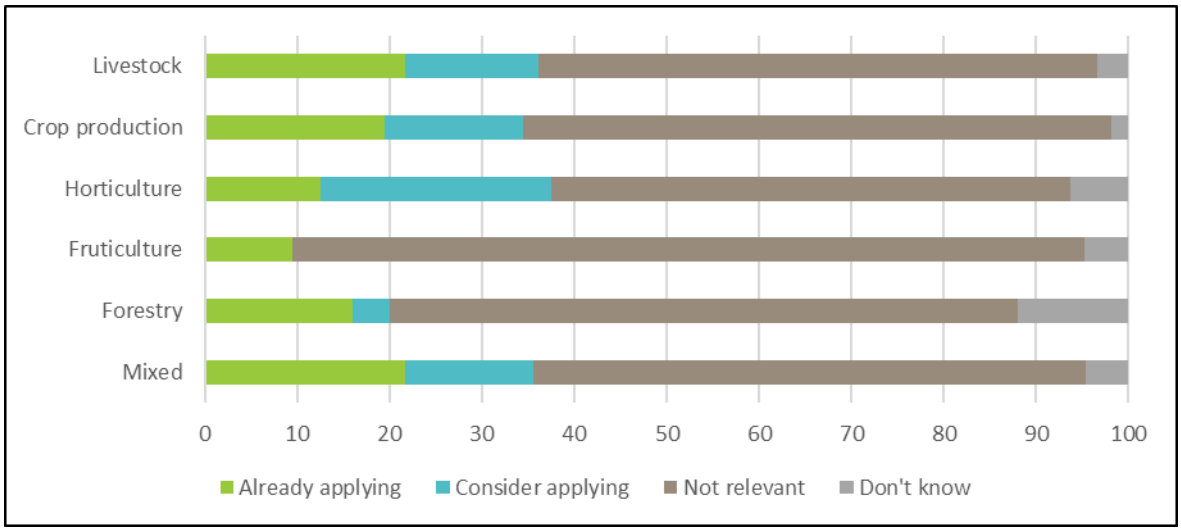


Figure 45: Farmers' answers to the question "Which management options do you apply or consider applying? – Zero tillage" crossed with farming system with responses from Danish farmers.

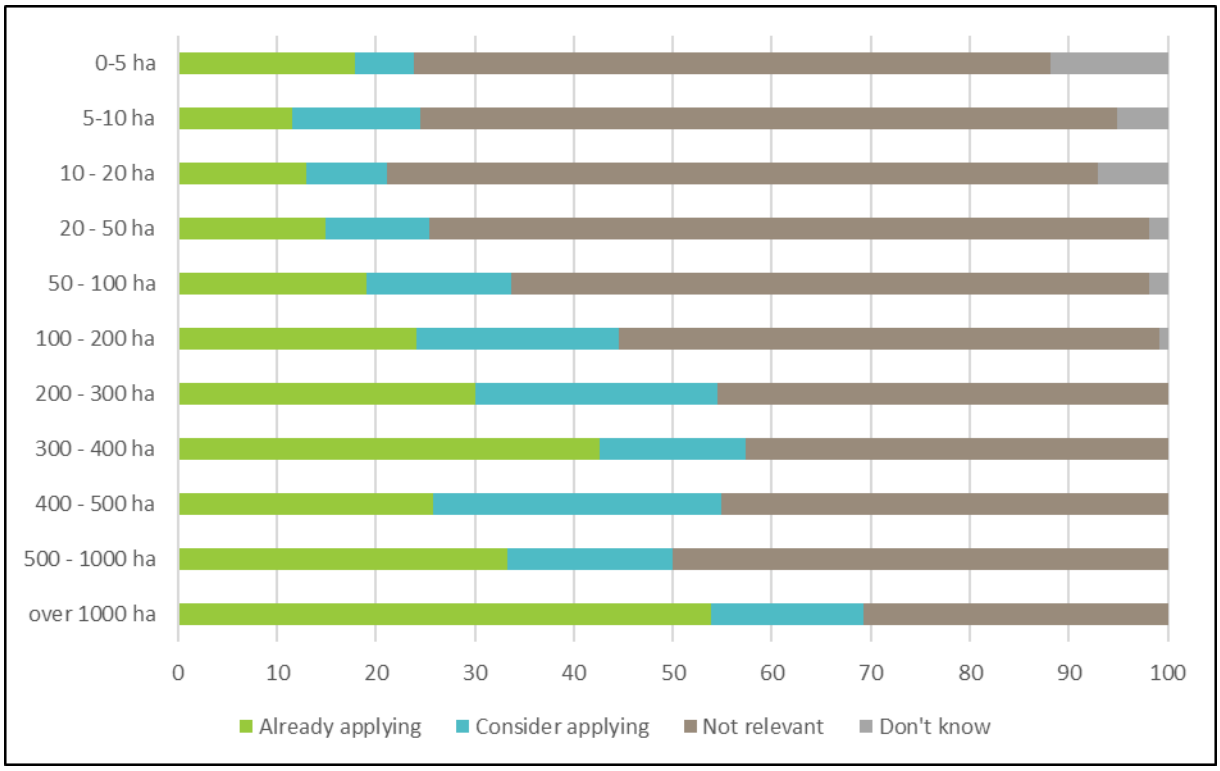


Figure 46: . Farmers' answers to the question "Which management options do you apply or consider applying? - Zero tillage" crossed with farm size with responses from Danish farmers.

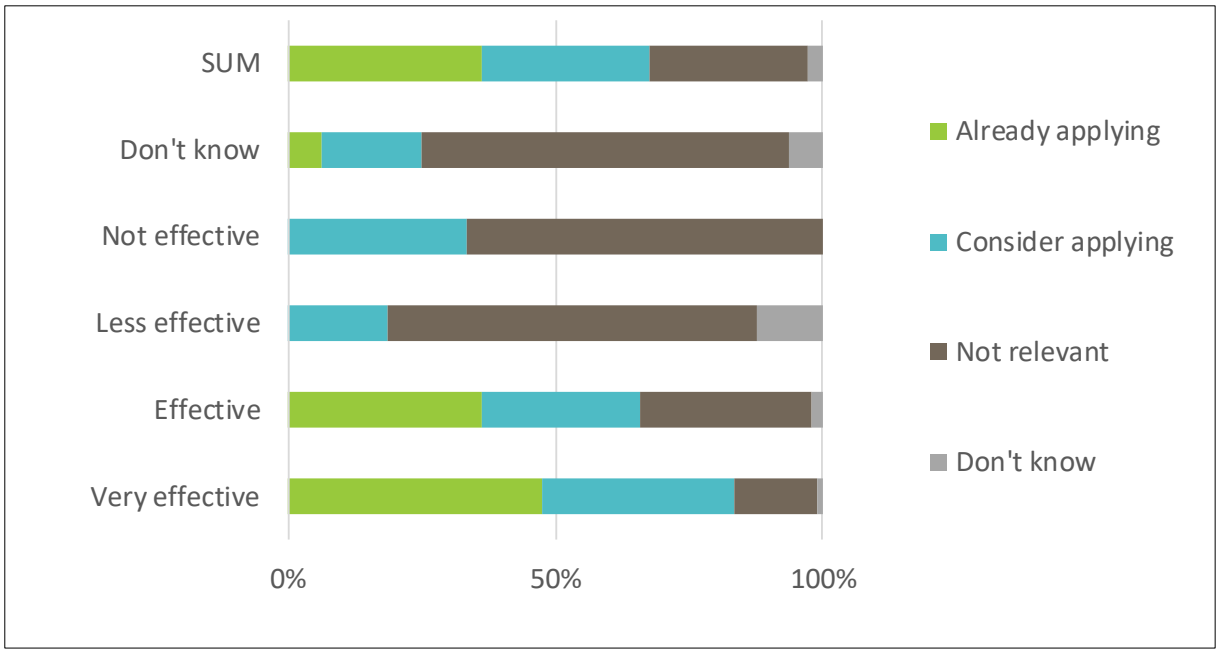


Figure 47: European farmers' answers to the question "In your opinion, how effective are zero tillage for enhancing and conserving SOC compared to current levels?" crossed with if they apply zero tillage.

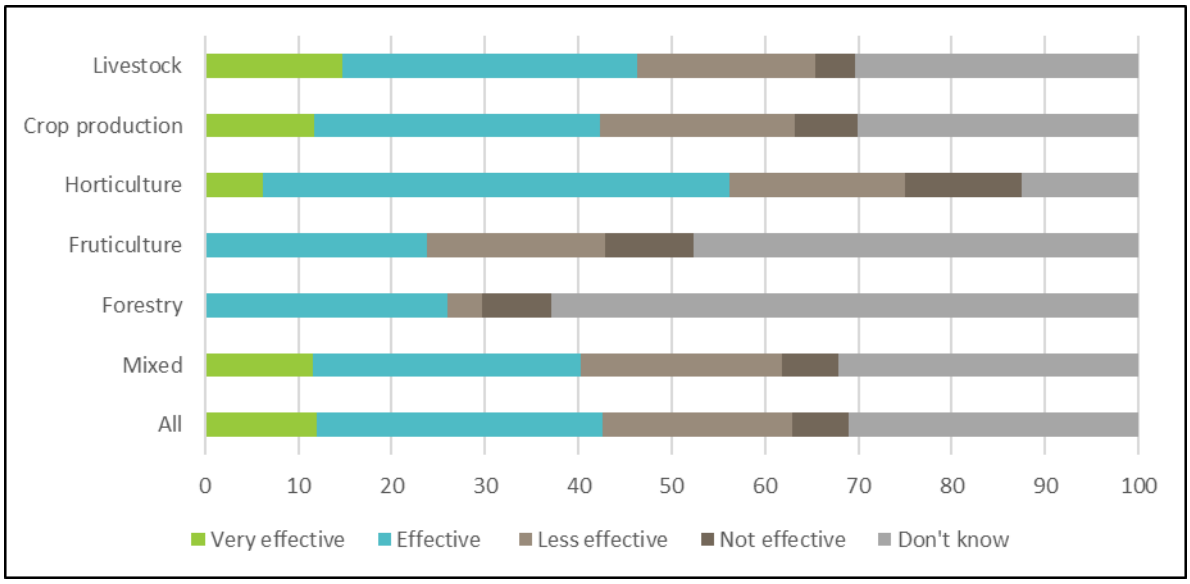


Figure 48: Danish farmers' answers to the question "In your opinion, how effective are zero tillage for enhancing and conserving SOC compared to current levels?" crossed with farm type.

MANURE AND COMPOST

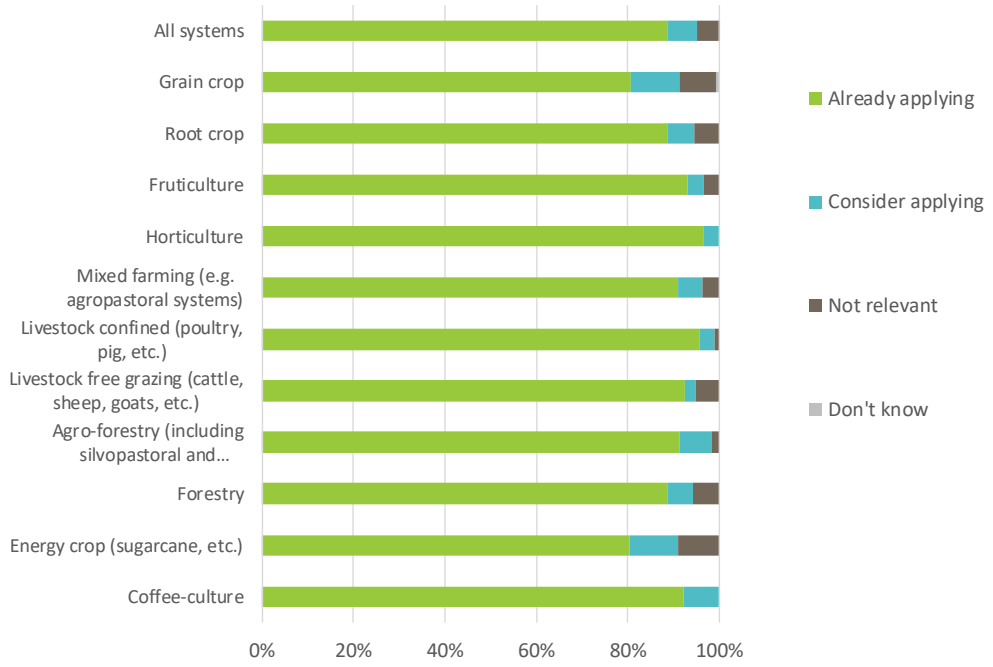


Figure 49: Farmers' answers to the question "Which management options do you apply or consider applying? – Manure and compost" crossed with farming system with responses from farmers from all regions.

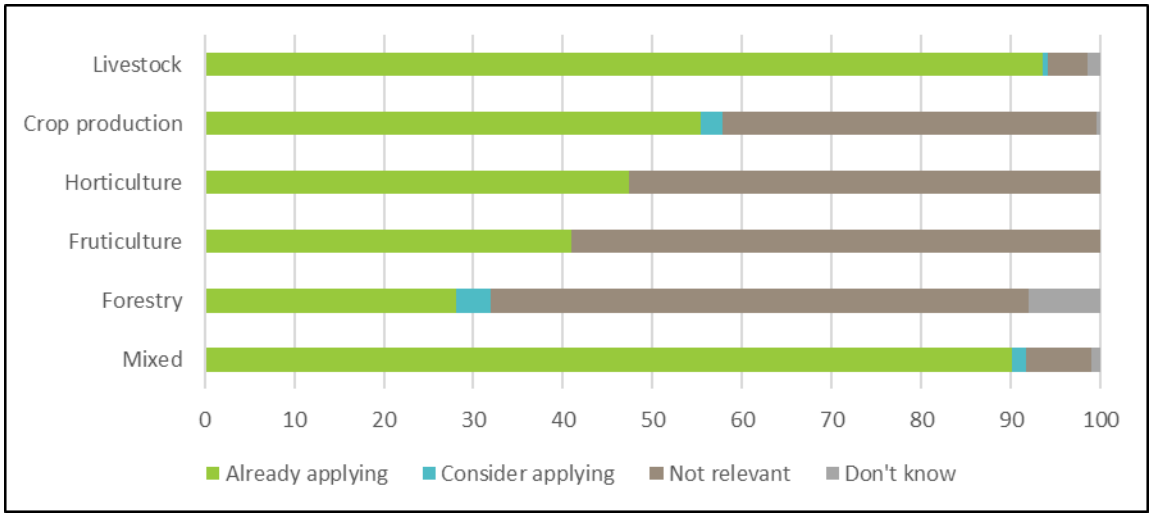


Figure 50: Farmers' answers to the question "Which management options do you apply or consider applying? – Manure and compost" crossed with farming system with responses from Danish farmers.

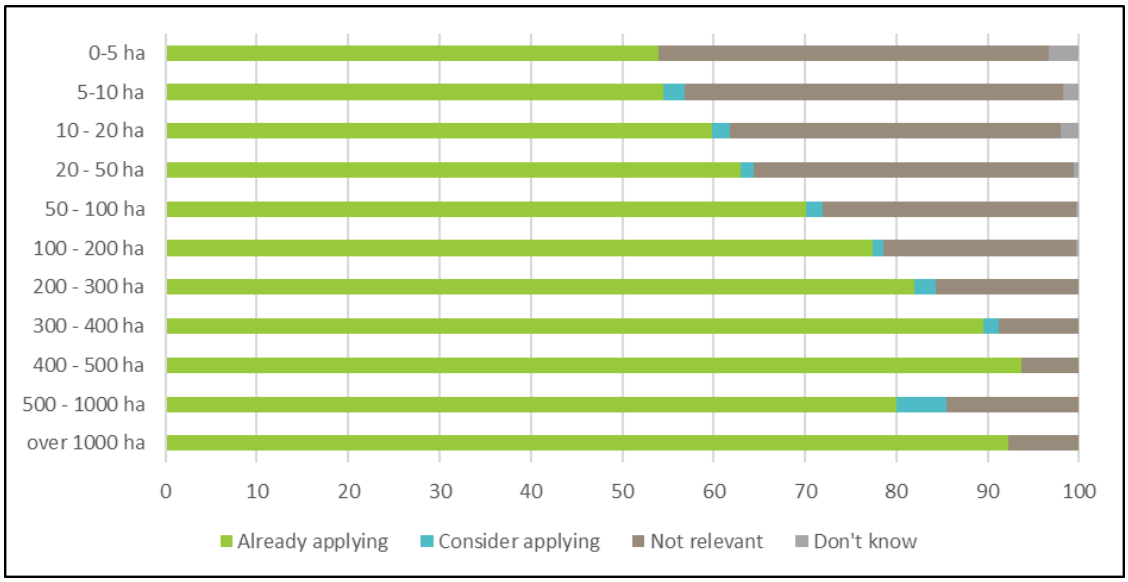


Figure 51: Farmers' answers to the question "Which management options do you apply or consider applying? - Manure and compost" crossed with farm size with responses from Danish farmers.

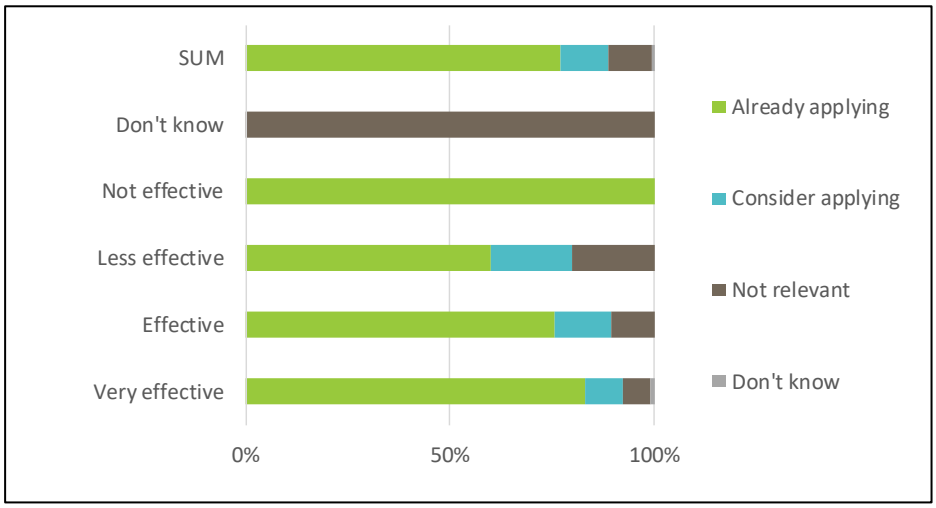


Figure 52: European farmer answers to the question "In your opinion, how effective are manure and compost for enhancing and conserving SOC compared to current levels?" crossed with if they apply manure and compost.

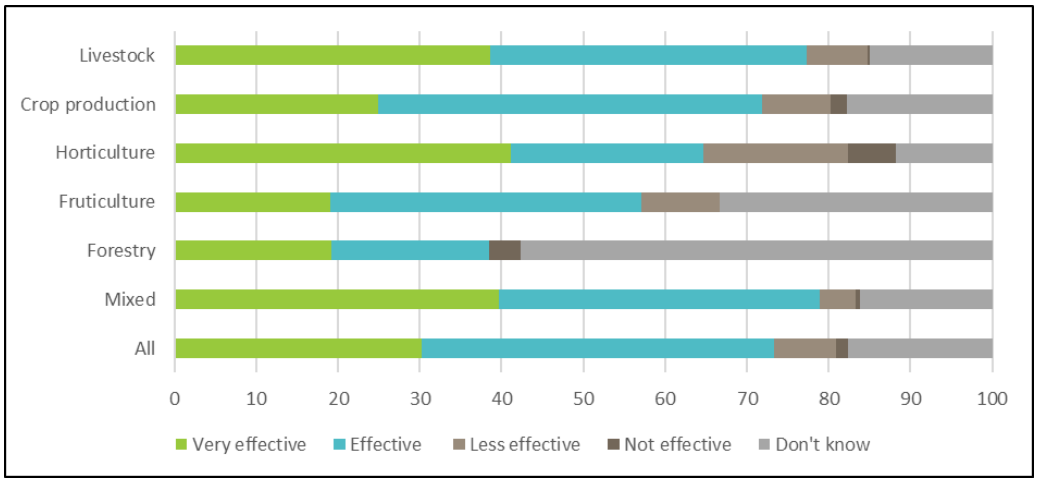


Figure 53: Danish farmers' answers to the question "In your opinion, how effective are manure and compost for enhancing and conserving SOC compared to current levels?" crossed with farm type.

GRASS IN ROTATION

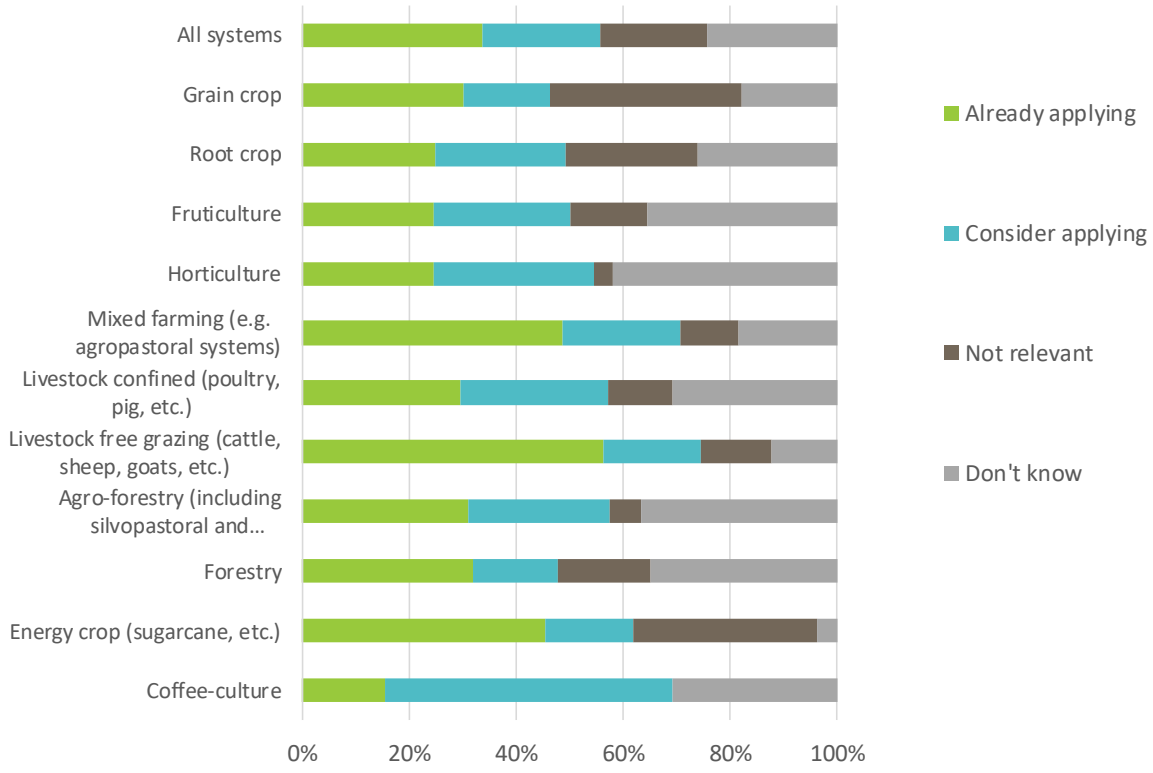


Figure 54: Farmer answers to the question "Which management options do you apply or consider applying? – Grass in rotation" crossed with farming system with responses from farmers from all regions.

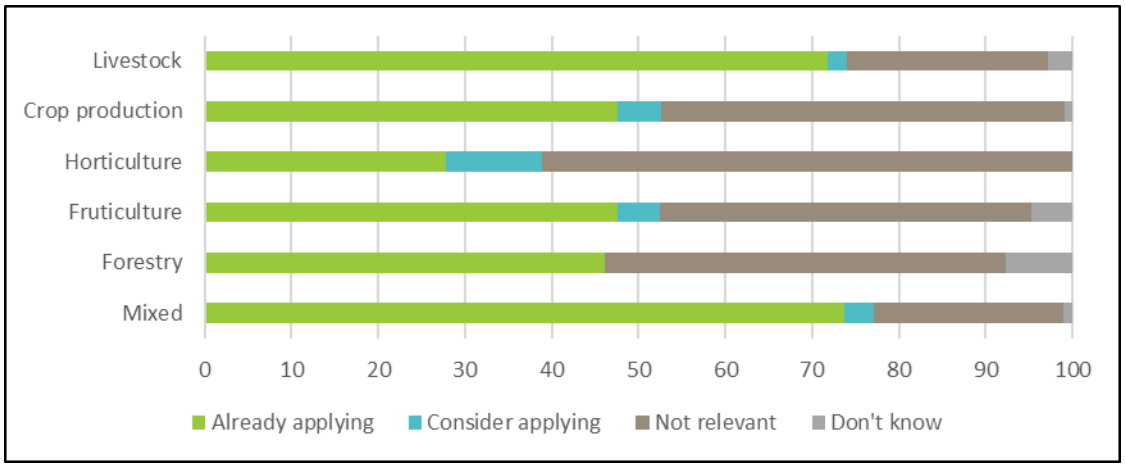


Figure 55: Farmers answers to the question "Which management options do you apply or consider applying? – Grass in rotation" crossed with farming system with responses from Danish farmers.

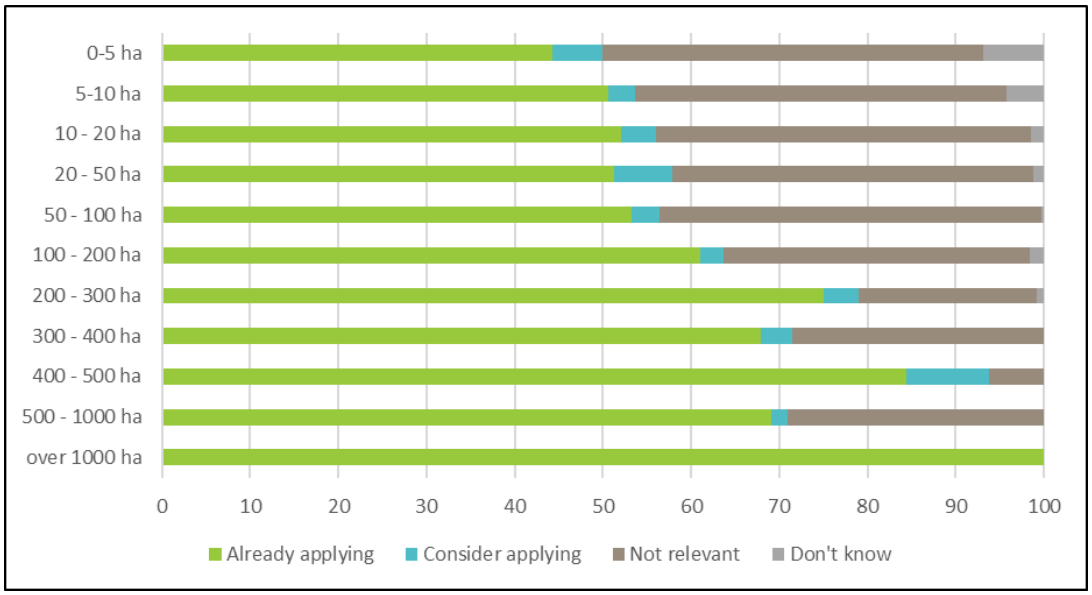


Figure 56: Farmer answers to the question "Which management options do you apply or consider applying? - Grass in rotation" crossed with farm size with responses from Danish farmers

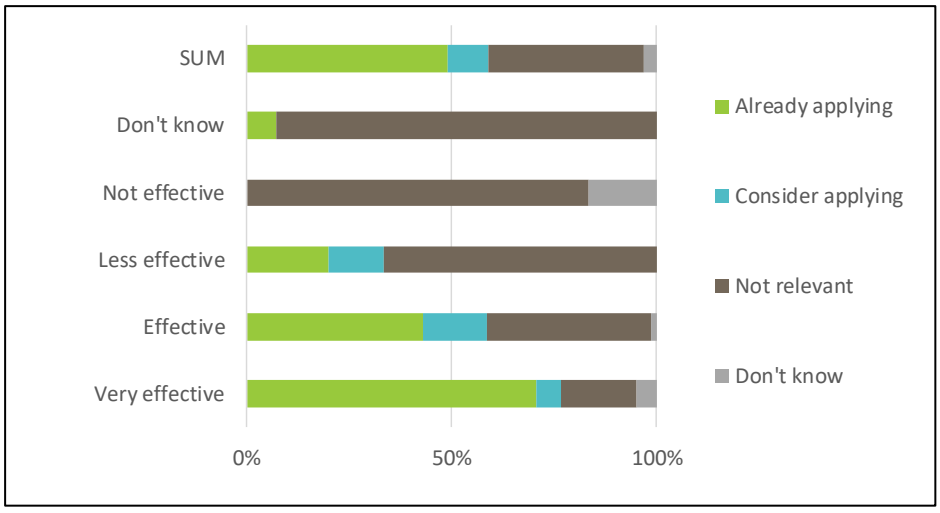


Figure 57: European farmer answers to the question "In your opinion, how effective are grass in rotation for enhancing and conserving SOC compared to current levels?" crossed with if they apply grass in rotation.

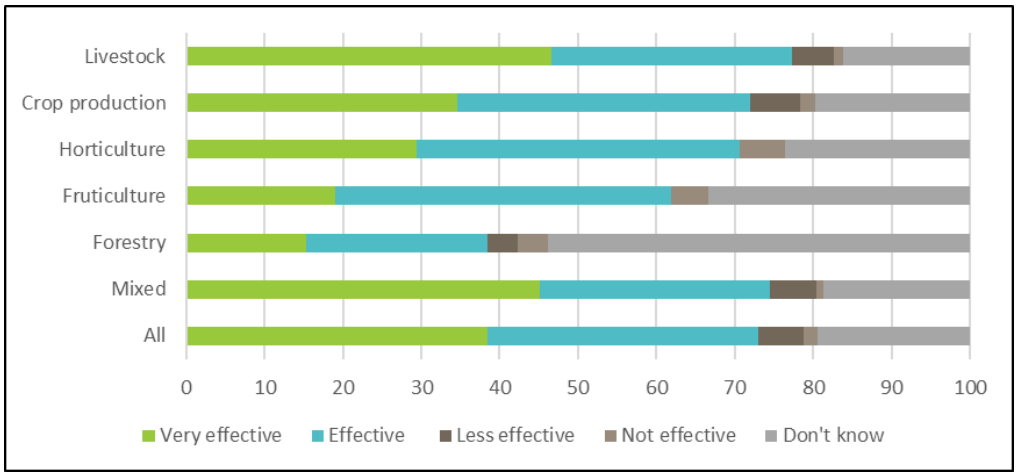


Figure 58: Danish farmer answers to the question "In your opinion, how effective are grass in rotation for enhancing and conserving SOC compared to current levels?" crossed with farm type.

COVER CROPS

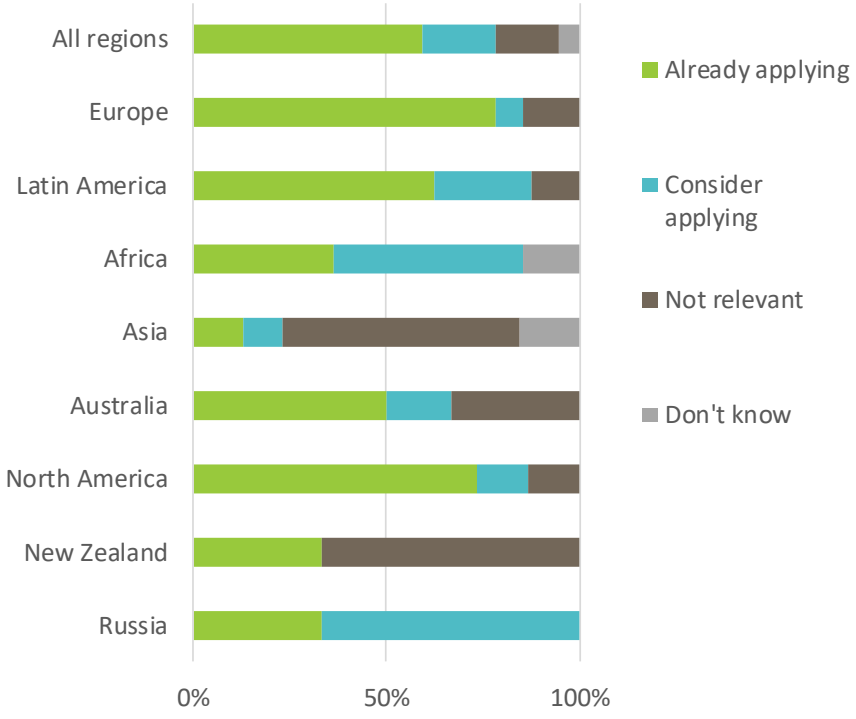


Figure 59: Farmer answers to the question "Which management options do you apply or consider applying? – Cover crops" crossed with region with responses from farmers from all regions.

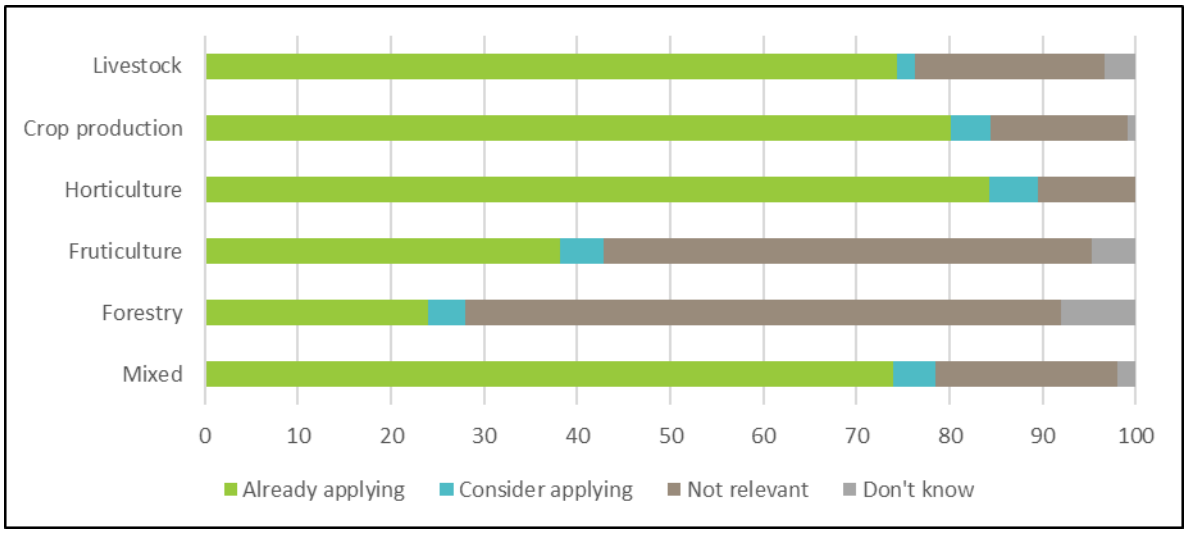


Figure 60: Farmers answers to the question "Which management options do you apply or consider applying? – Cover crops" crossed with farming system with responses from Danish farmers.

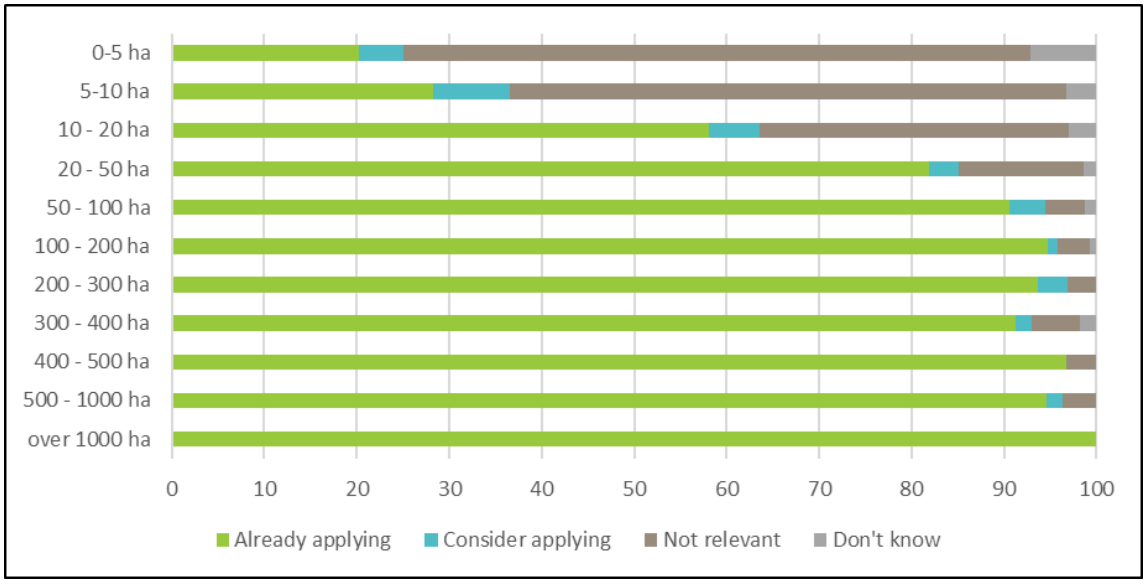


Figure 61: Farmer answers to the question "Which management options do you apply or consider applying? - Cover crops e" crossed with farm size with responses from Danish farmers.

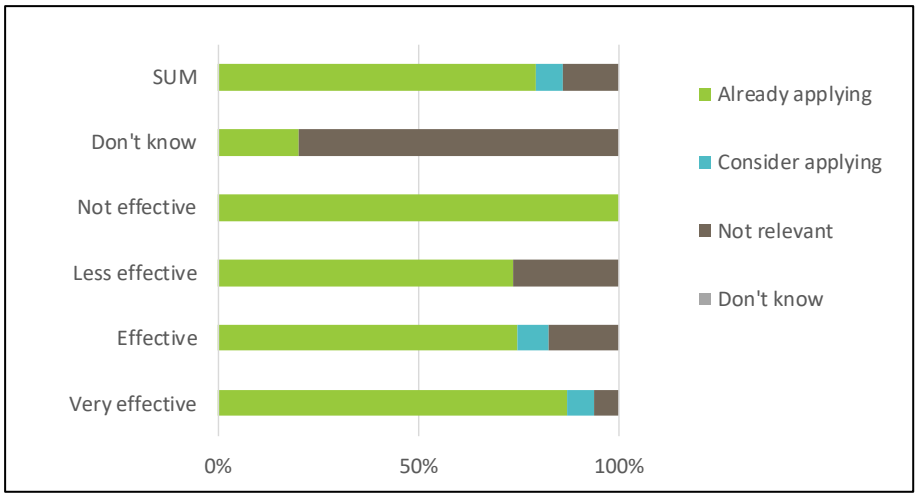


Figure 62: European farmer answers to the question "In your opinion, how effective are cover crops for enhancing and conserving SOC compared to current levels?" crossed with if they apply cover crops.

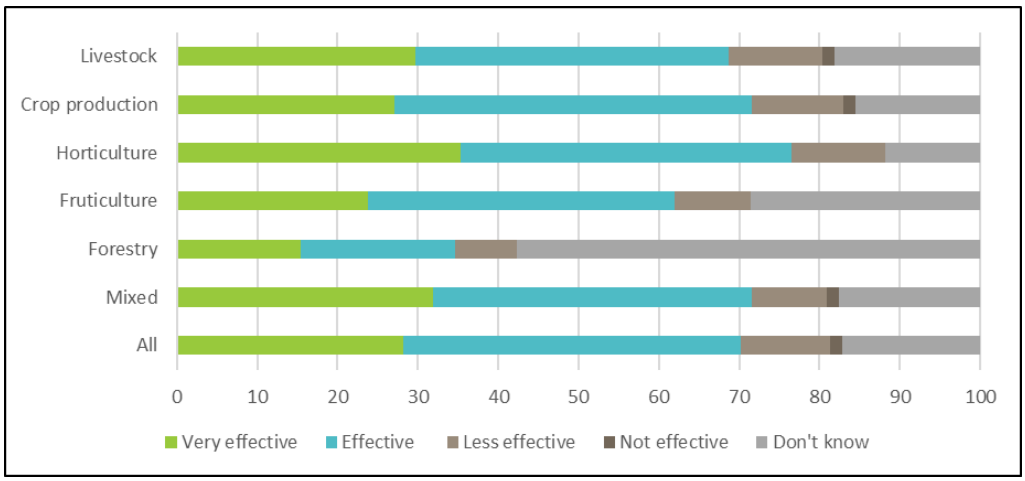


Figure 63: Danish farmer answers to the question "In your opinion, how effective are cover crops for enhancing and conserving SOC compared to current levels?" crossed with farm type.

GRAIN LEGUMES

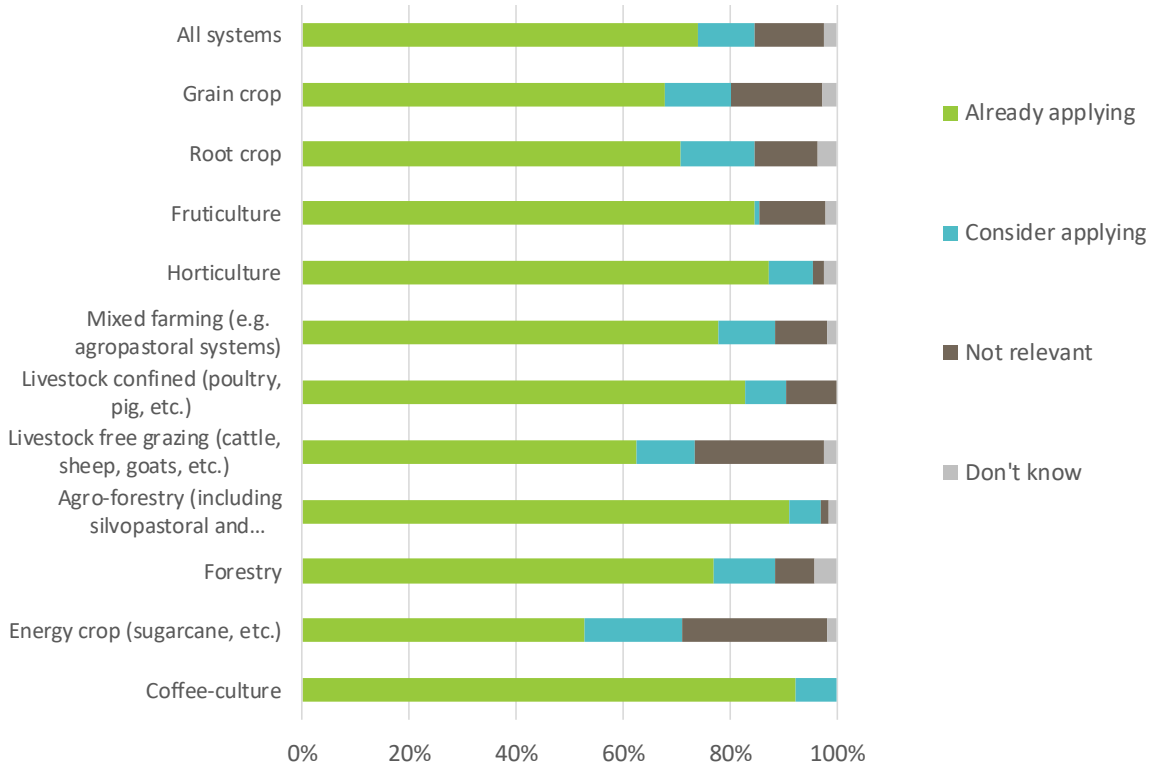


Figure 64: Farmer answers to the question "Which management options do you apply or consider applying? – Grain legumes" crossed with farming system with responses from farmers from all regions.

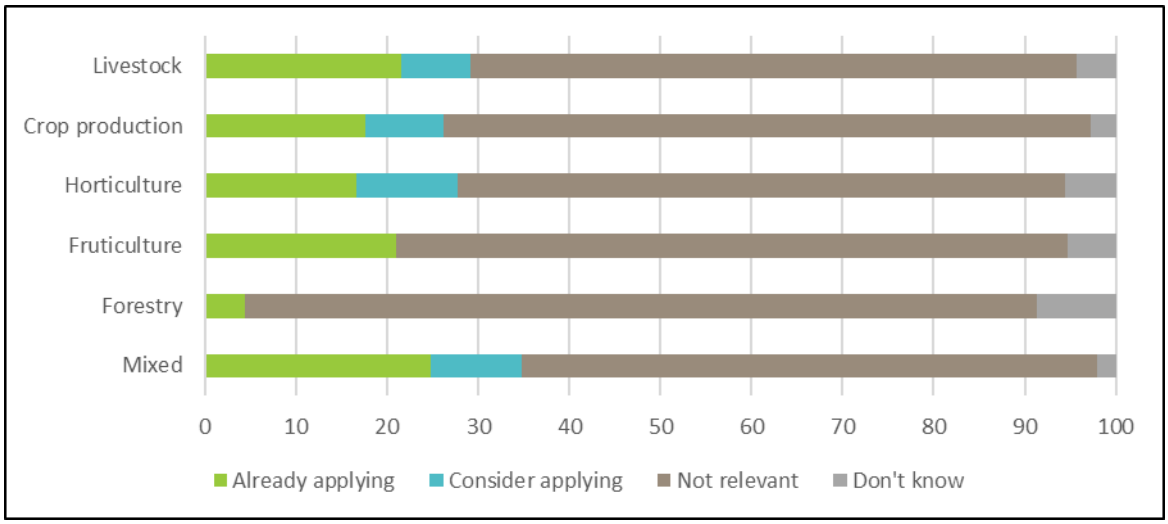


Figure 65: Farmers answers to the question "Which management options do you apply or consider applying? – Grain legumes" crossed with farming system with responses from Danish farmers.

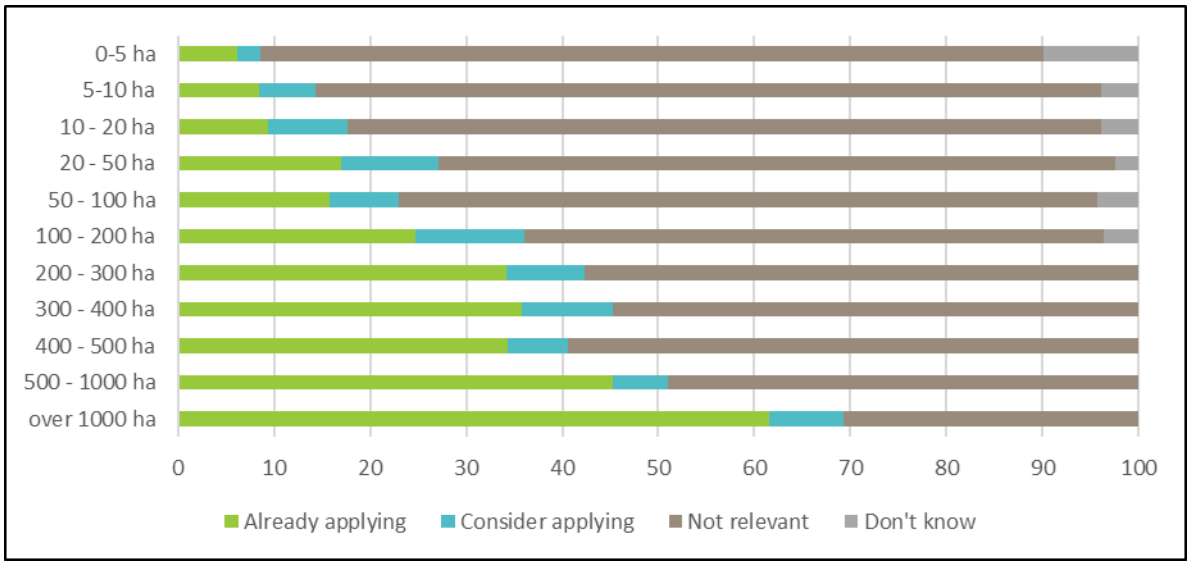


Figure 66: Farmer answers to the question "Which management options do you apply or consider applying? - Grain legumes" crossed with farm size with responses from Danish farmers.

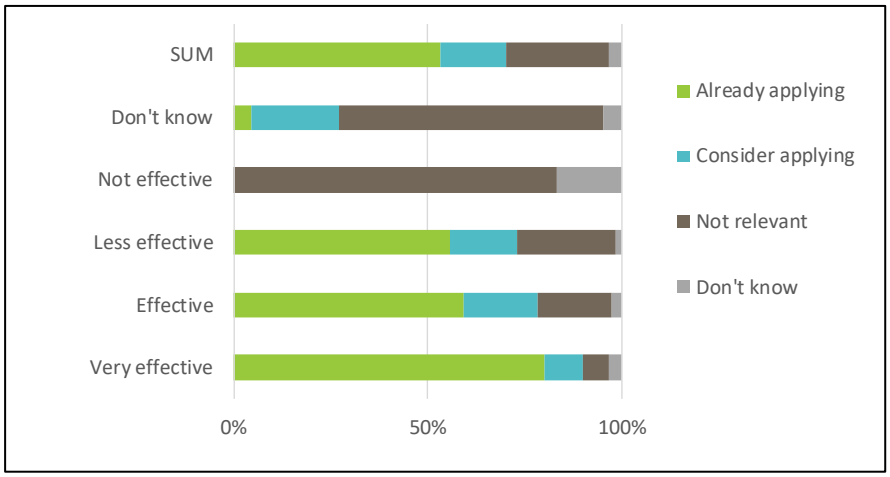


Figure 67: European farmer answers to the question "In your opinion, how effective are grain legumes for enhancing and conserving SOC compared to current levels?" crossed with if they apply grain legumes.

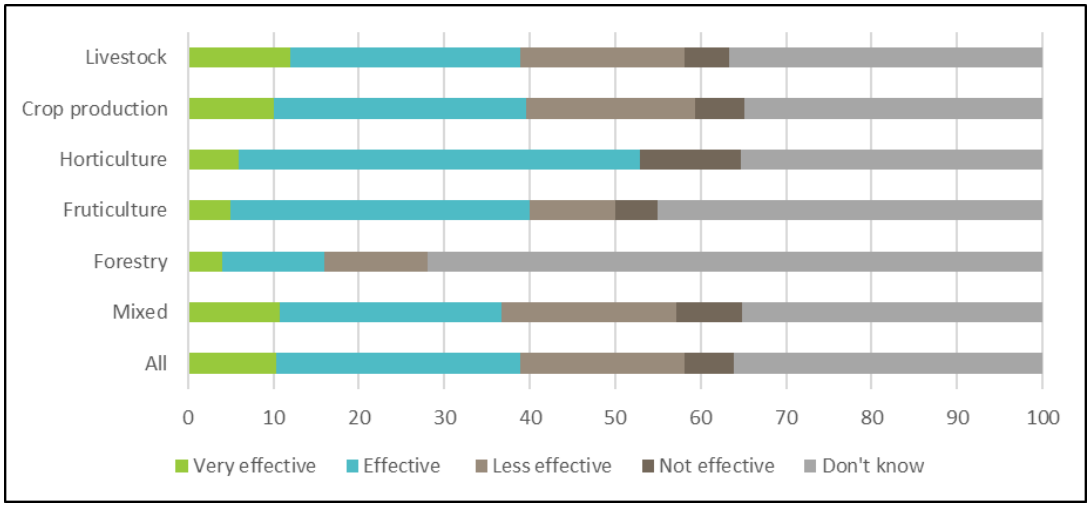


Figure 68: Danish farmer answers to the question "In your opinion, how effective are grain legumes for enhancing and conserving SOC compared to current levels?" crossed with farm type.

FORAGE LEGUMES

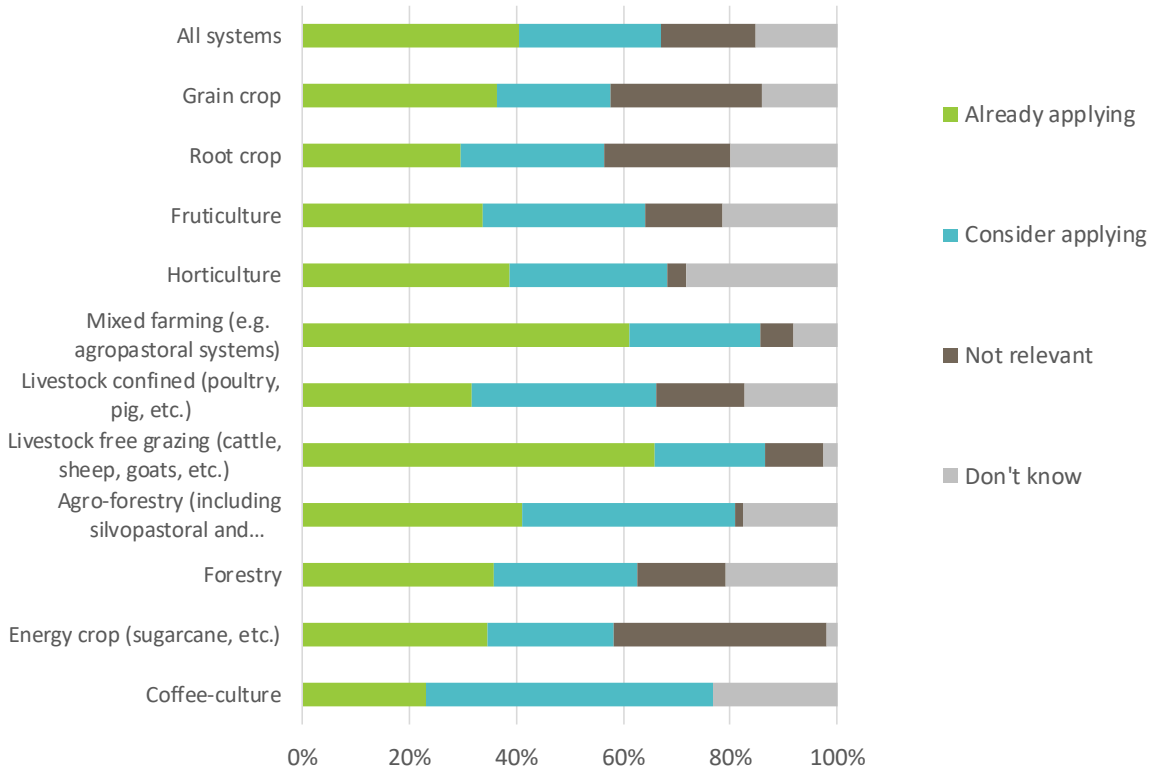


Figure 69: Farmer answers to the question "Which management options do you apply or consider applying? – Forage legumes" crossed with farming system with responses from farmers from all regions.

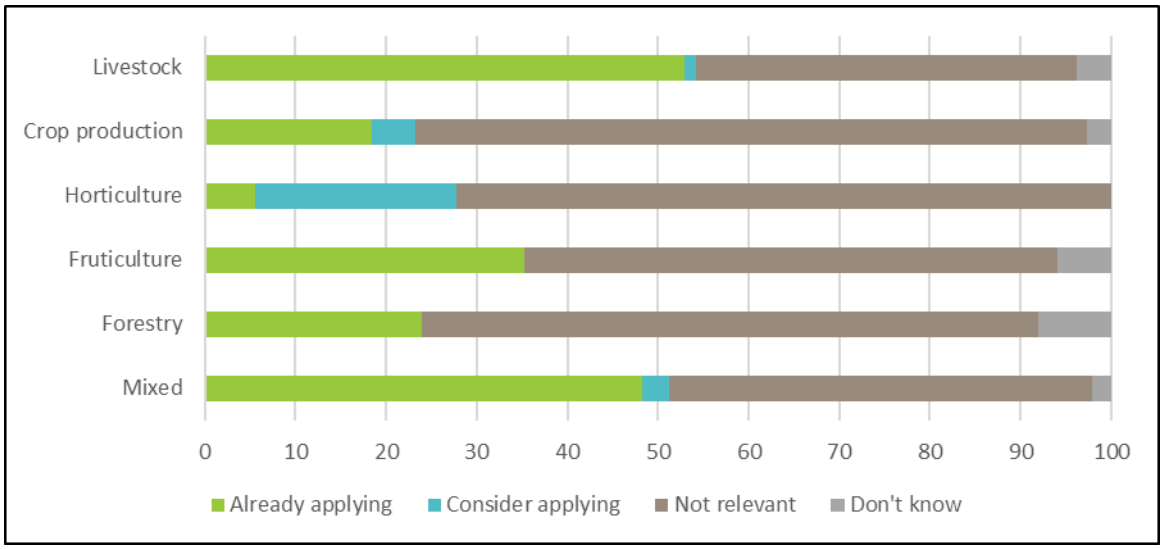


Figure 70:Farmers answers to the question "Which management options do you apply or consider applying? – Forage legumes" crossed with farming system with responses from Danish farmers.

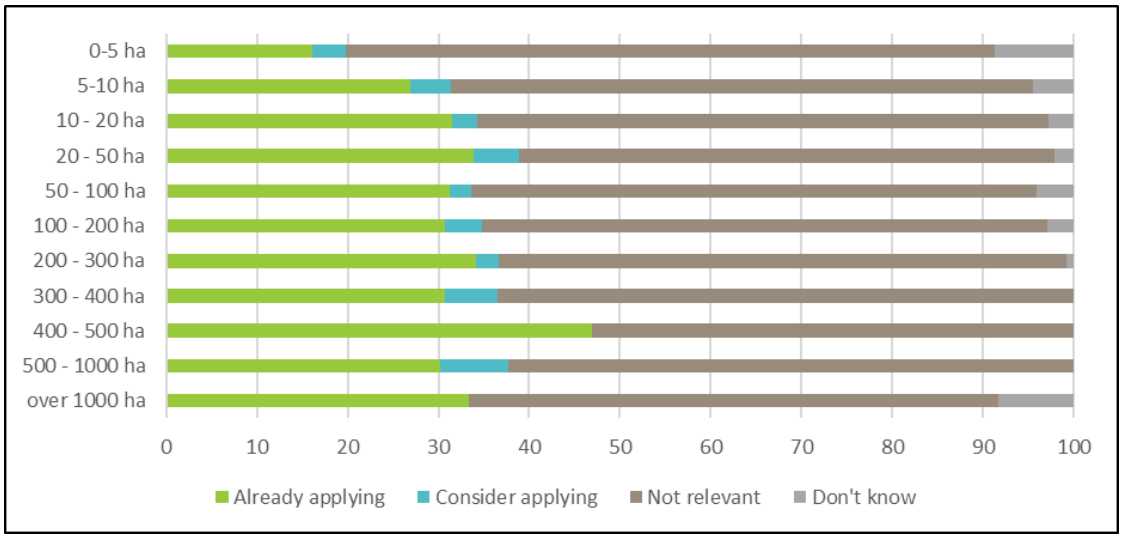


Figure 71: Farmer answers to the question "Which management options do you apply or consider applying? - Forage legumes" crossed with farm size with responses from Danish farmers.

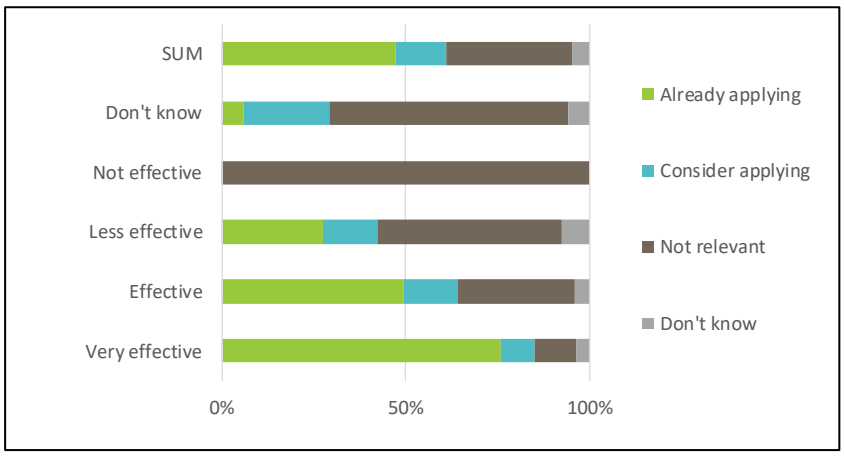


Figure 72: European farmer answers to the question "In your opinion, how effective are forage legumes for enhancing and conserving SOC compared to current levels?" crossed with if they apply forage legumes

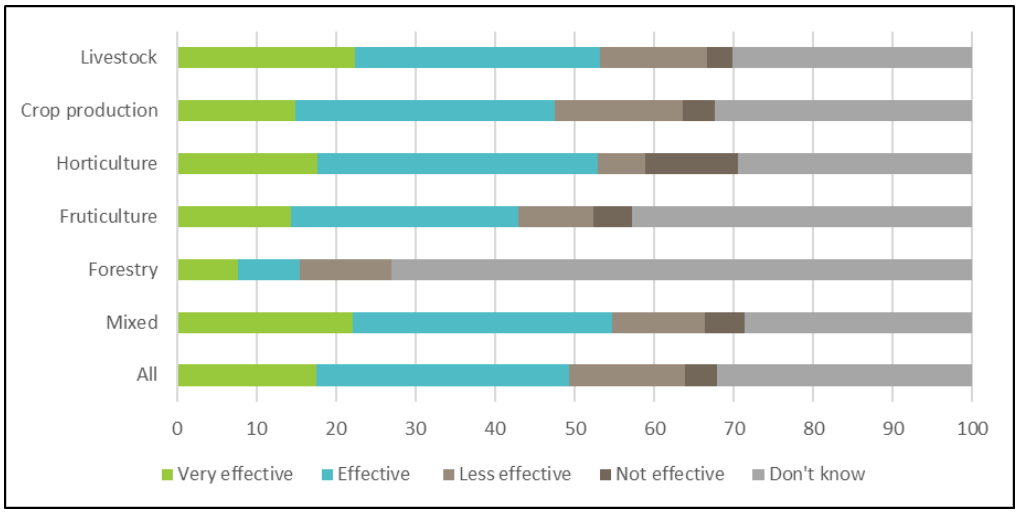


Figure 73: Danish farmer answers to the question "In your opinion, how effective are forage legumes for enhancing and conserving SOC compared to current levels?" crossed with farm type.

PERMANENT GRASSLAND MANAGEMENT

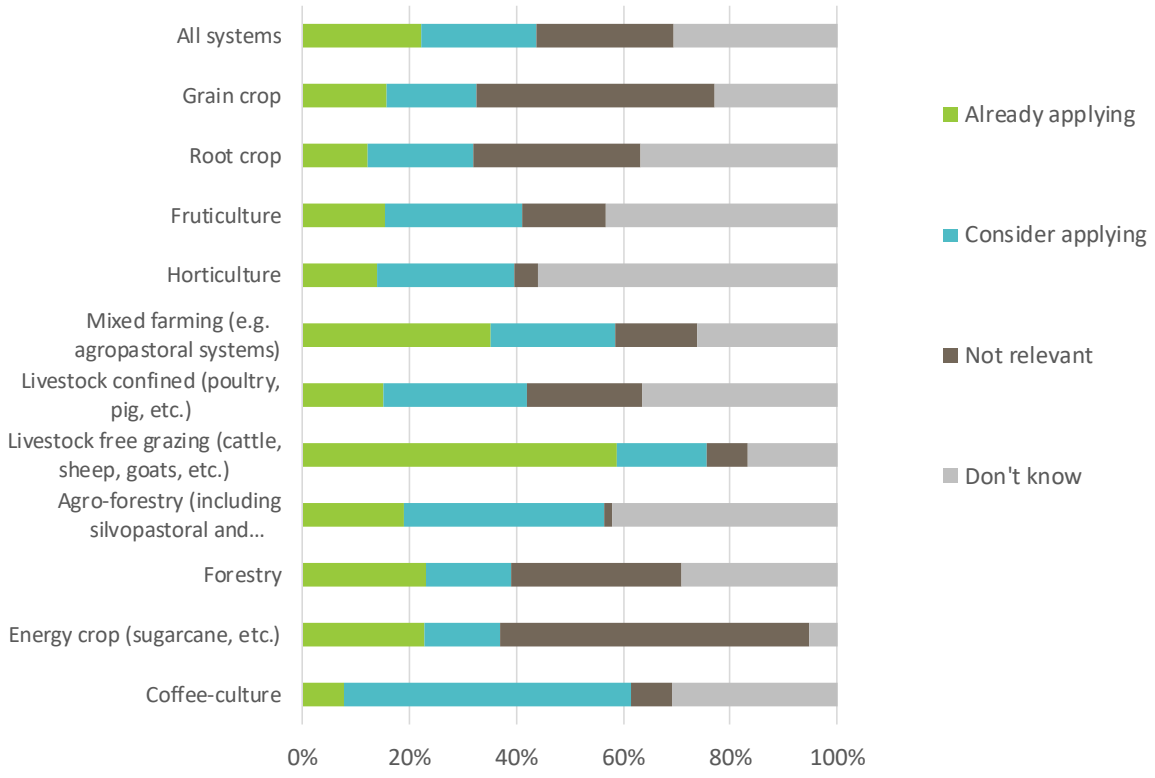


Figure 74:Farmer answers to the question "Which management options do you apply or consider applying? – Permanent grassland management" crossed with farming system with responses from farmers from all regions.

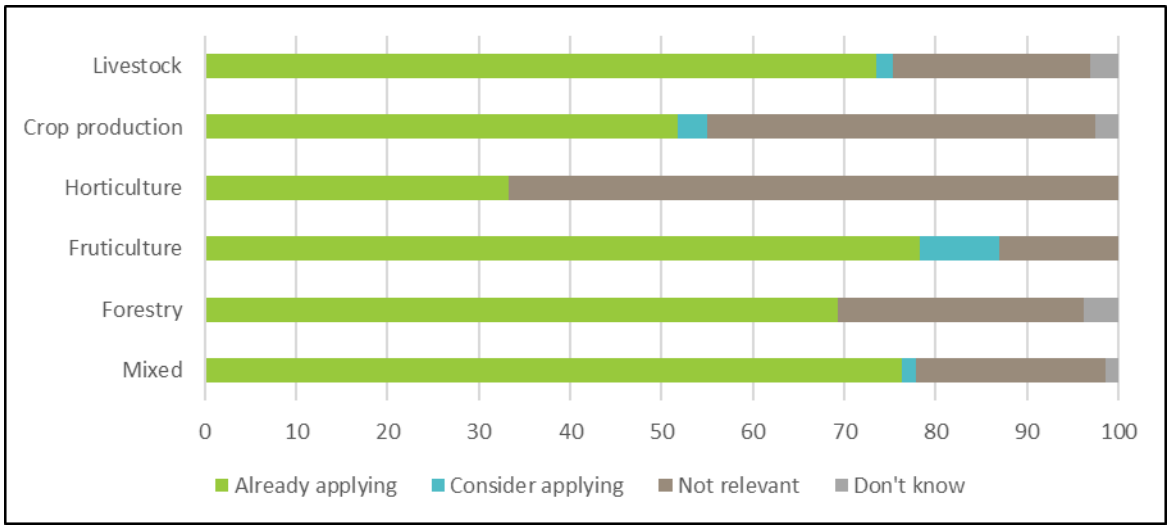


Figure 75: Farmers answers to the question "Which management options do you apply or consider applying? – Permanent grassland management" crossed with farming system with responses from Danish farmers.

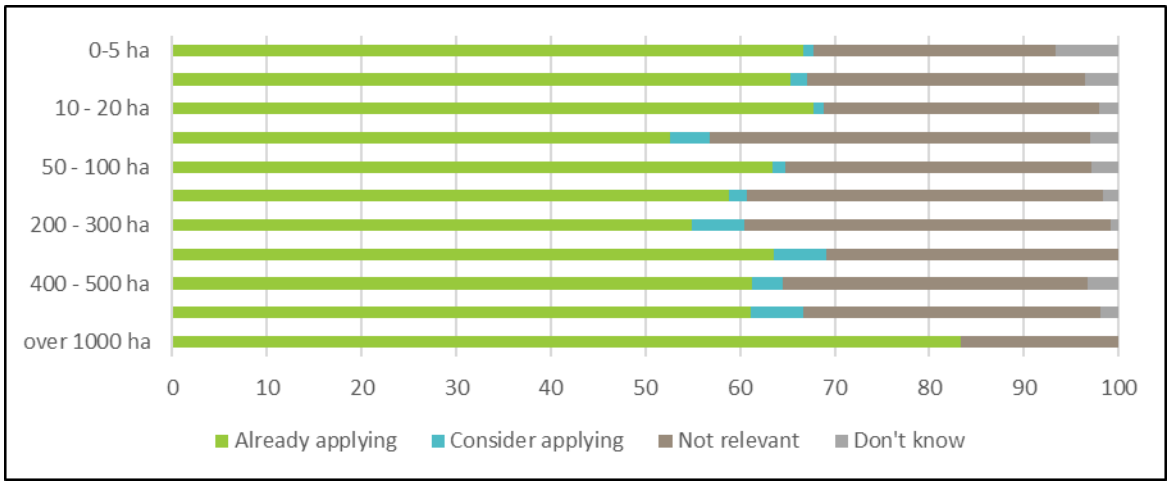


Figure 76: Farmer answers to the question "Which management options do you apply or consider applying? - Permanent grassland management" crossed with farm size with responses from Danish farmers.

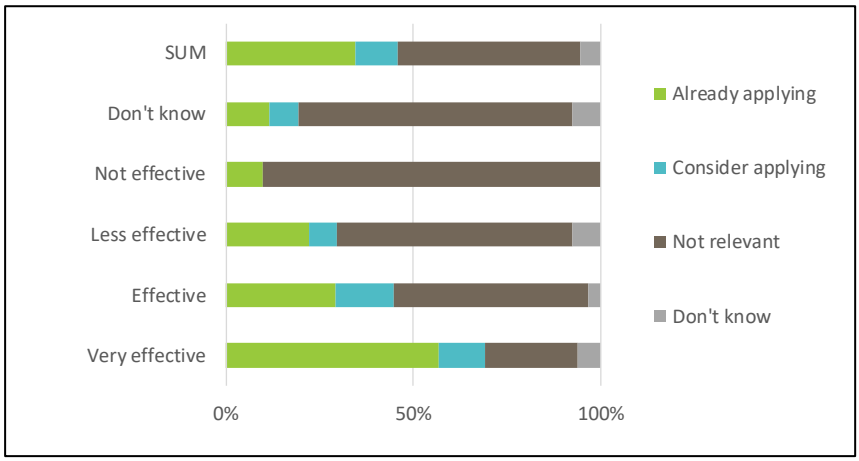


Figure 77: European farmer answers to the question "In your opinion, how effective are permanent grassland management for enhancing and conserving SOC compared to current levels?" crossed with if they apply permanent grassland management

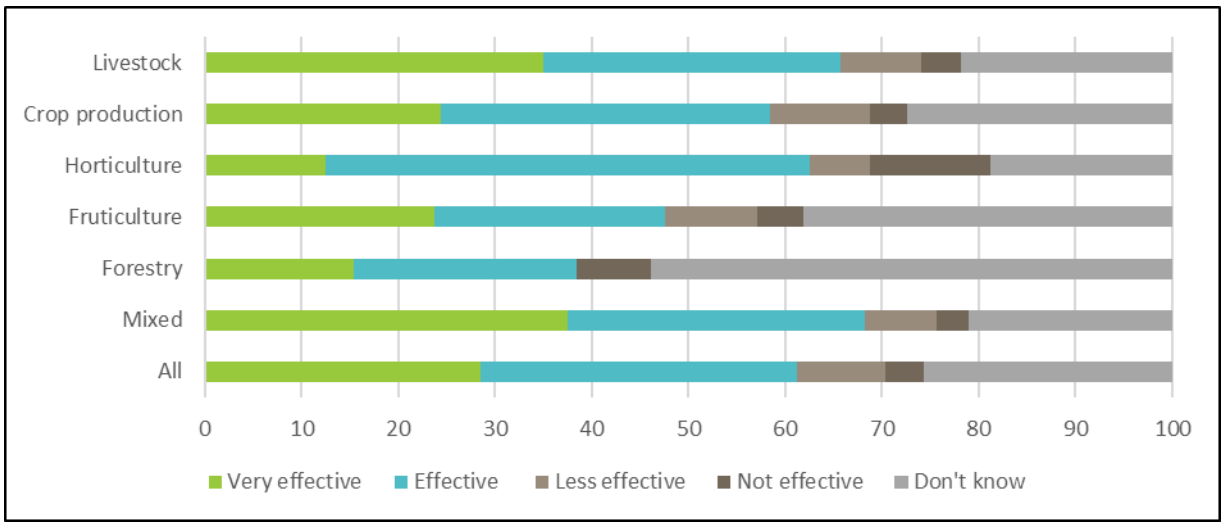
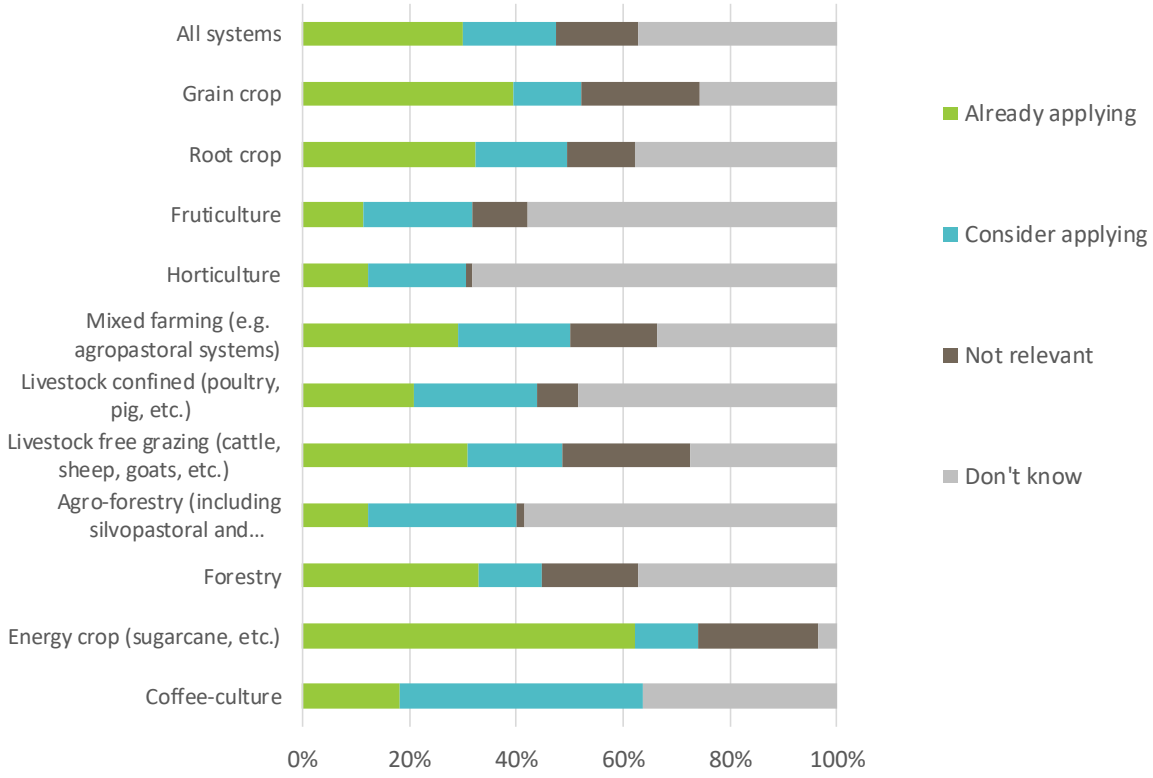


Figure 78: Danish farmer answers to the question "In your opinion, how effective are permanent grassland management for enhancing and conserving SOC compared to current levels?" crossed with farm type.

BUFFER STRIPS AND SET-ASIDE



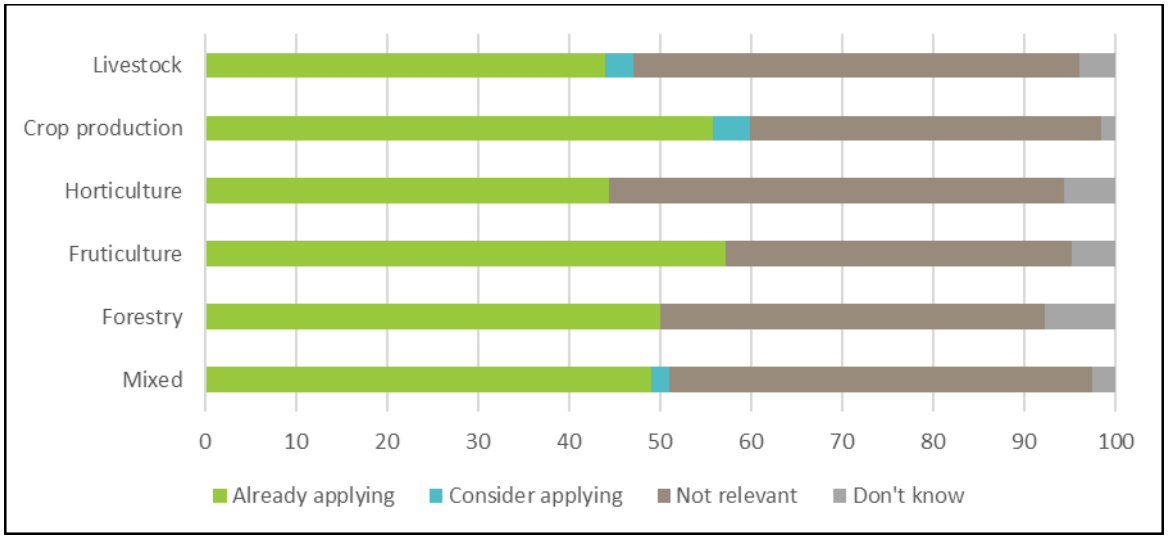


Figure 79: Farmers answers to the question "Which management options do you apply or consider applying? – Buffer strips and set-aside" crossed with farming system with responses from Danish farmers.

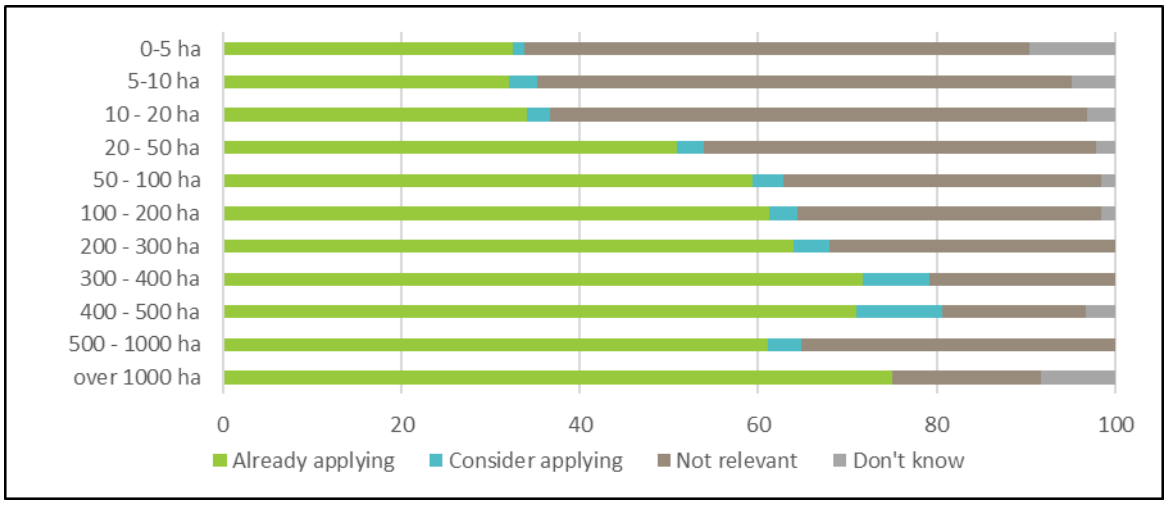


Figure 80: Farmer answers to the question "Which management options do you apply or consider applying? - Buffer strips and set-aside" crossed with farm size with responses from Danish farmers.

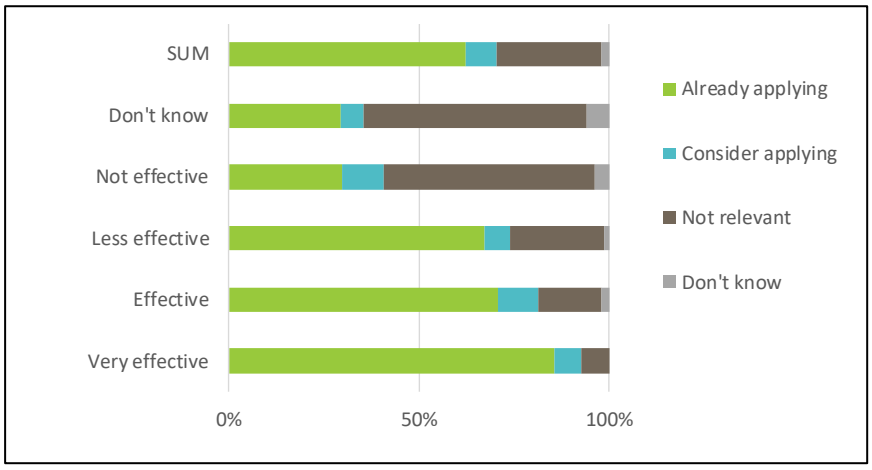


Figure 81: European farmer answers to the question "In your opinion, how effective are buffer strips and set-aside for enhancing and conserving SOC compared to current levels?" crossed with if they apply buffer strips and set-aside.

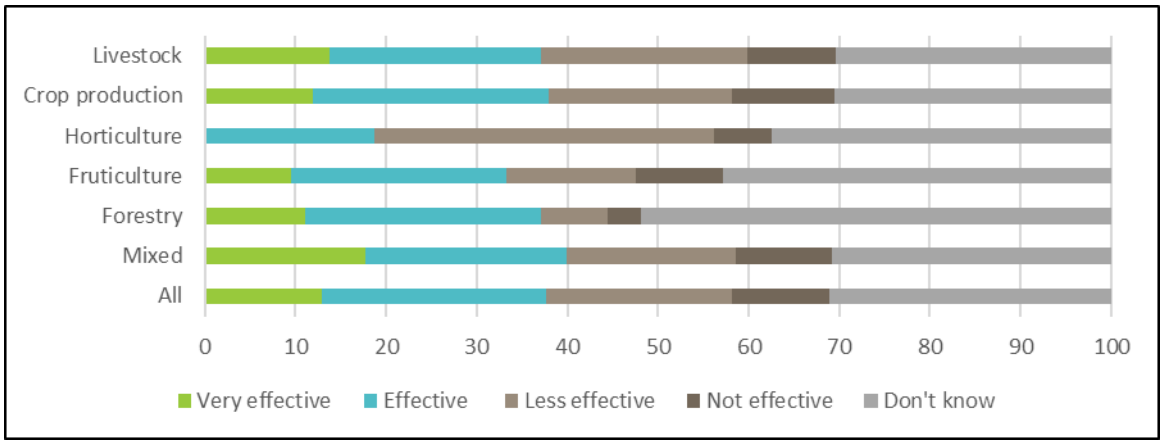


Figure 82: Danish farmer answers to the question "In your opinion, how effective are buffer strips and set-aside for enhancing and conserving SOC compared to current levels?" crossed with farm type.

CROP-LIVESTOCK SYSTEMS

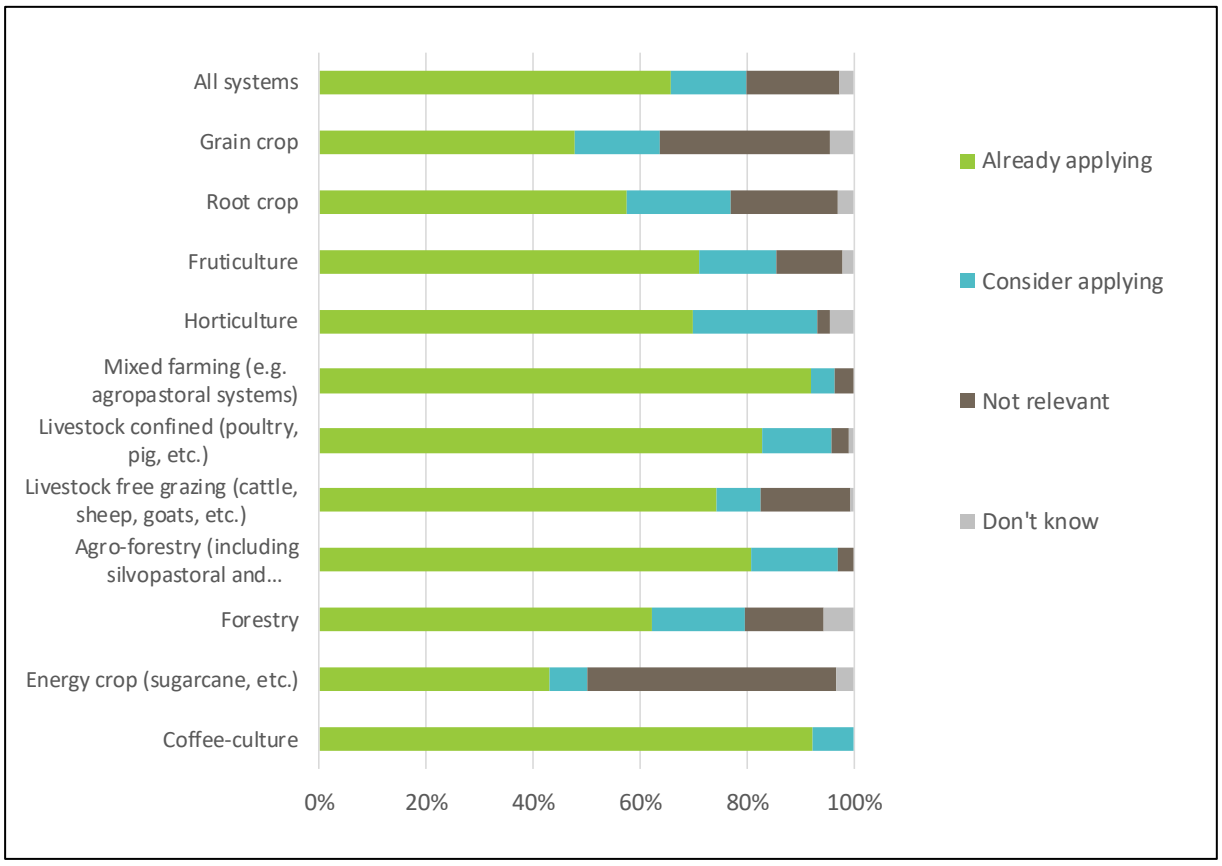


Figure 83: Farmer answers to the question "Which management options do you apply or consider applying? – Crop-livestock systems" crossed with farming system with responses from farmers from all regions.

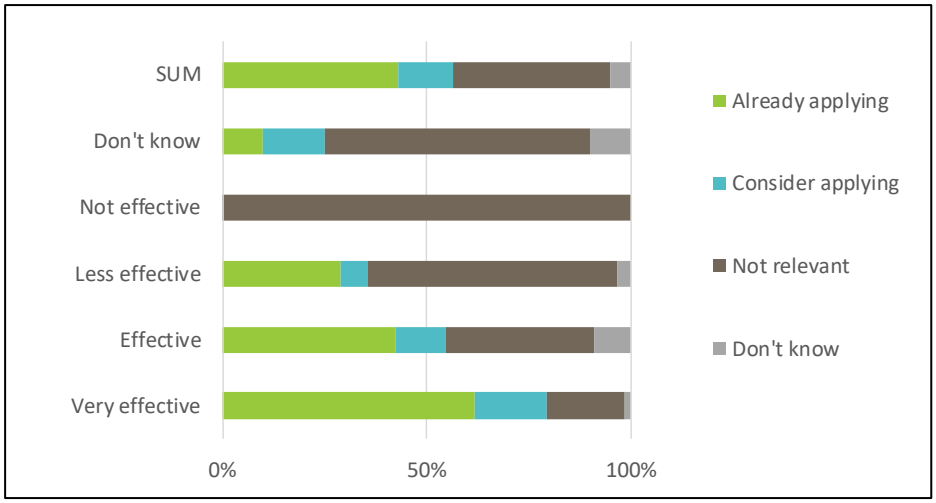


Figure 84: European farmer answers to the question "In your opinion, how effective are crop-livestock systems for enhancing and conserving SOC compared to current levels?" crossed with if they apply crop-livestock systems.

AGRO-FORESTRY IN CROPLAND

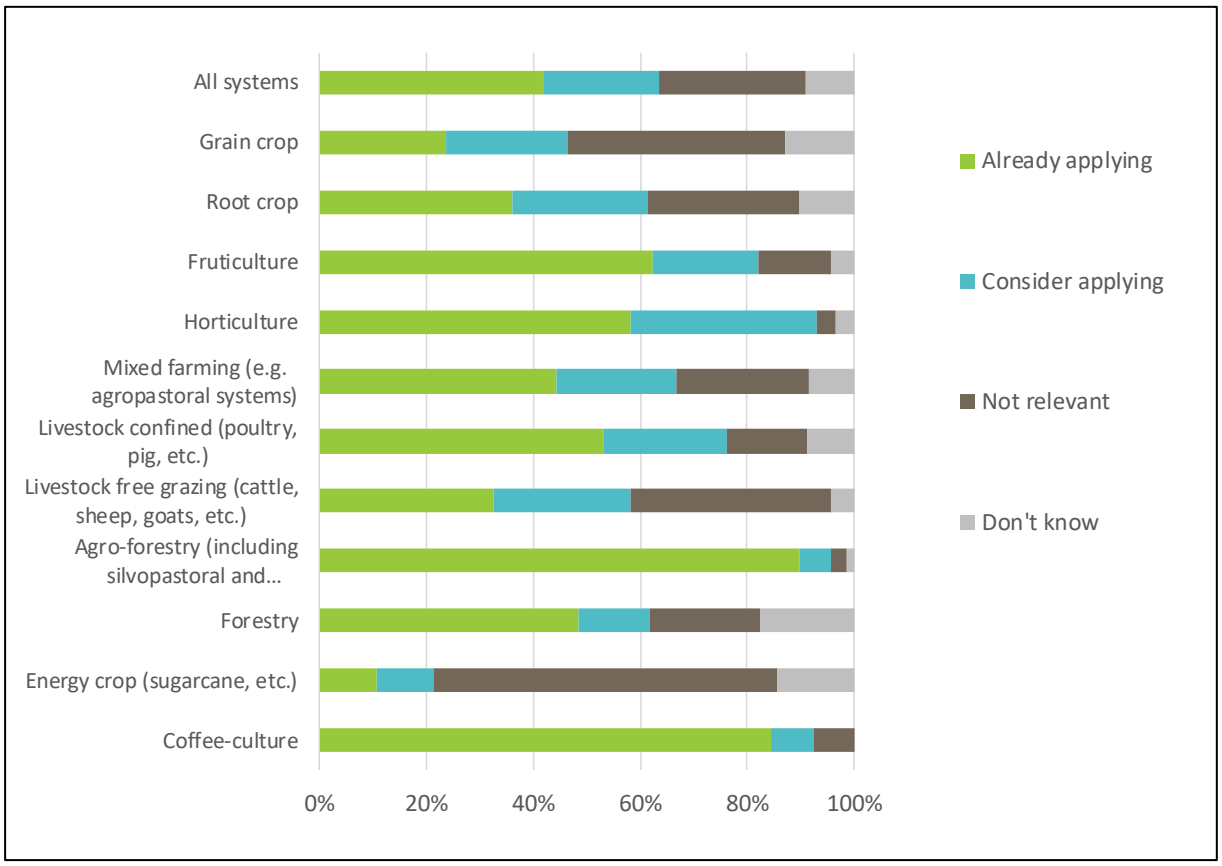


Figure 85: Farmer answers to the question "Which management options do you apply or consider applying? – Agro-forestry in cropland" crossed with farming system with responses from farmers from all regions.

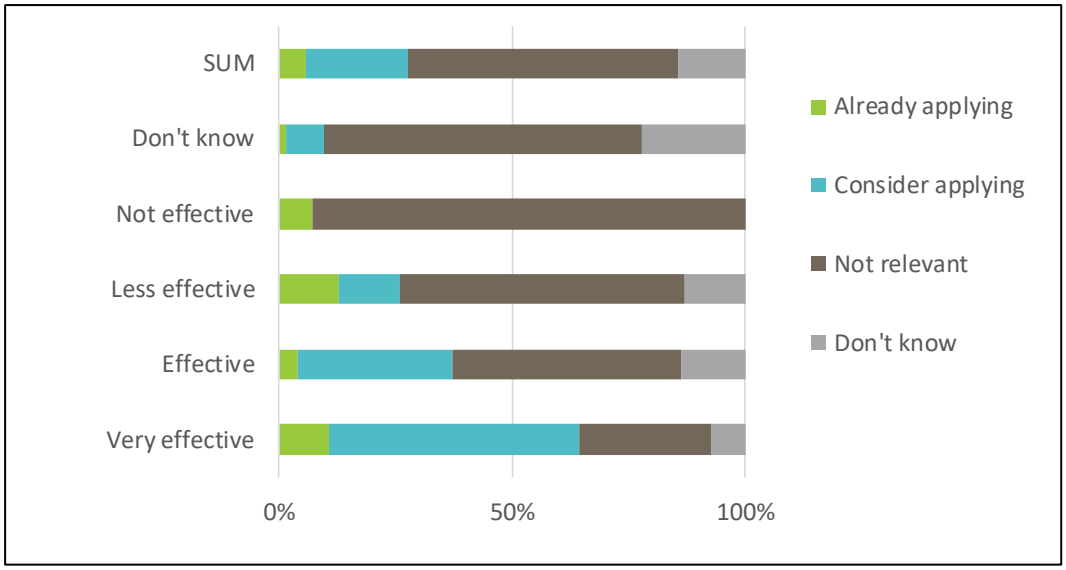


Figure 86: . European farmer answers to the question "In your opinion, how effective are agro-forestry in cropland for enhancing and conserving SOC compared to current levels?" crossed with if they apply agro-forestry in cropland.

AGRO-FORESTRY IN GRAZING LANDS

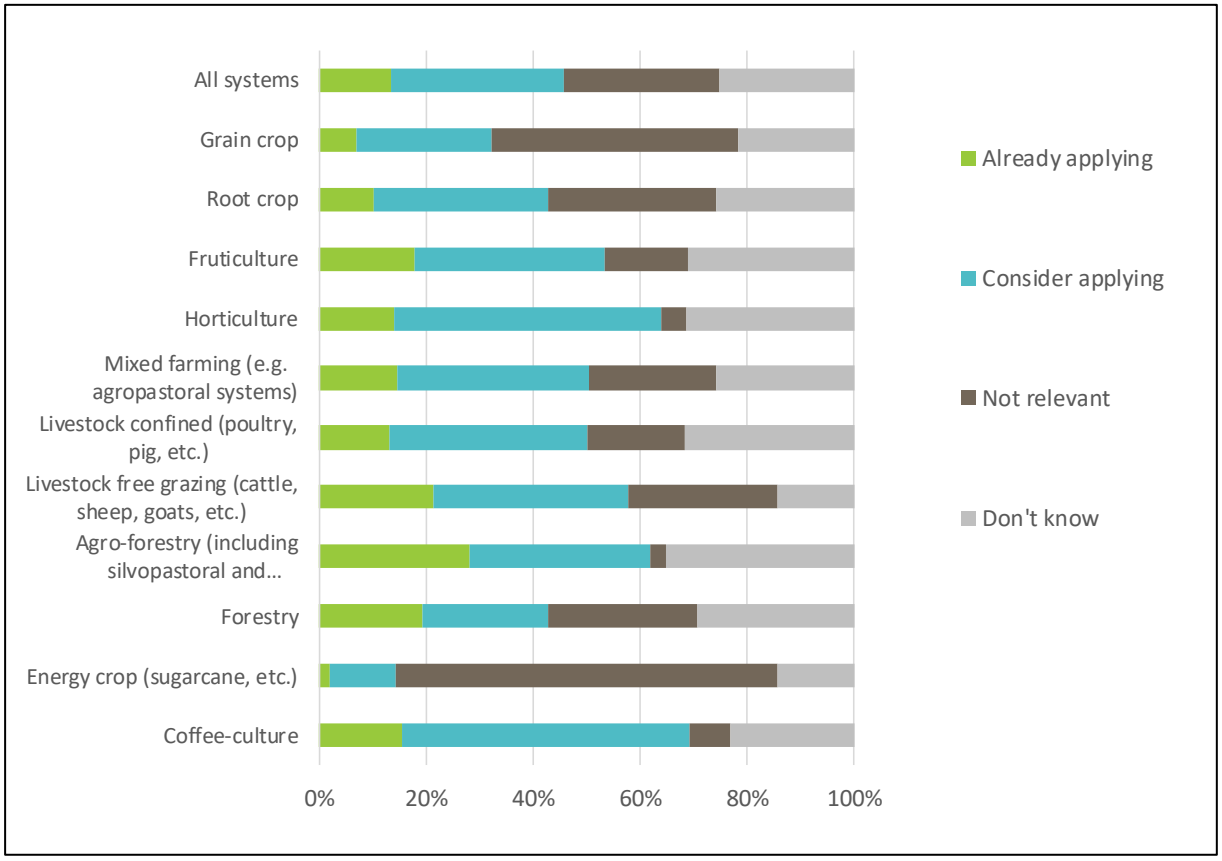


Figure 87: Farmer answers to the question "Which management options do you apply or consider applying? – Agro-forestry in grazing lands" crossed with farming system with responses from farmers from all regions.

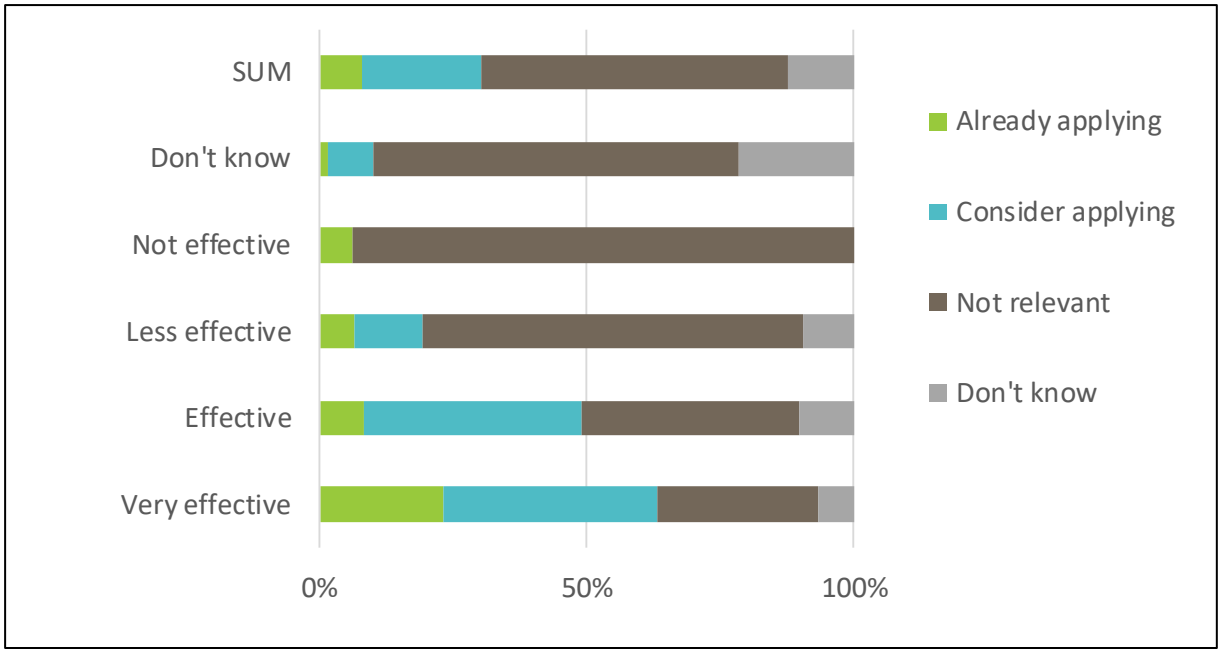


Figure 88: European farmer answers to the question "In your opinion, how effective are agro-forestry in grazing lands for enhancing and conserving SOC compared to current levels?" crossed with if they apply agro-forestry in grazing lands.

AGRO-FORESTRY IN MIXED CROP-LIVESTOCK SYSTEMS

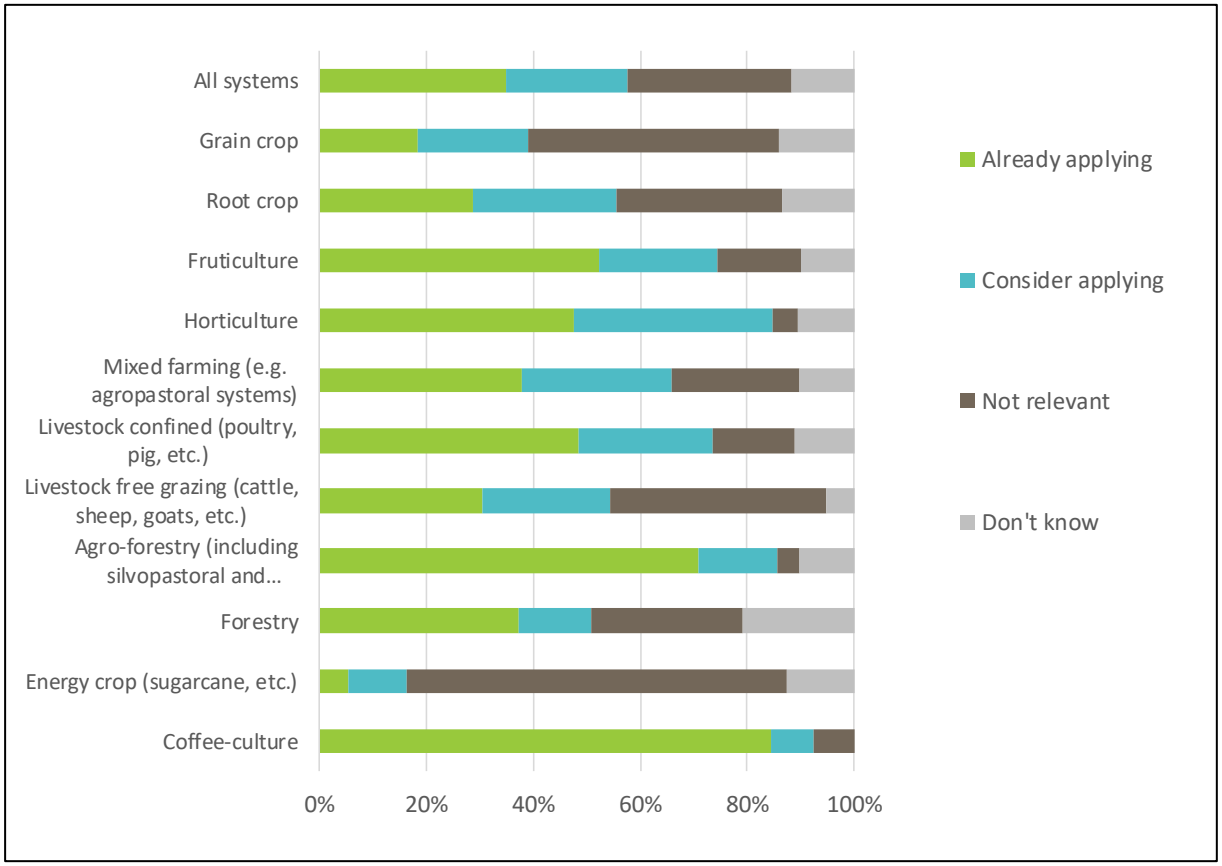


Figure 89: Farmer answers to the question "Which management options do you apply or consider applying? – Agro-forestry in mixed crop-livestock systems" crossed with farming system with responses from farmers from all regions.

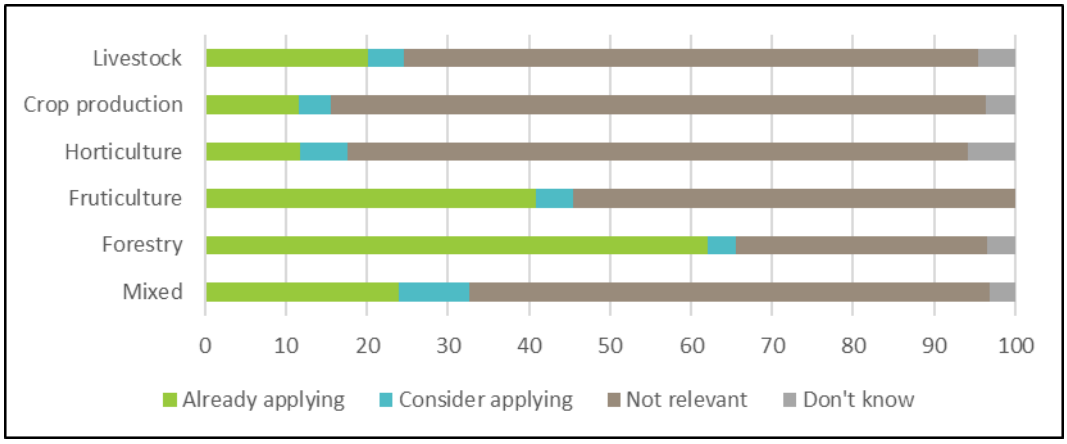


Figure 90: Farmers answers to the question "Which management options do you apply or consider applying? – Agro-forestry" crossed with farming system with responses from Danish farmers.

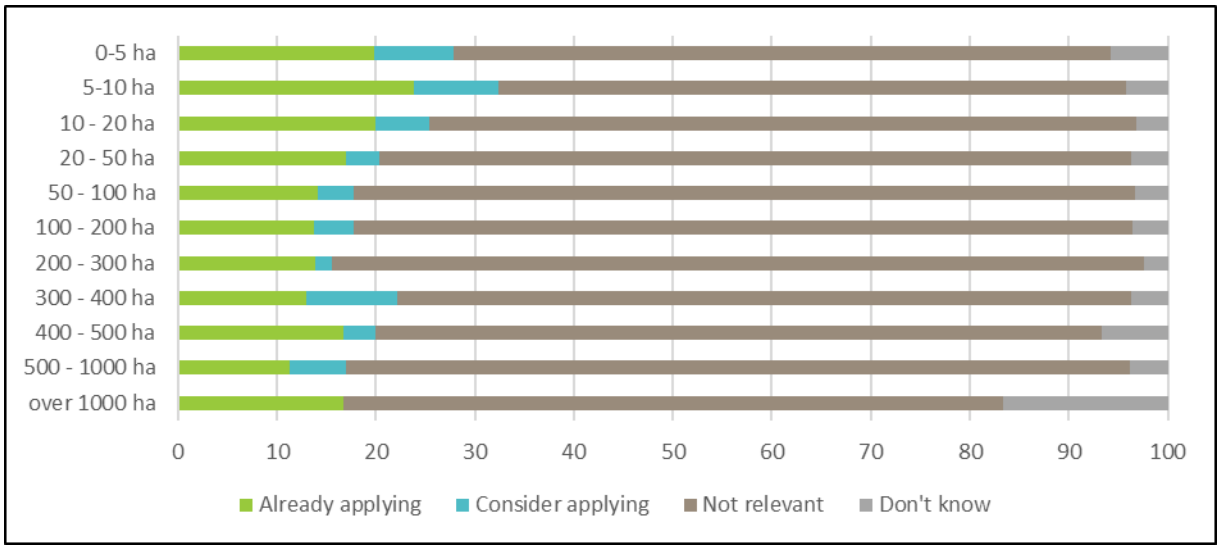


Figure 91: Farmer answers to the question "Which management options do you apply or consider applying? – Agro-forestry" crossed with farm size with responses from Danish farmers.

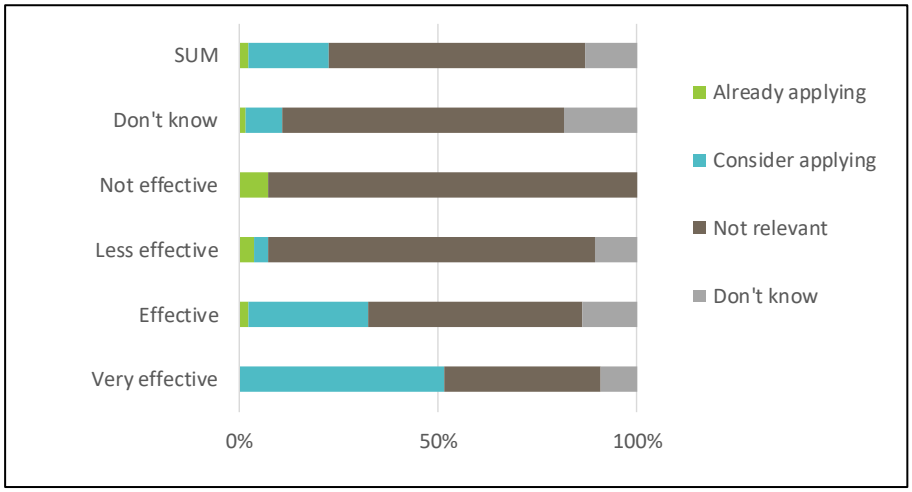


Figure 92: European farmer answers to the question "In your opinion, how effective are agro-forestry in mixed crop-livestock systems e for enhancing and conserving SOC compared to current levels?" crossed with if they apply agro-forestry in mixed crop-livestock s

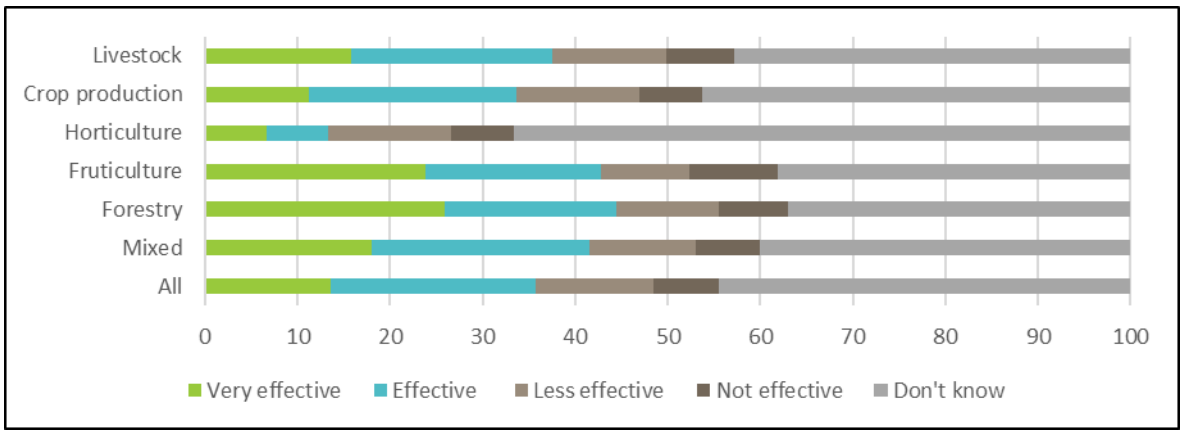


Figure 93: Danish farmer answers to the question "In your opinion, how effective are agro-forestry for enhancing and conserving SOC compared to current levels?" crossed with farm type.

BIOCHAR

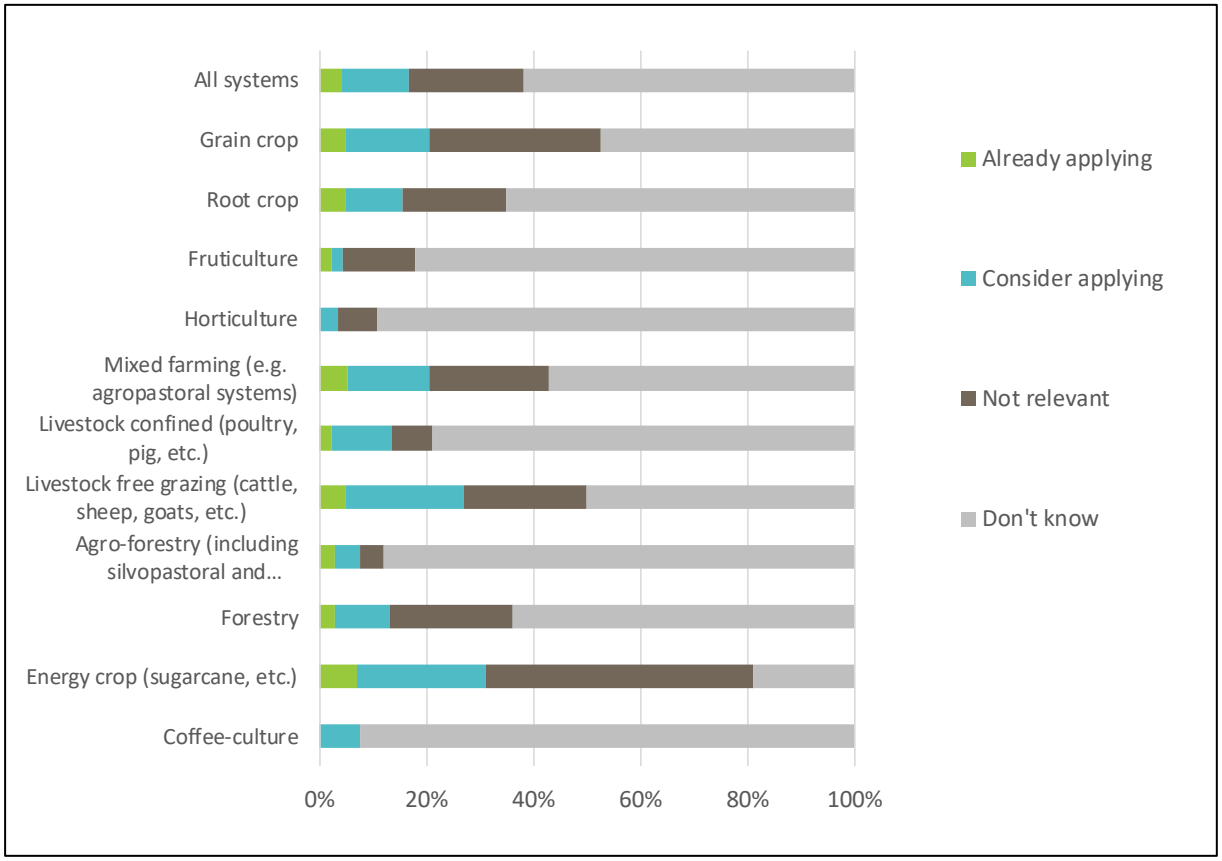


Figure 94: Farmer answers to the question "Which management options do you apply or consider applying? – Biochar" crossed with farming system with responses from farmers from all regions.

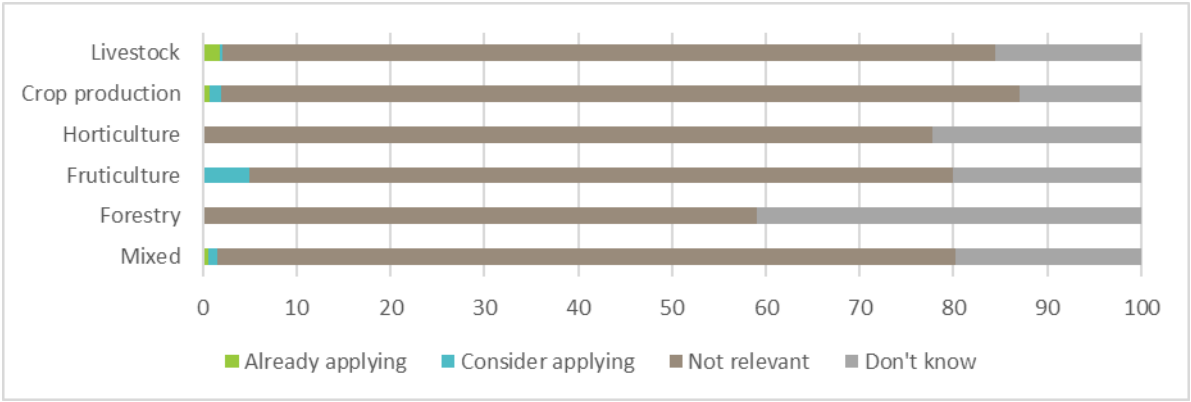


Figure 95: Farmers answers to the question "Which management options do you apply or consider applying? – Biochar" crossed with farming system with responses from Danish farmers.

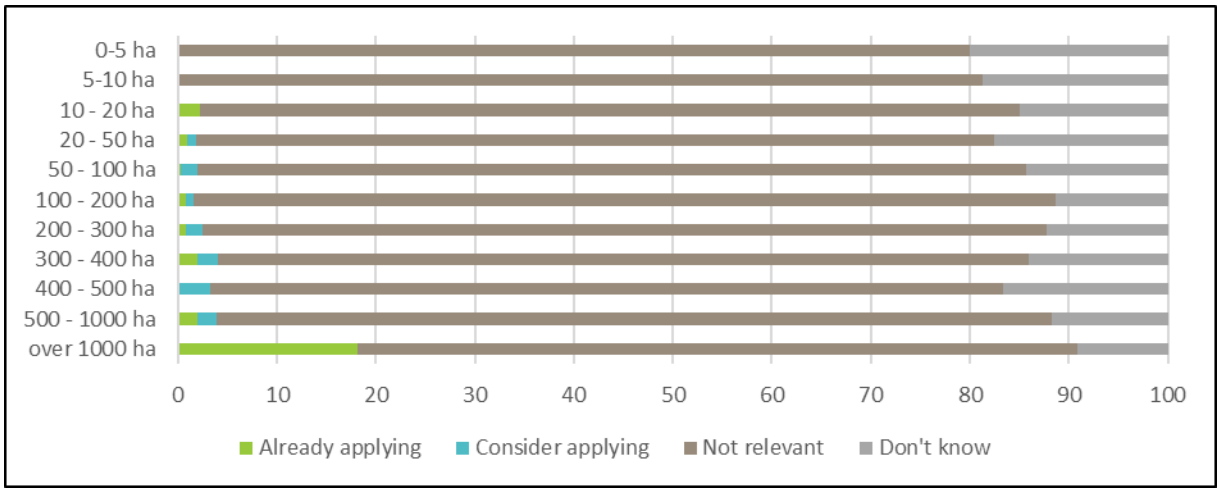


Figure 96: Farmer answers to the question "Which management options do you apply or consider applying? - Biochar" crossed with farm size with responses from Danish farmers.

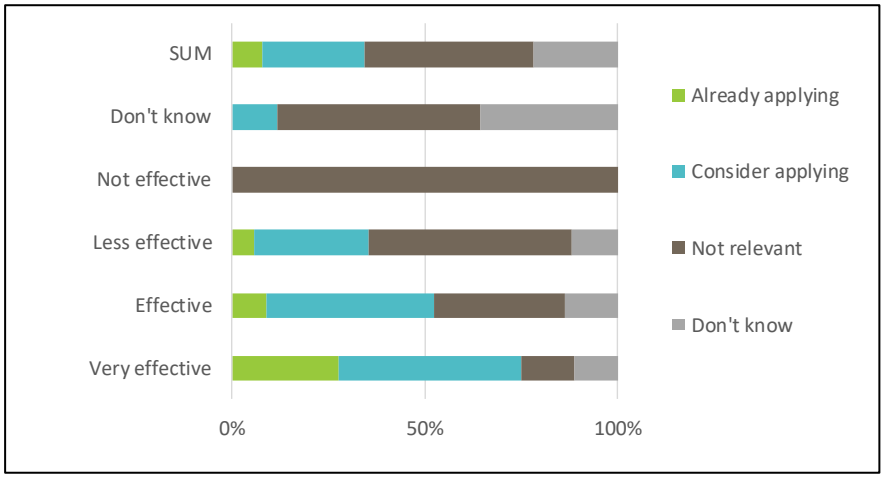


Figure 97: European farmer answers to the question "In your opinion, how effective are biochar for enhancing and conserving SOC compared to current levels?" crossed with if they apply biochar.

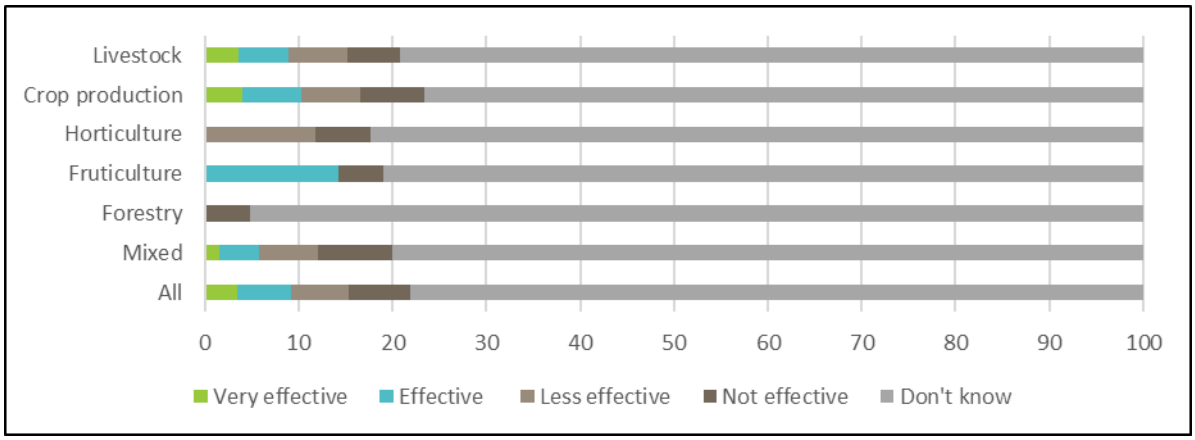


Figure 98: . Danish farmer answers to the question "In your opinion, how effective are biochar for enhancing and conserving SOC compared to current levels?" crossed with farm type.

REWETTING OF ORGANIC SOILS

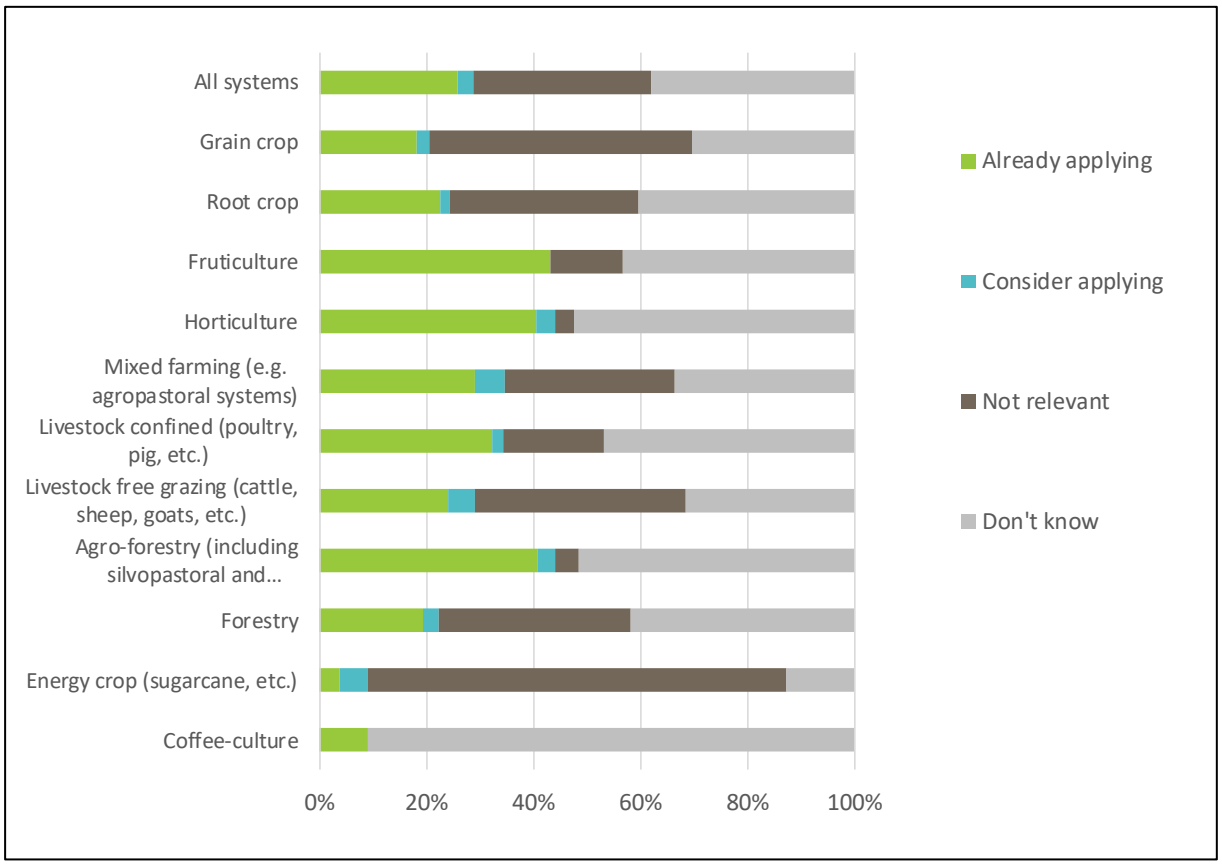


Figure 99: Farmer answers to the question "Which management options do you apply or consider applying? – Rewetting of organic soils" crossed with farming system with responses from farmers from all regions.

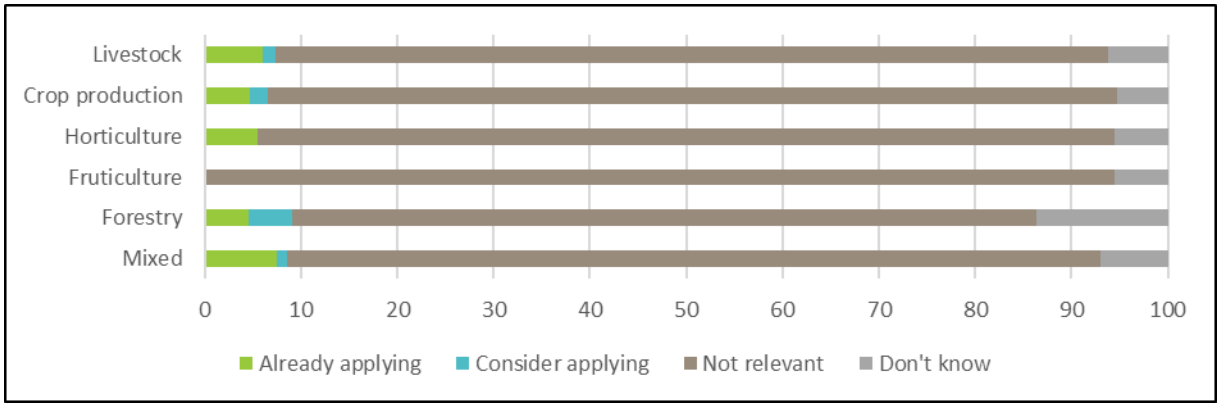


Figure 100: Farmers answers to the question "Which management options do you apply or consider applying? – Rewetting of organic soils" crossed with farming system with responses from Danish farmers.

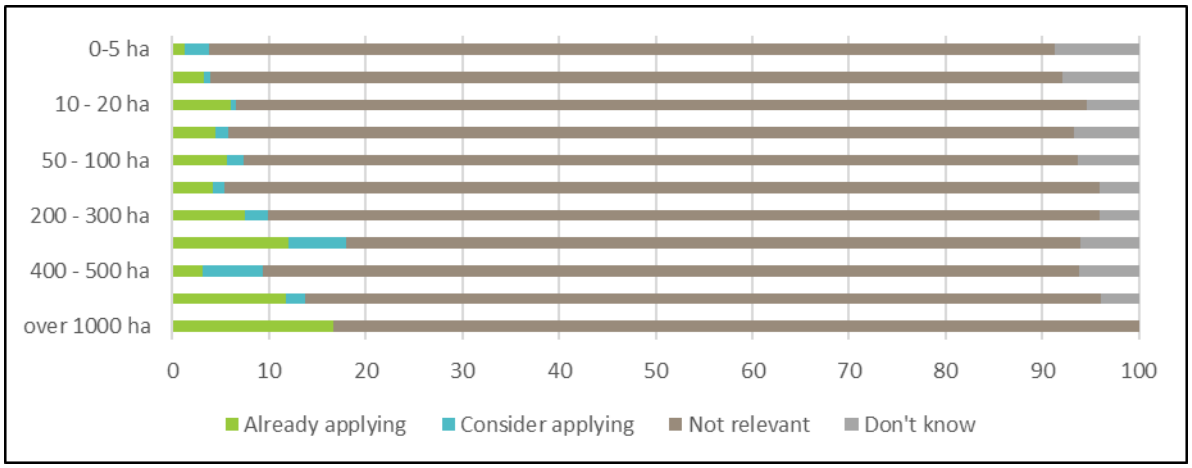


Figure 101: Farmer answers to the question "Which management options do you apply or consider applying? – Rewetting of organic soils" crossed with farm size with responses from Danish farmers.

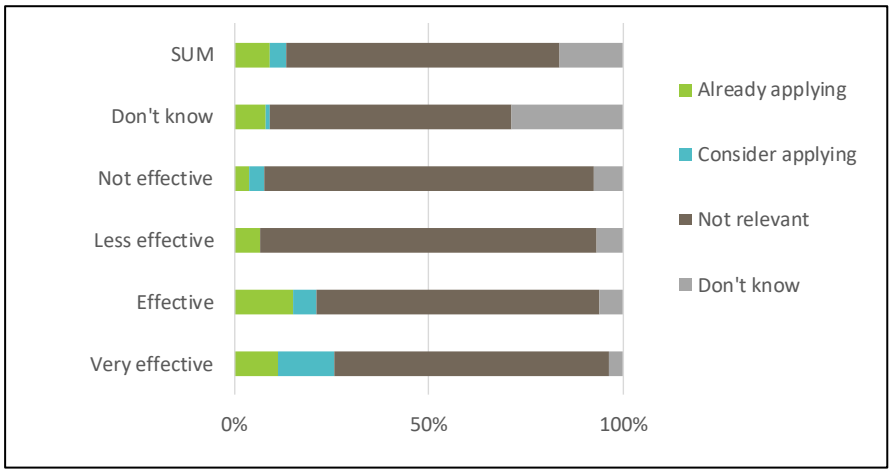


Figure 102: European farmer answers to the question "In your opinion, how effective are rewetting of organic soils for enhancing and conserving SOC compared to current levels?" crossed with if they apply rewetting of organic soils.

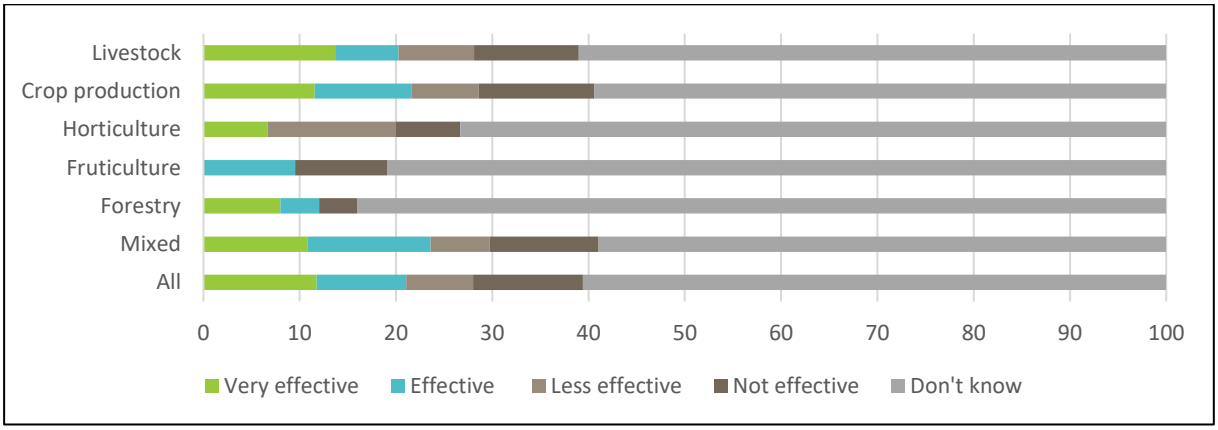


Figure 103: Danish farmer answers to the question "In your opinion, how effective are rewetting of organic soils for enhancing and conserving SOC compared to current levels?" crossed with farm type.

PREVENTING SOIL EROSION

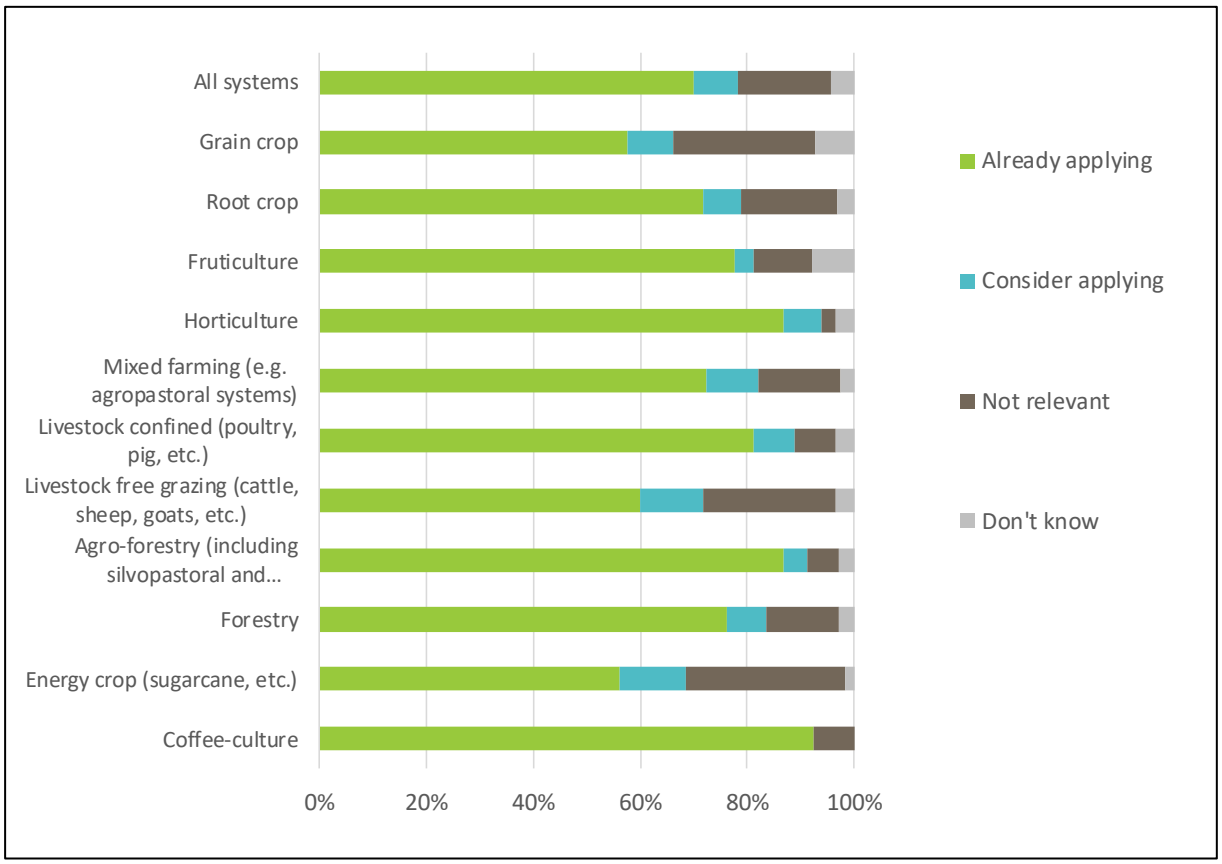


Figure 104: Farmer answers to the question "Which management options do you apply or consider applying? – Zero tillage" crossed with farming system with responses from farmers from all regions.

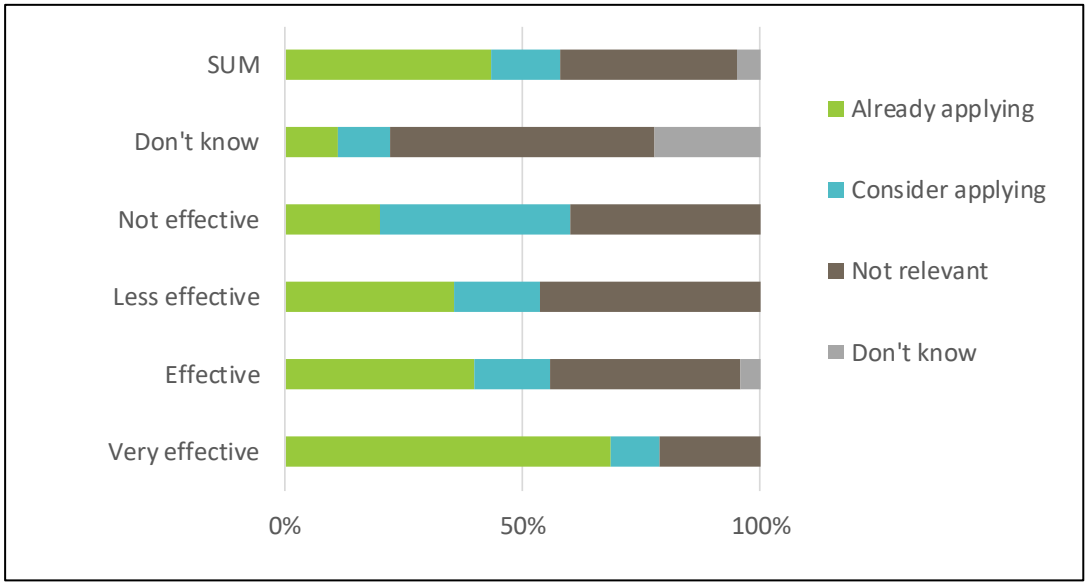


Figure 105: European farmer answers to the question "In your opinion, how effective are zero tillage for enhancing and conserving SOC compared to current levels?" crossed with if they apply residue management.

Annex 7: Contribution of SOC management to ecosystem services and SDGs

ZERO HUNGER (SDG2)

To what extent does SOC enhance yield potential

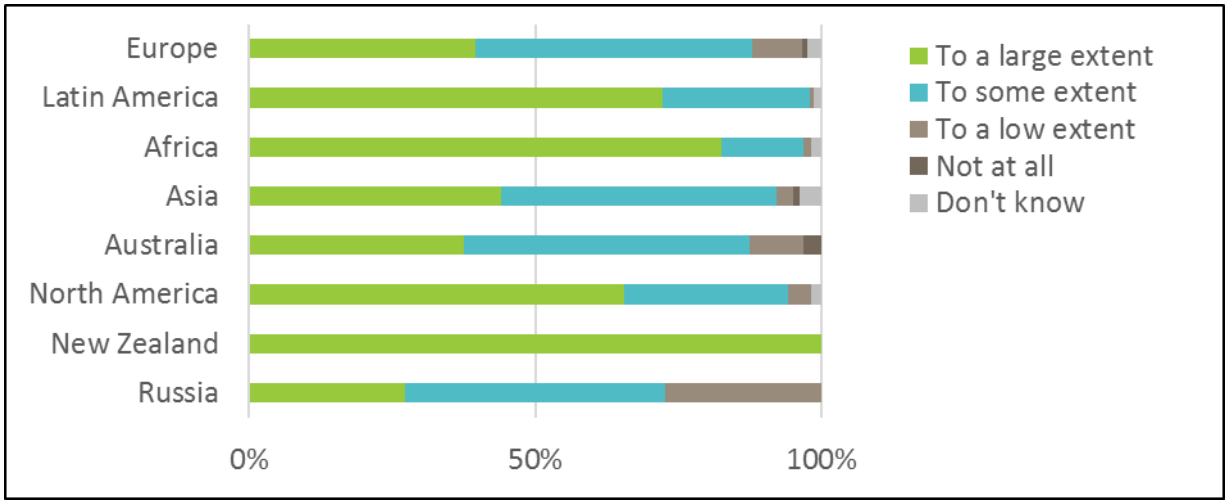


Figure 106: To what extent does SOC enhance yield potential (Global).

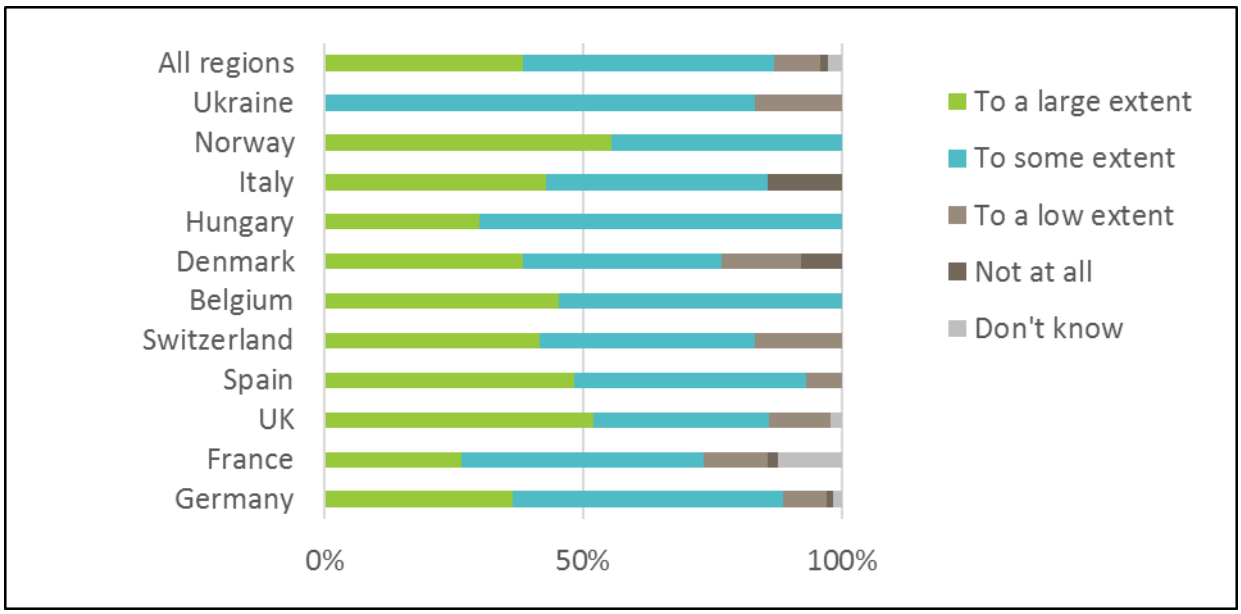


Figure 107: To what extent does SOC enhance yield potential (EU)

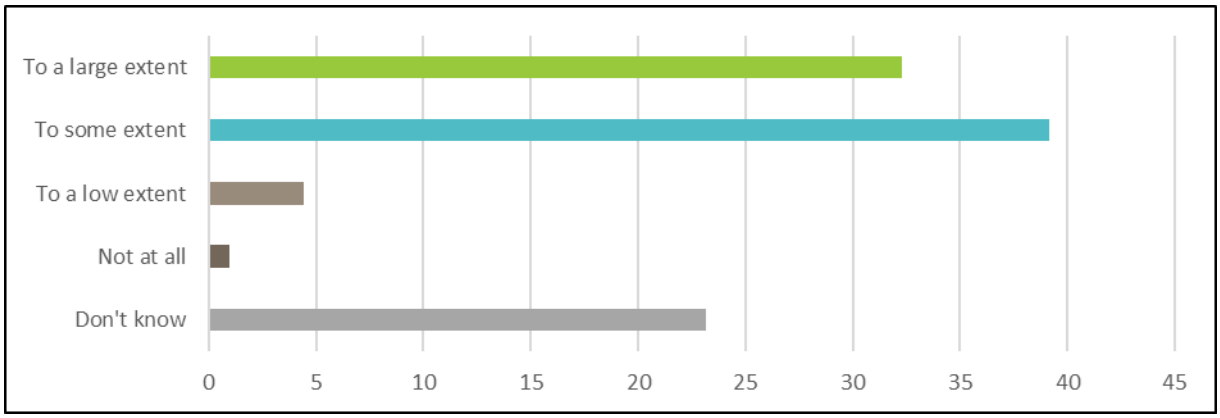


Figure 108: To what extent does SOC enhance yield potential (Denmark). Farmers only.

To what extent does SOC enhance yield stability

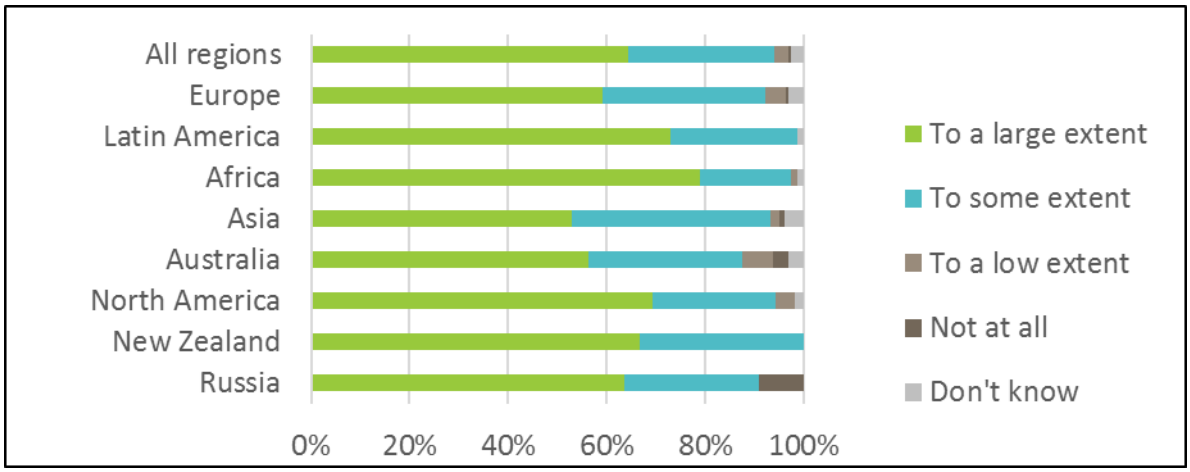


Figure 109: To what extent does SOC enhance yield stability (Global)

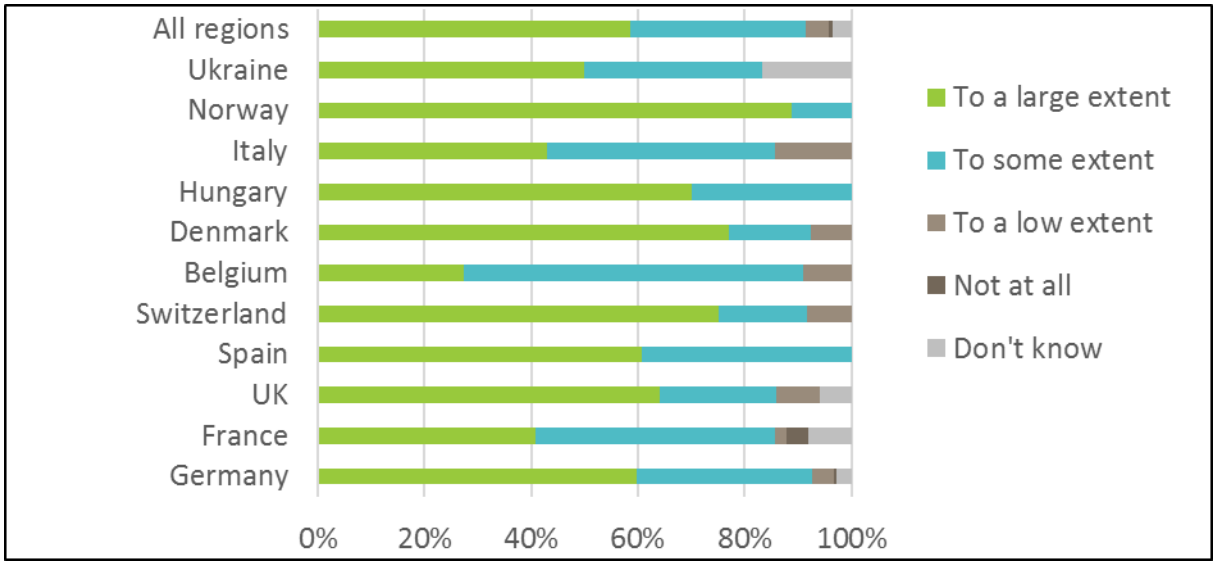


Figure 110: To what extent does SOC enhance yield stability (Europe)

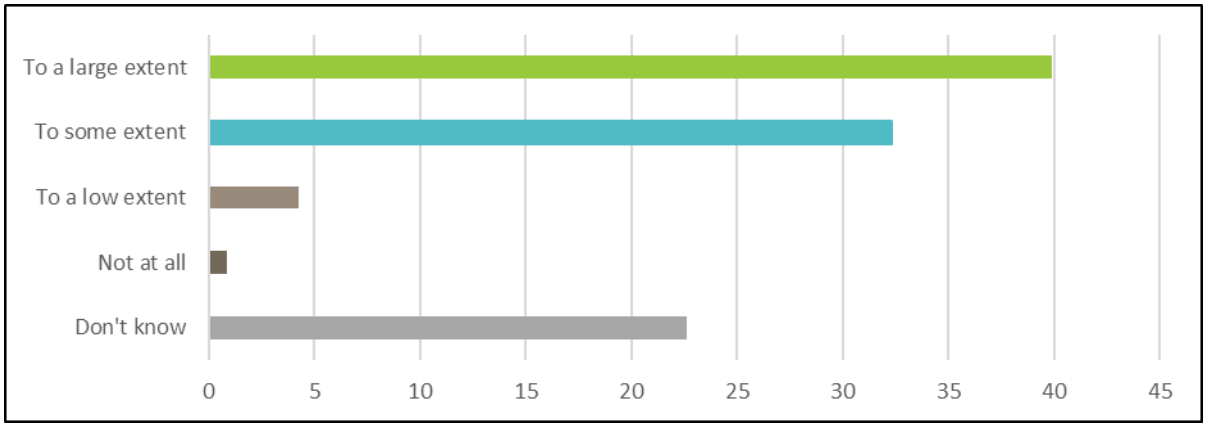


Figure 111: To what extent does SOC enhance yield stability (Danish farmers)

To what extent does SOC enhance product quality (e.g., higher value)

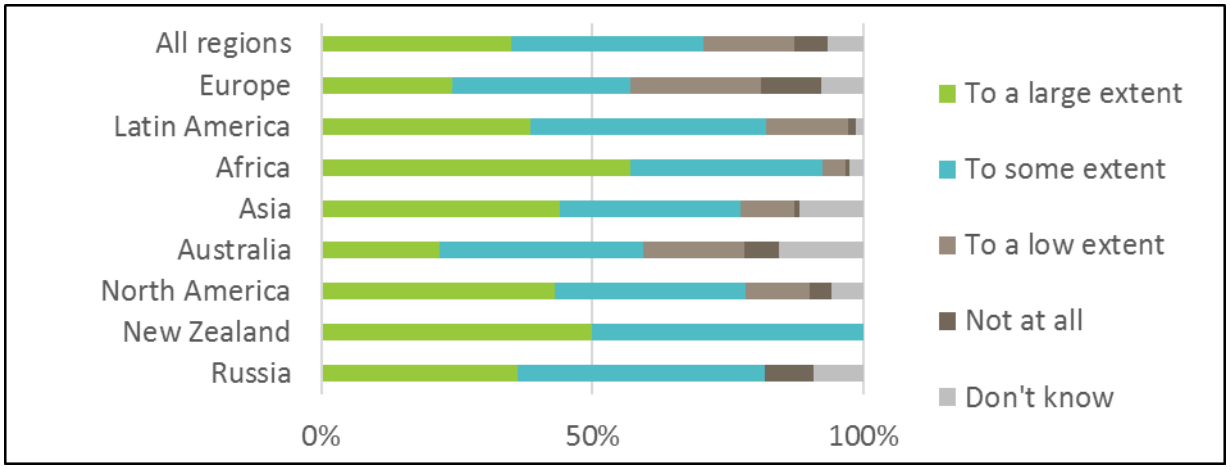


Figure 112: To what extent does SOC enhance product quality (eg. Higher value) (Global)

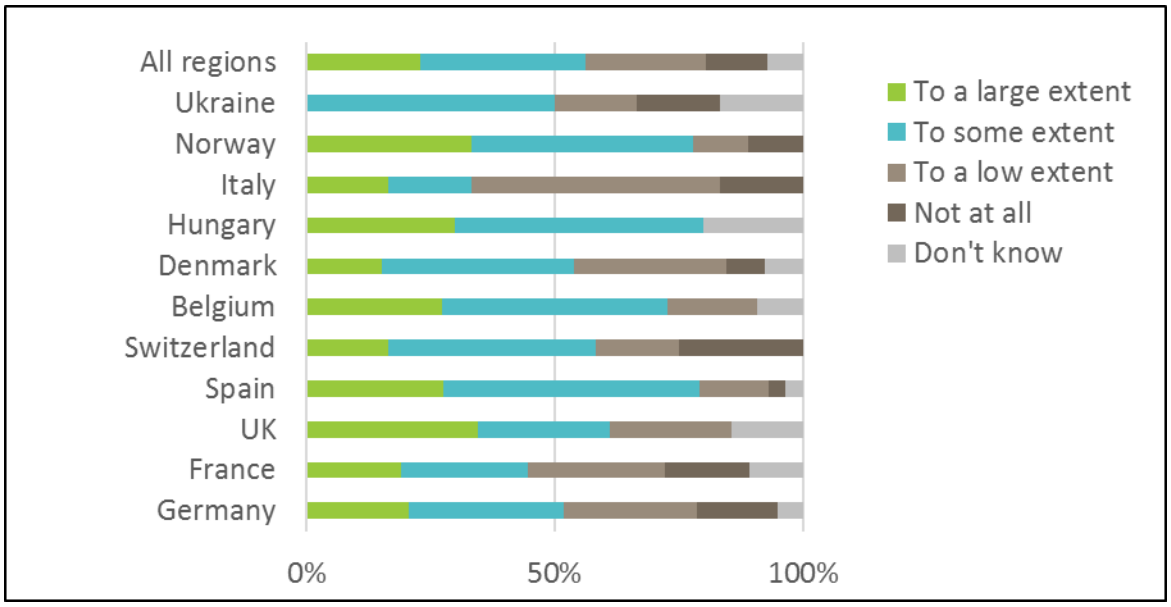


Figure 113: To what extent does SOC enhance product quality (e.g. higher value) (Europe)

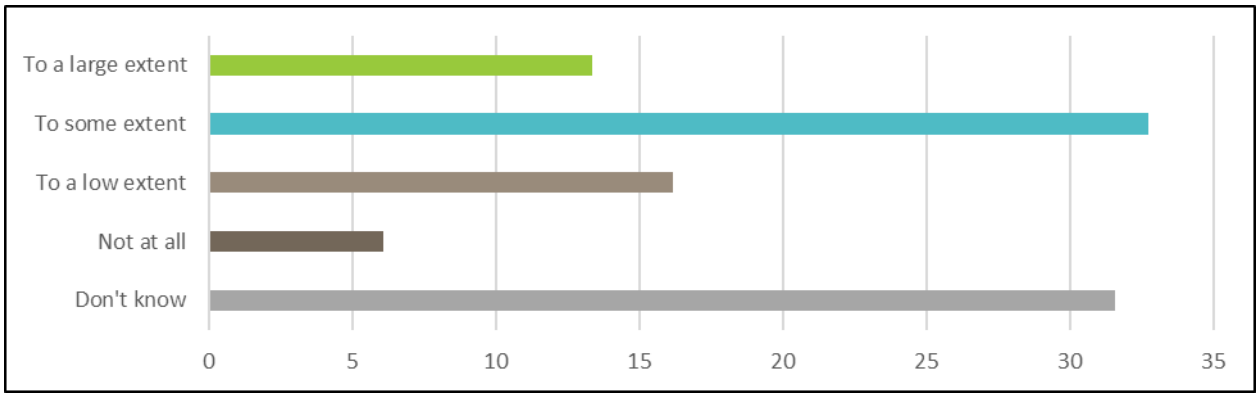


Figure 114: To what extent does SOC enhance product quality (e.g. higher value) (Danish farmers)

To what extent does SOC reduce crop protection needs (pests and diseases)

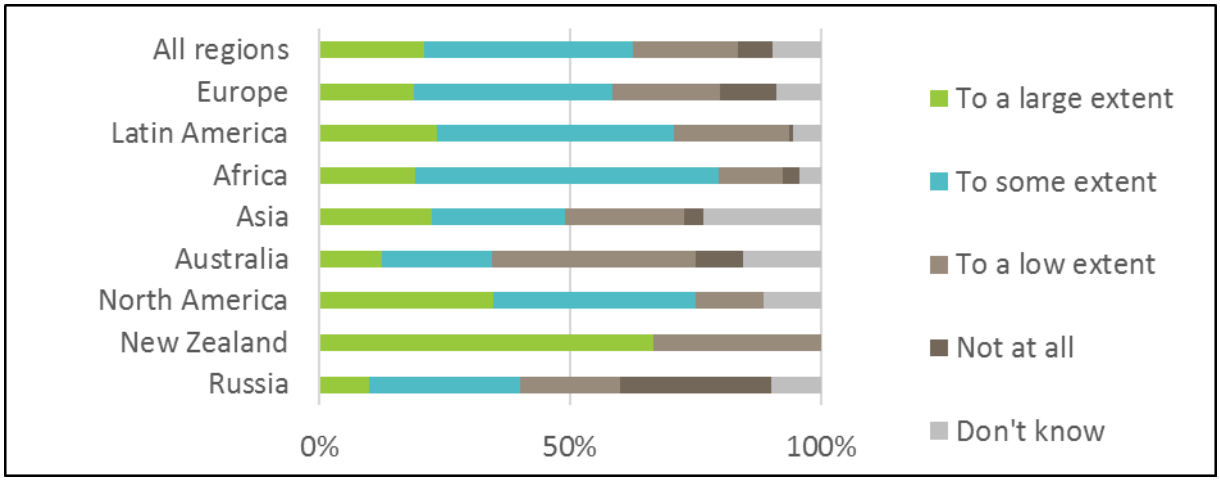


Figure 115: To what extent does SOC reduce crop protection needs (pests and diseases) (Global)

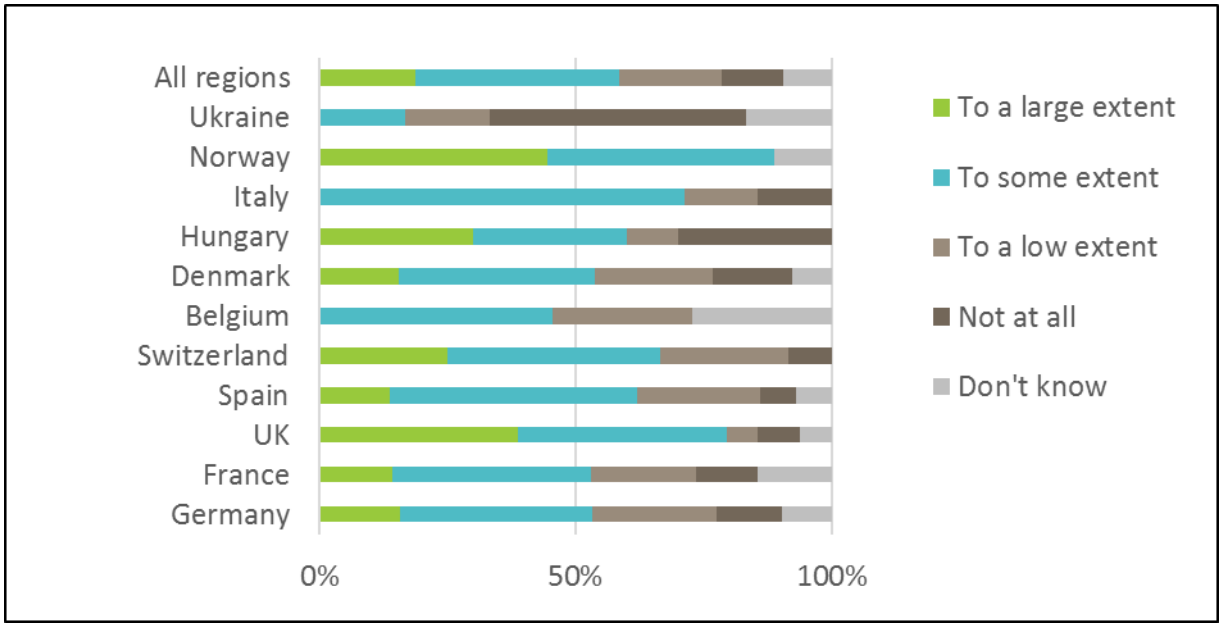


Figure 116: To what extent does SOC reduce crop protection needs (pests and diseases) (Europe)

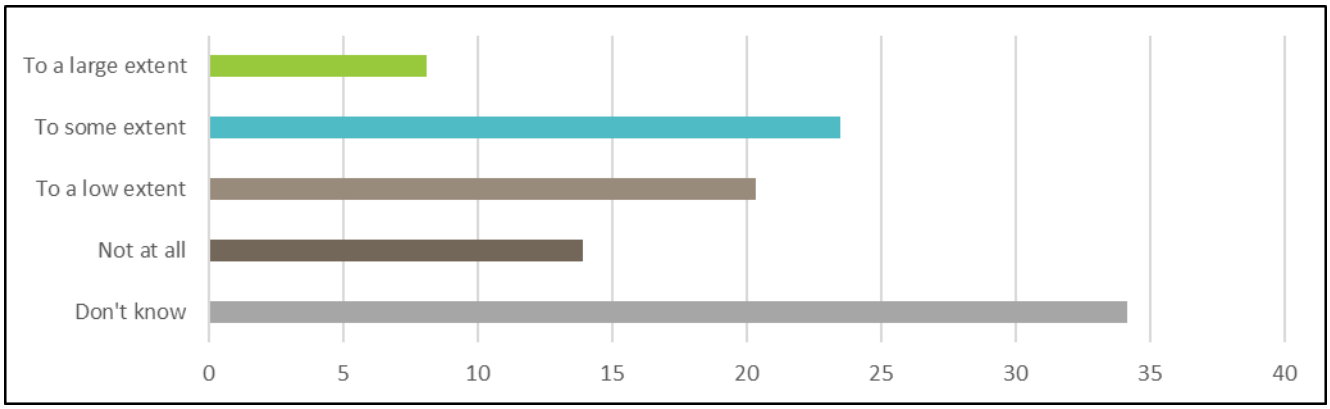


Figure 117: To what extent does SOC reduce crop protection needs (pests and diseases) (Danish farmers)

To what extent do you agree with the following? [Higher SOC would protect against soil degradation under climate change]

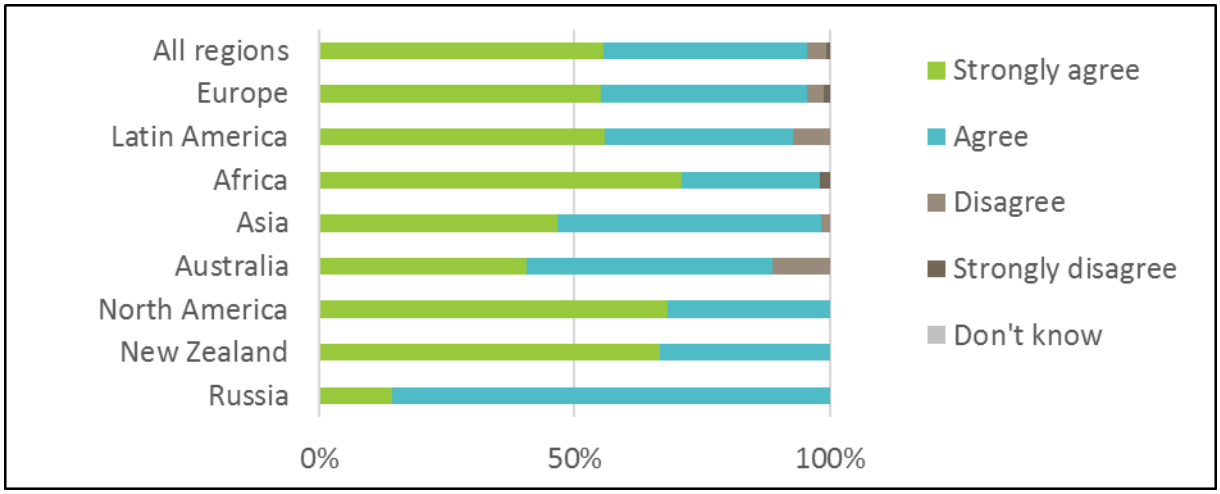


Figure 118: To what extent do you agree with the following? [Higher SOC would protect against soil degradation under climate change] (Global)

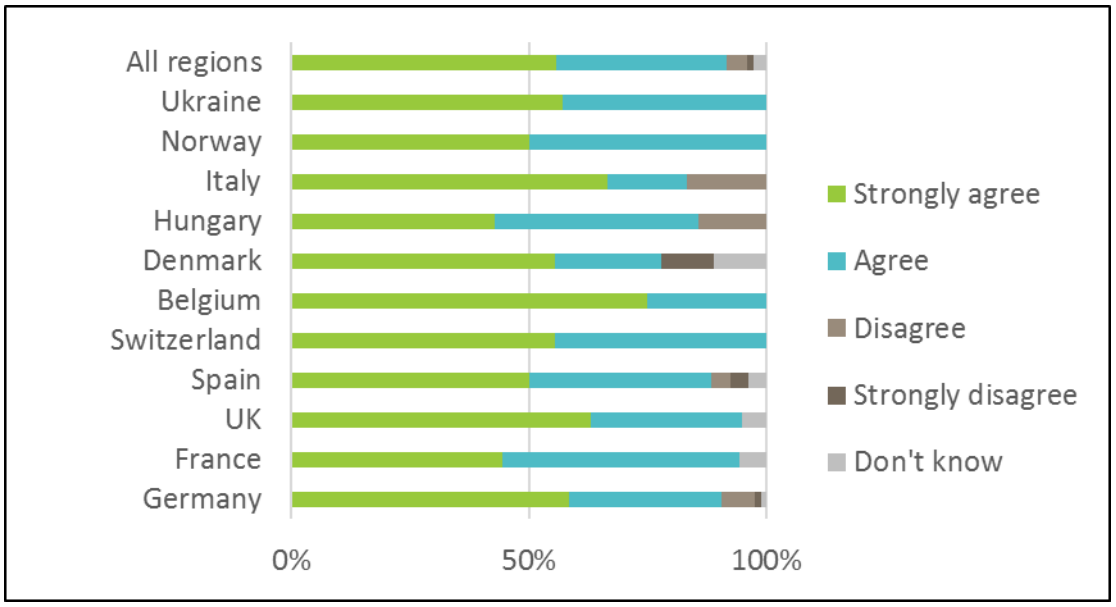


Figure 119: To what extent do you agree with the following? [Higher SOC would protect against soil degradation under climate change] (Europe)

To what extent do you agree with the following? [SOC management is relevant to climate change adaptation]

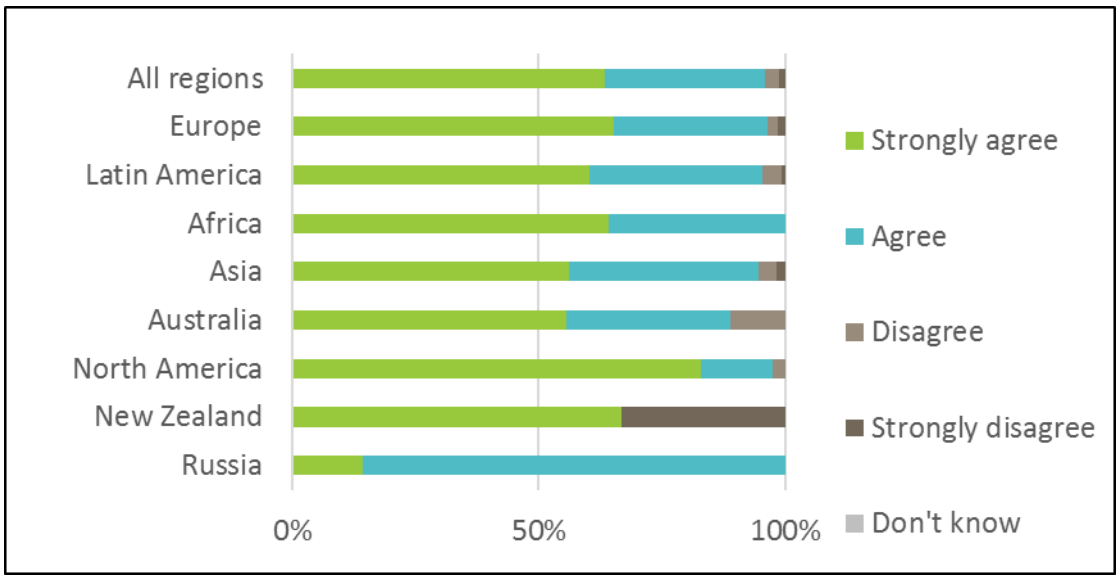


Figure 120: To what extent do you agree with the following? [SOC management is relevant to climate change adaptation]

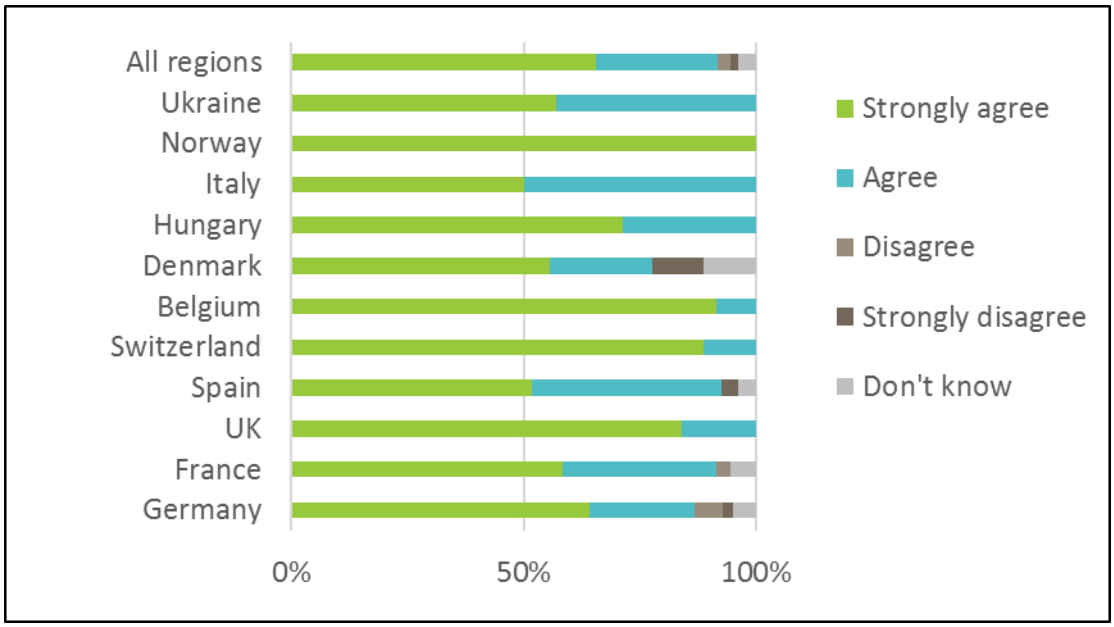


Figure 121: To what extent do you agree with the following? [SOC management is relevant to climate change adaptation]

To what extent do you agree with the following? [SOC management is relevant to food security]

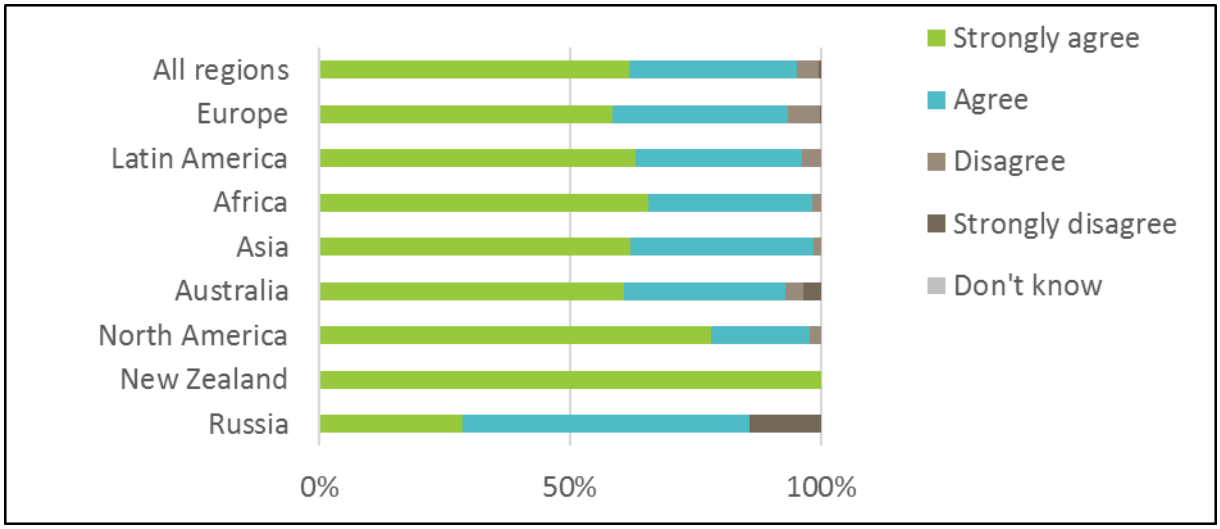


Figure 122: To what extent do you agree with the following? [SOC management is relevant to food security] (Global)

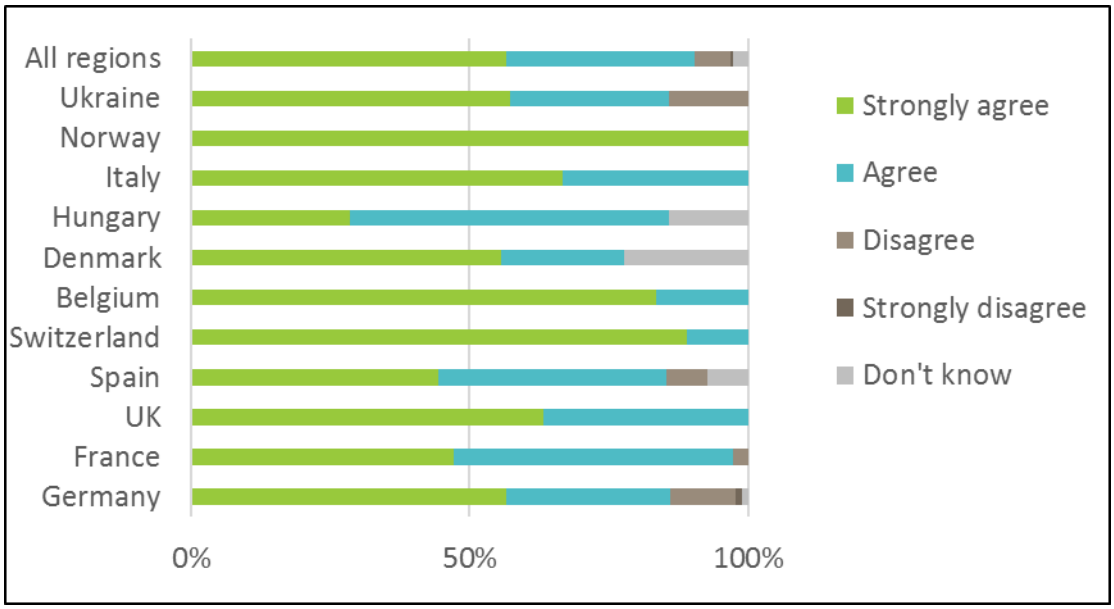


Figure 123: To what extent do you agree with the following? [SOC management is relevant to food security] (Europe)

CLEAN WATER AND SANITATION (SDG6)

To what extent does SOC reduce irrigation demand

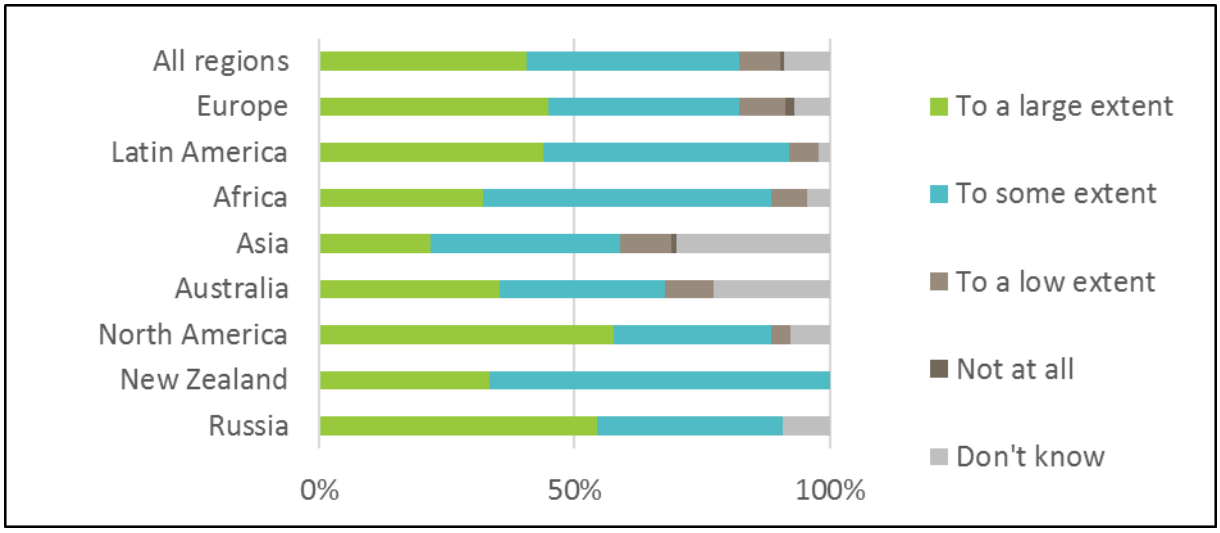


Figure 124: To what extent does SOC reduce irrigation demand (Global)

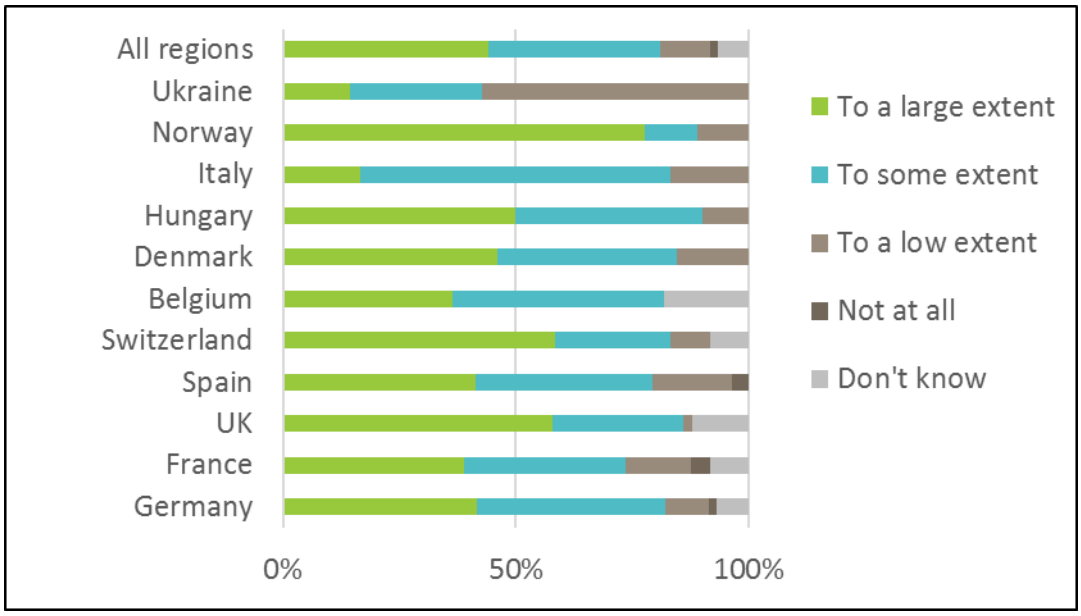


Figure 125: To what extent does SOC reduce irrigation demand (Europe)

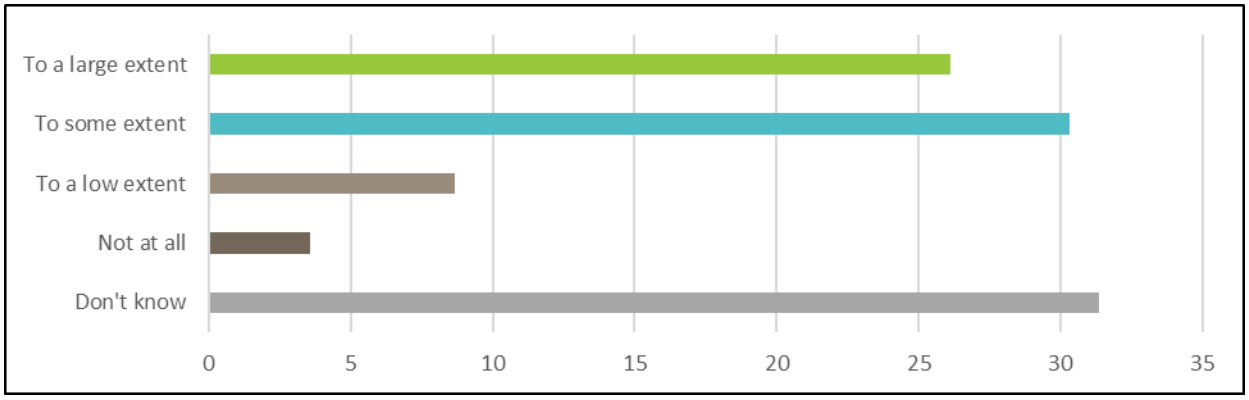


Figure 126: To what extent does SOC reduce irrigation demand (Danish farmers)

To what extent does SOC reduce demand for fertilizer

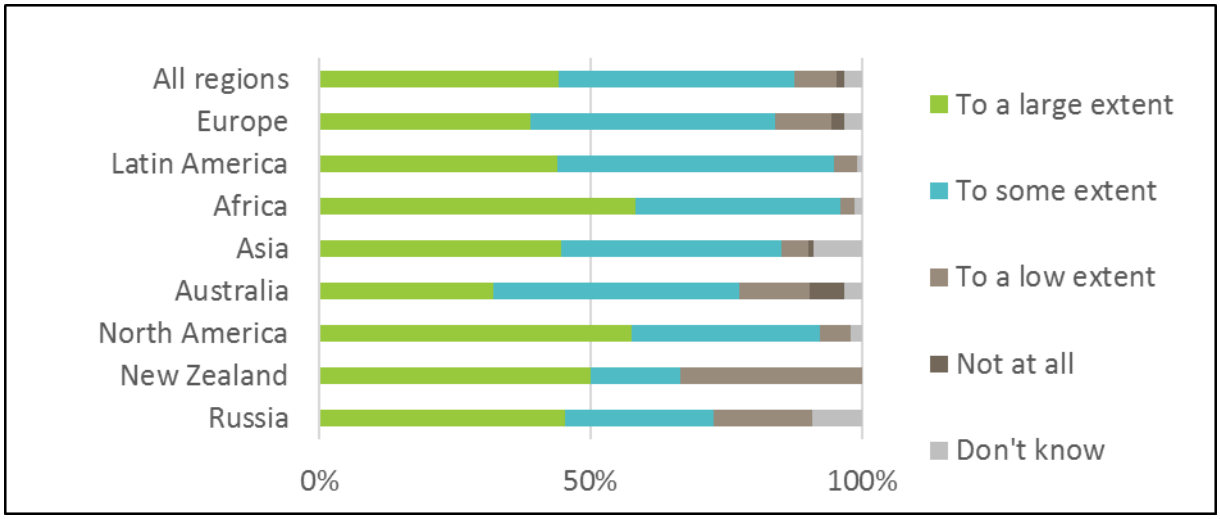


Figure 127: To what extent does SOC reduce demand for fertilizer (Global

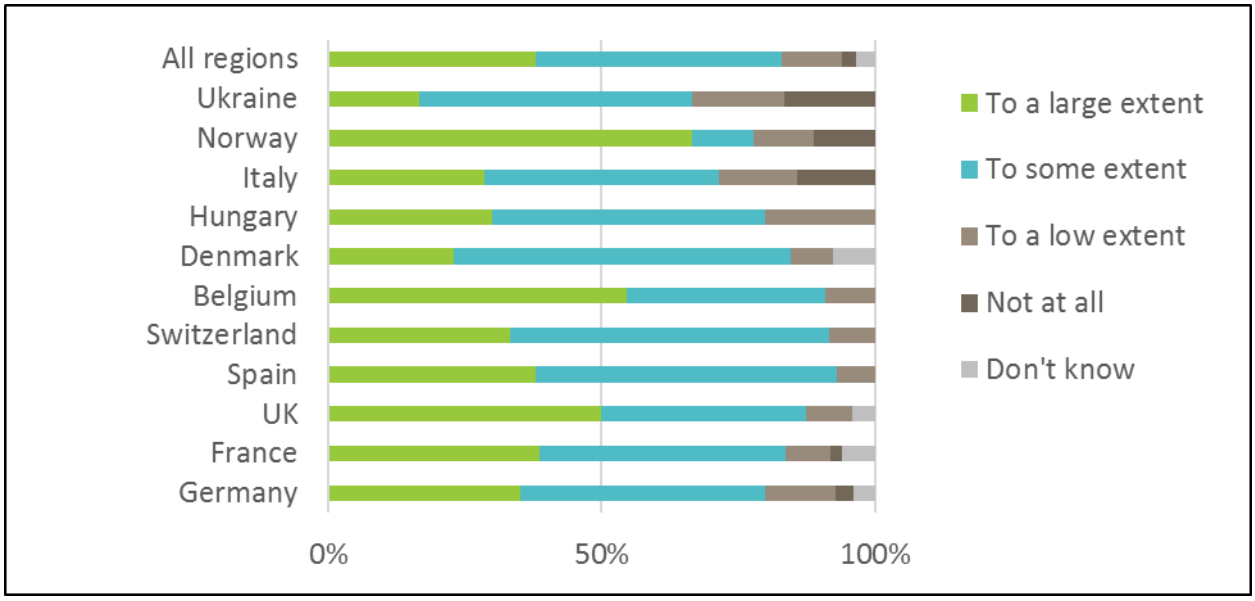


Figure 128: To what extent does SOC reduce demand for fertilizer (Europe)

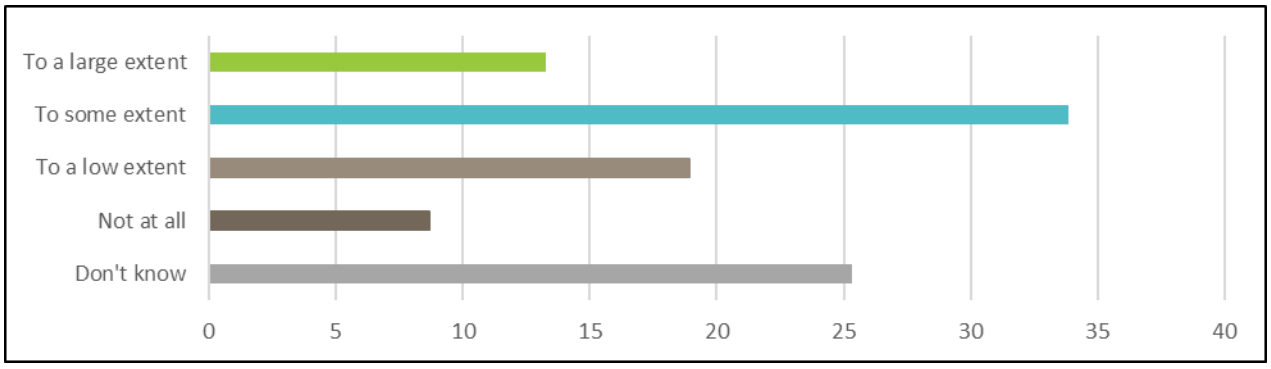


Figure 129: To what extent does SOC reduce demand for fertilizer (Danish farmers)

To what extent does SOC prevent nutrient leakage

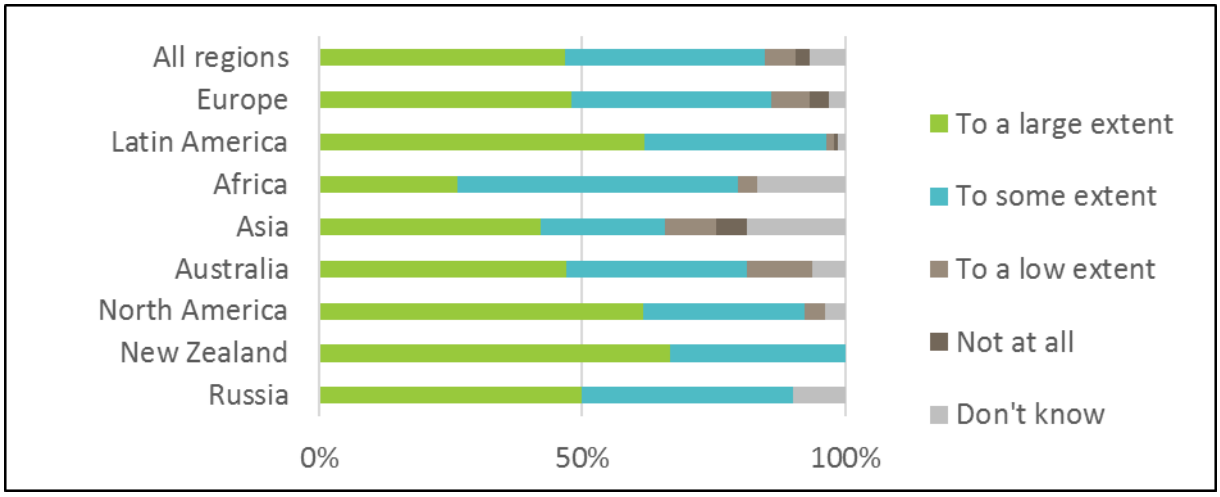


Figure 130: To what extent does SOC prevent nutrient leakage (Global)

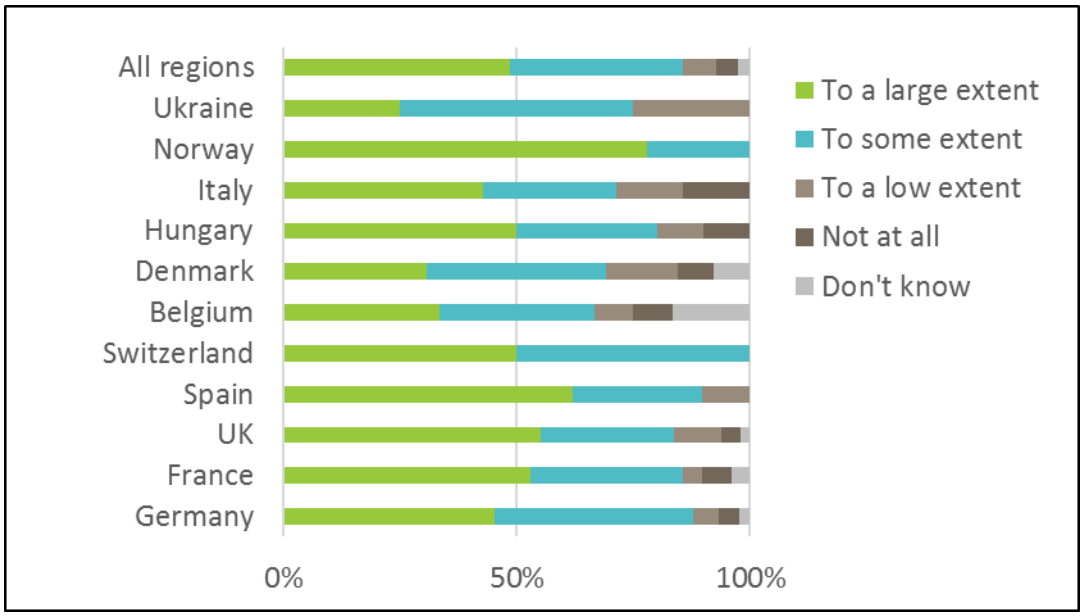


Figure 131: To what extent does SOC prevent nutrient leakage (Europe)

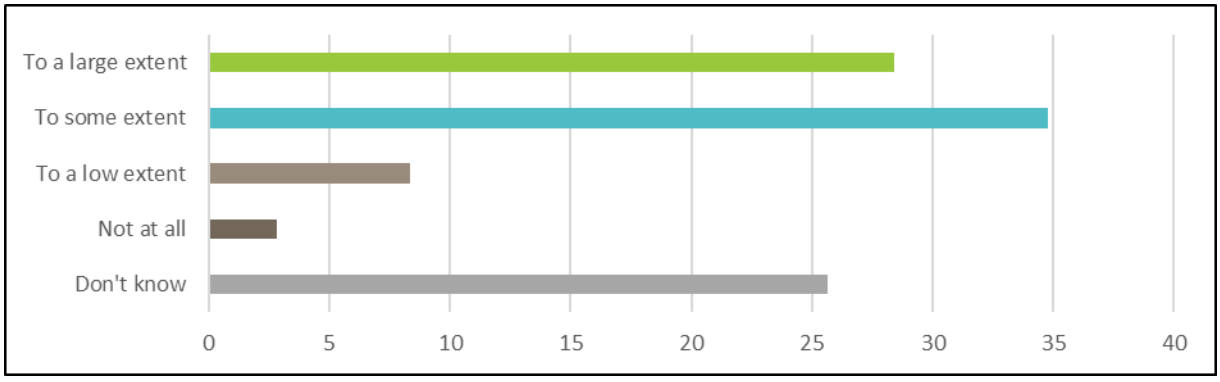


Figure 132: To what extent does SOC prevent nutrient leakage (Danish farmers)

CLIMATE ACTION (SDG13)

To what extent do you agree with the following: SOC management affects GHG emissions from soils

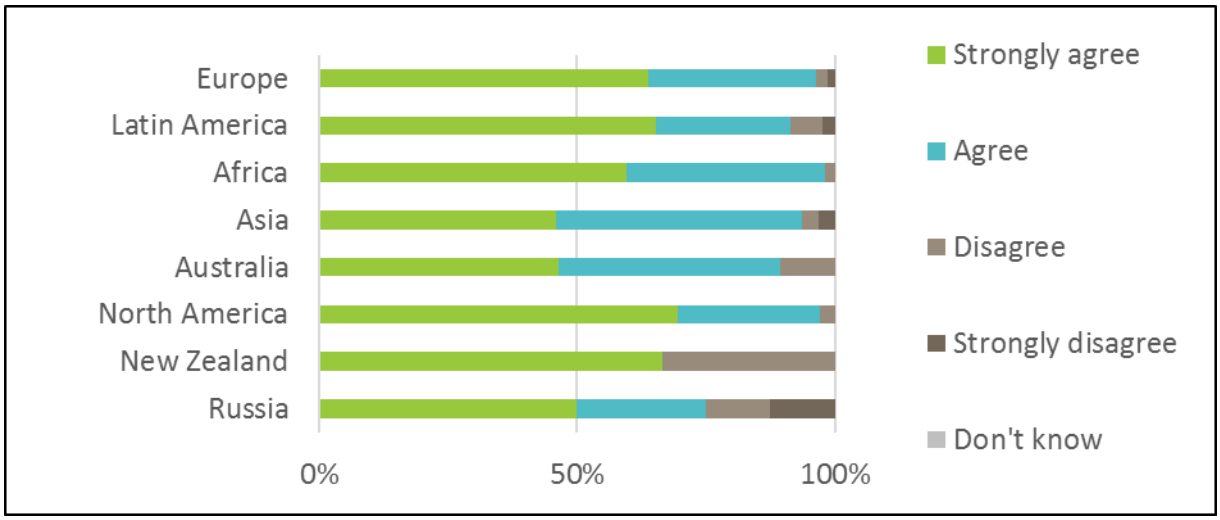


Figure 133: To what extent do you agree with the following: SOC management affects GHG emissions from soils (Global)

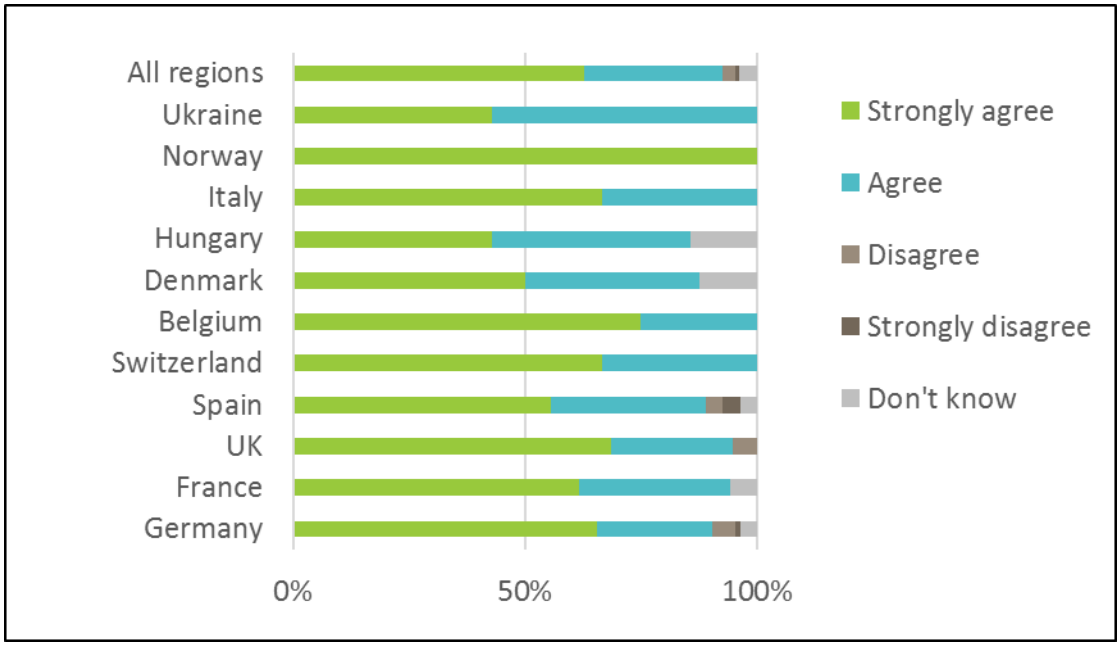


Figure 134: To what extent do you agree with the following: SOC management affects GHG emissions from soils (Europe)

To what extent do you agree with the following: GHG emissions should be a concern for SOC management

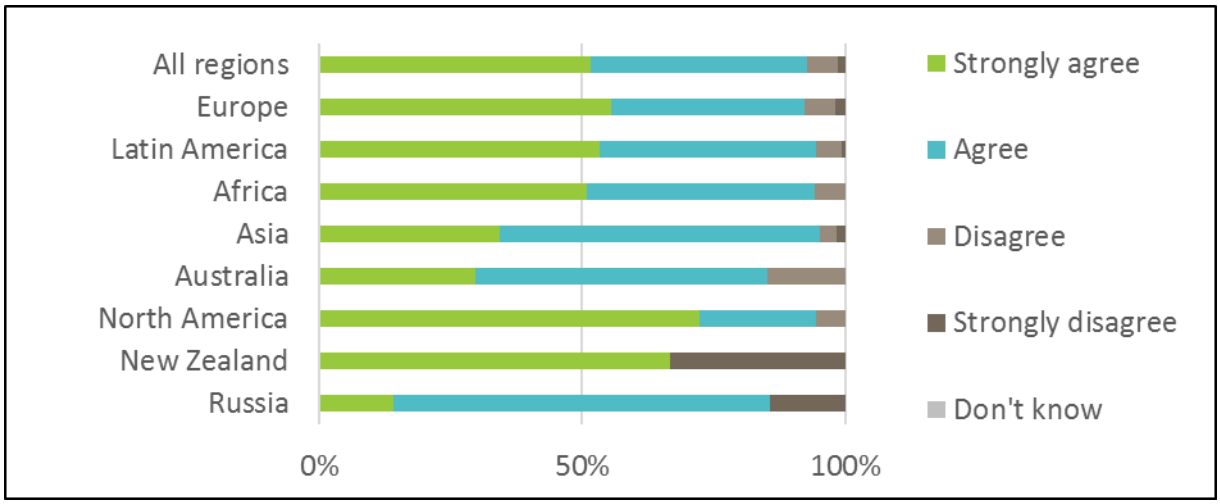


Figure 135: To what extent do you agree with the following: GHG emissions should be a concern for SOC management (Global)

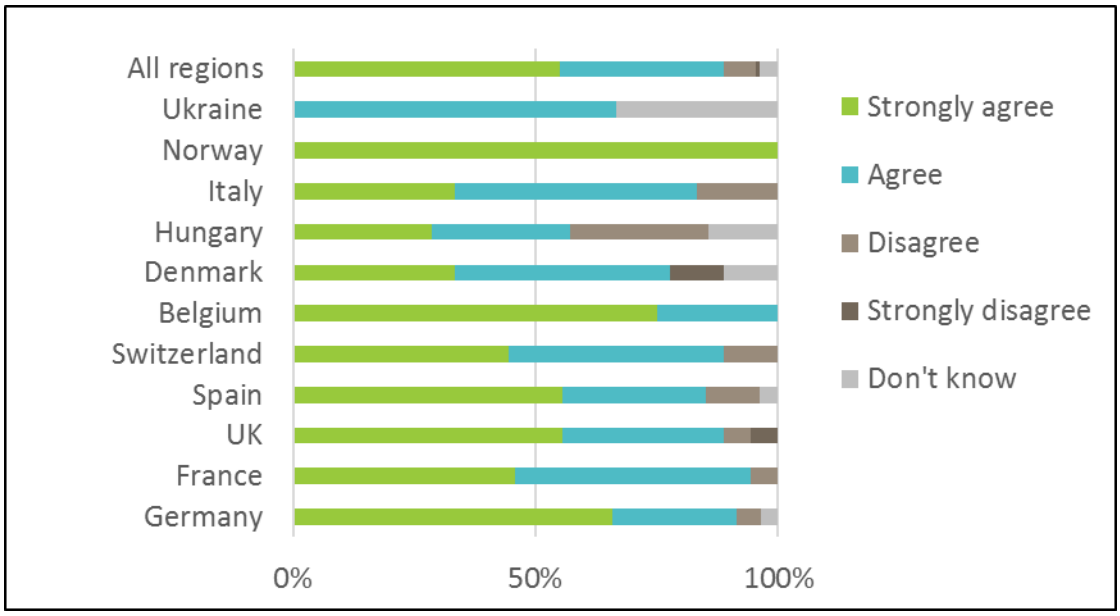


Figure 136: To what extent do you agree with the following: GHG emissions should be a concern for SOC management (Europe)

To what extent do you agree with the following? [SOC management compensates other agricultural GHG emissions (nitrous oxide and methane)]

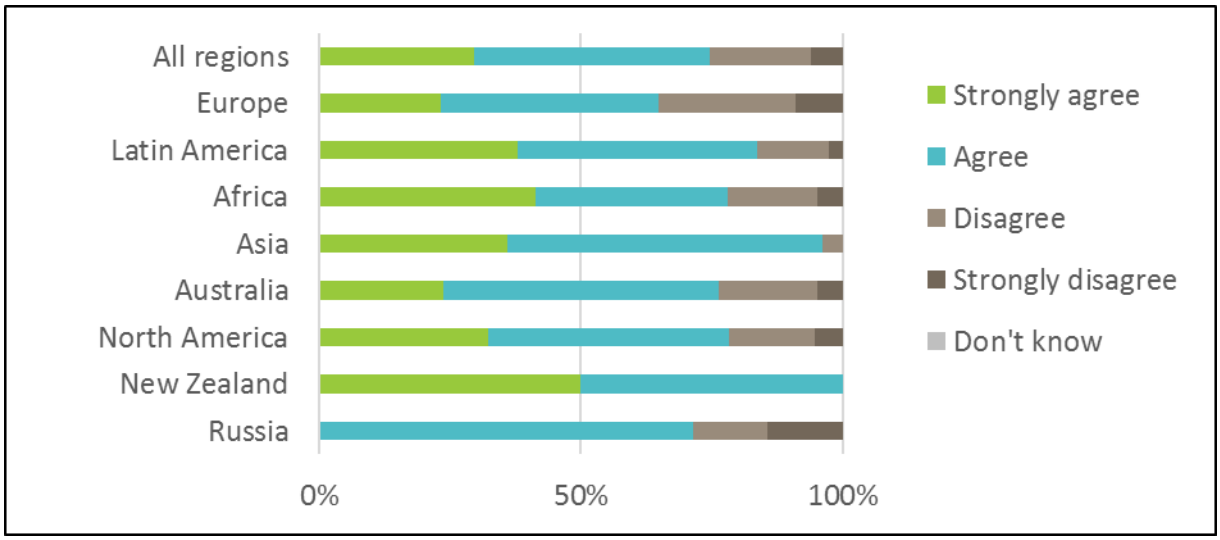


Figure 137: To what extent do you agree with the following? [SOC management compensates other agricultural GHG emissions (nitrous oxide and methane)] (Global)

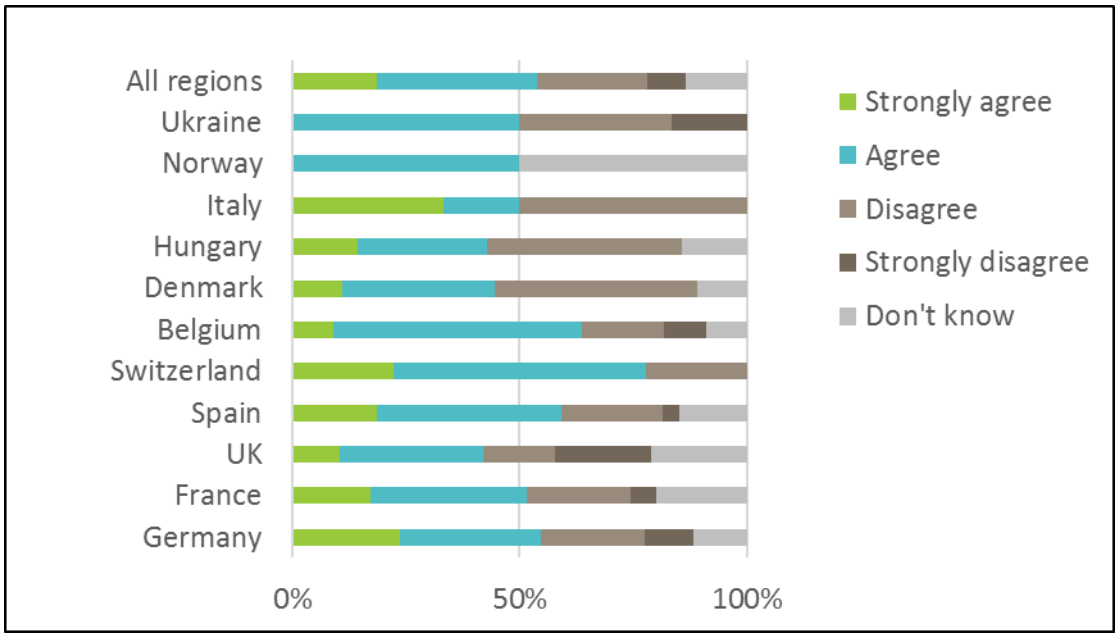


Figure 138: To what extent do you agree with the following? [SOC management compensates other agricultural GHG emissions (nitrous oxide and methane)] (Europe)

To what extent do you agree with the following? [SOC management compensates emissions from fossil fuels (energy and transport in society)]

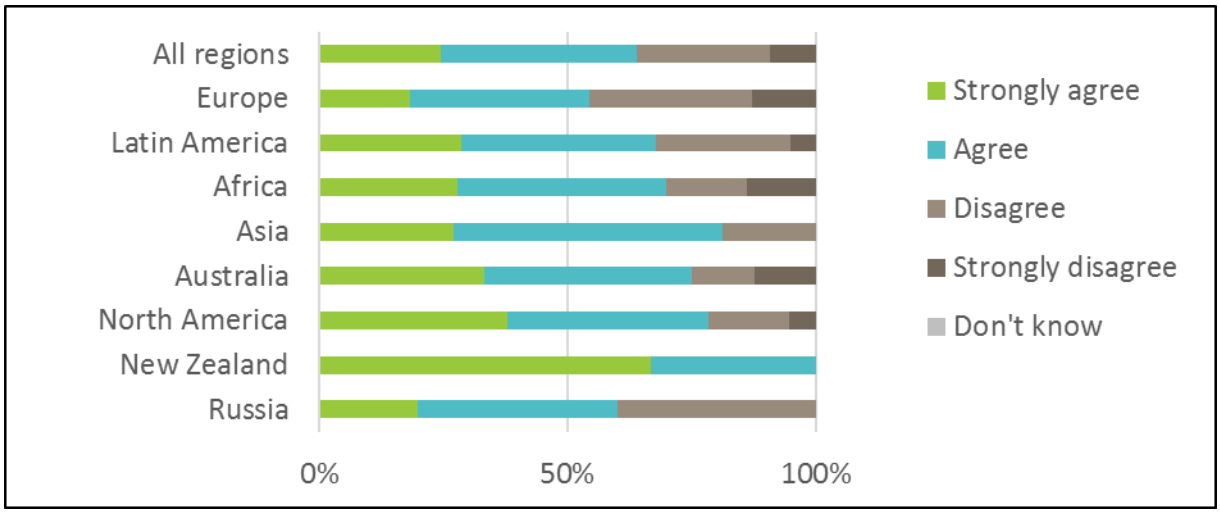


Figure 139: To what extent do you agree with the following? [SOC management compensates emissions from fossil fuels (energy and transport in society)] (Global)

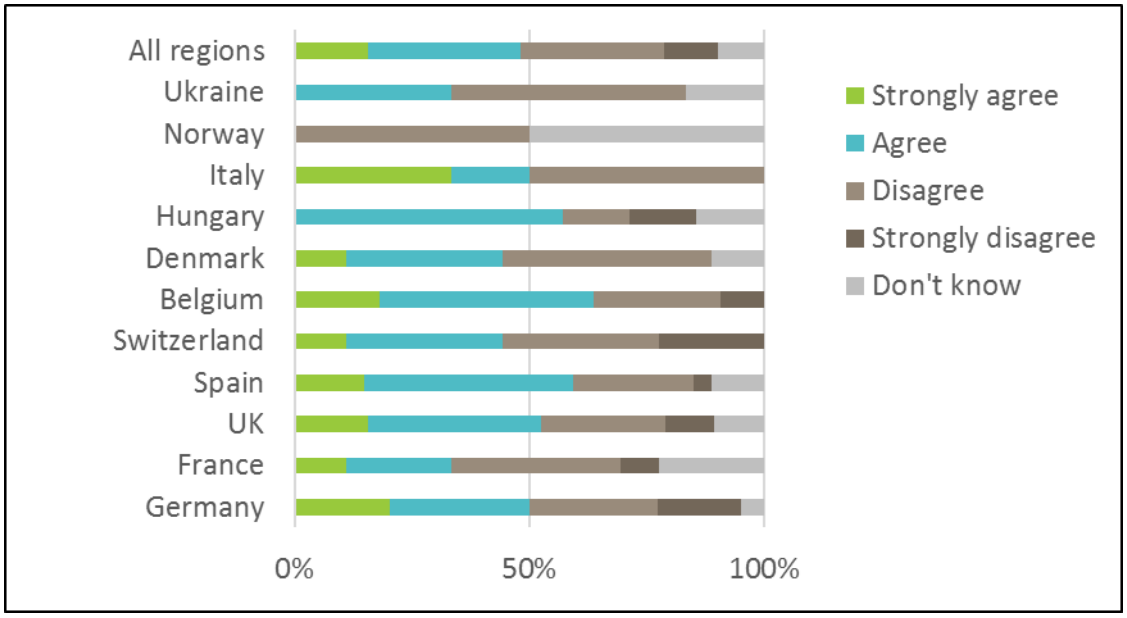


Figure 140: To what extent do you agree with the following? [SOC management compensates emissions from fossil fuels (energy and transport in society)] (Europe)

LIFE ON LAND (SDG15)

To what extent does SOC improve soil quality

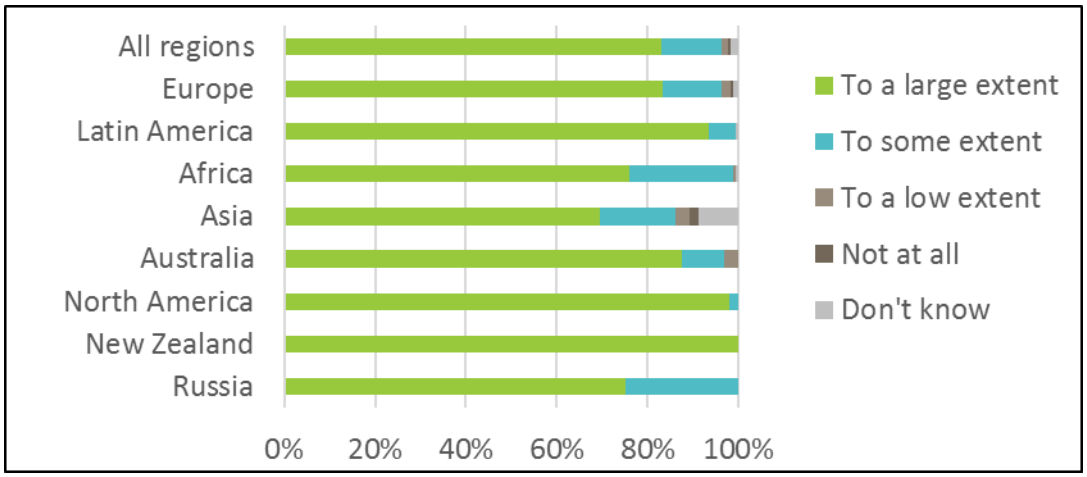


Figure 141: To what extent does SOC improve soil quality (Global)

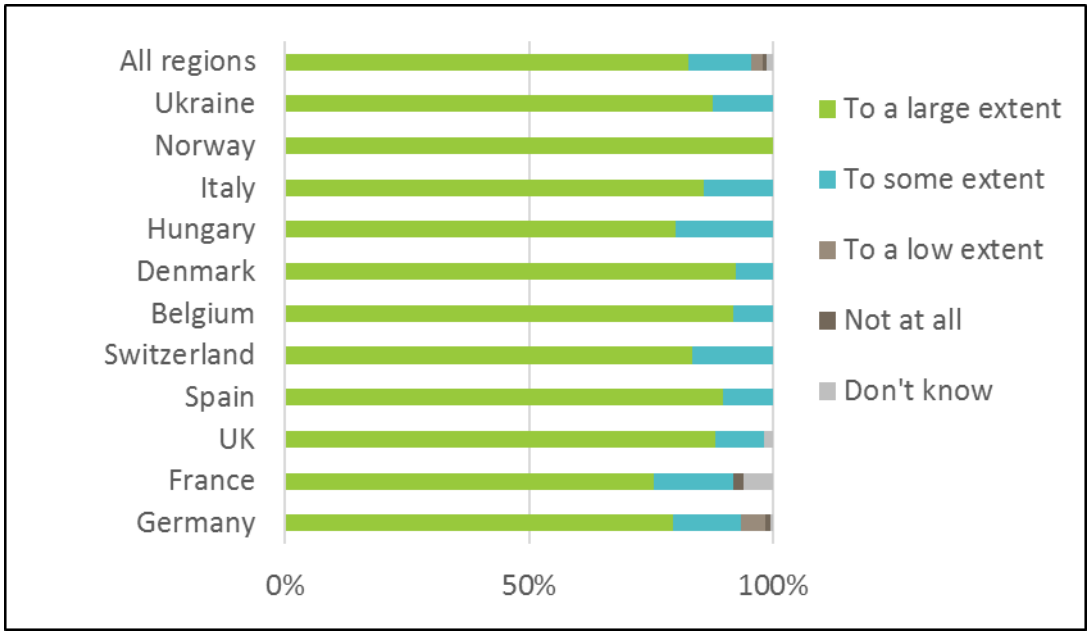


Figure 142: To what extent does SOC improve soil quality (Europe)

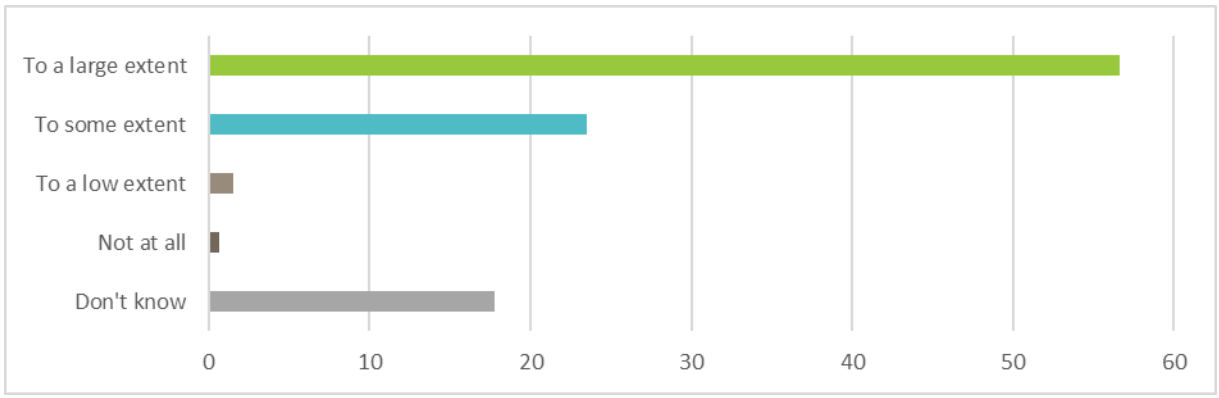


Figure 143: To what extent does SOC improve soil quality (Danish Farmers)

To what extent does SOC improve soil workability

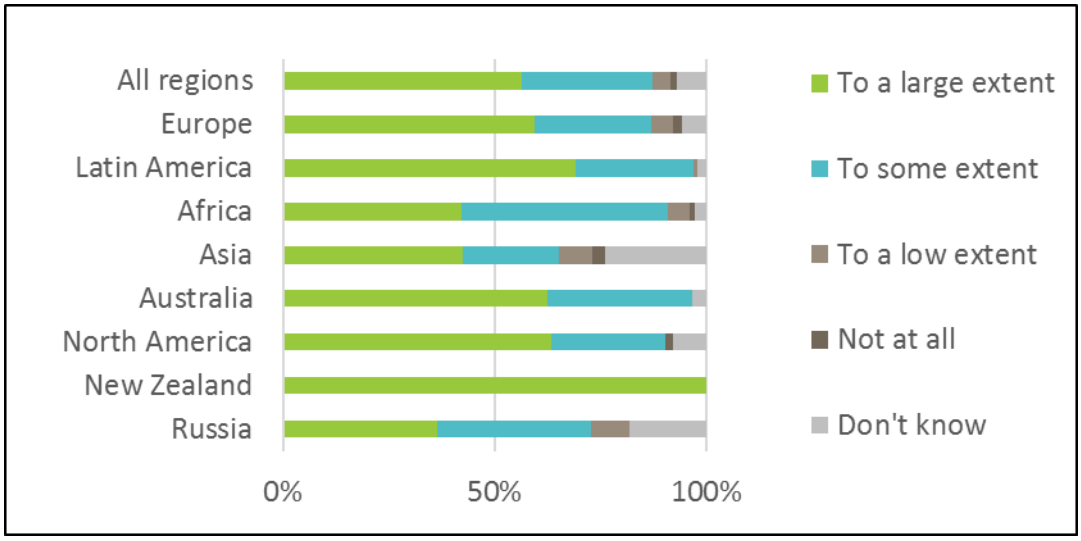


Figure 144: To what extent does SOC improve soil workability (Global)

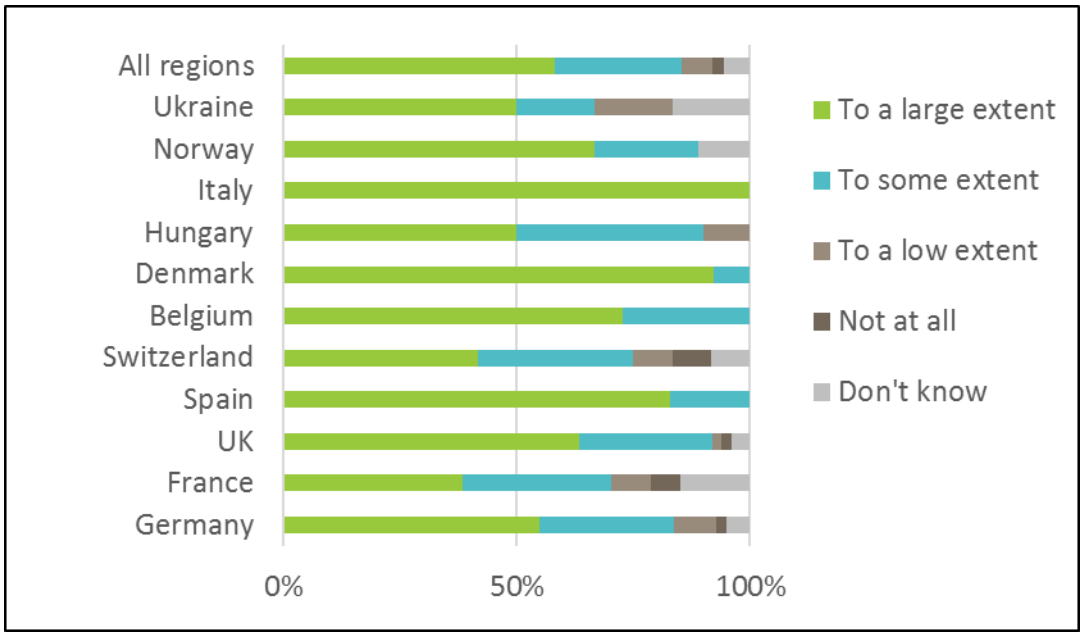


Figure 145: To what extent does SOC improve soil workability (Europe)

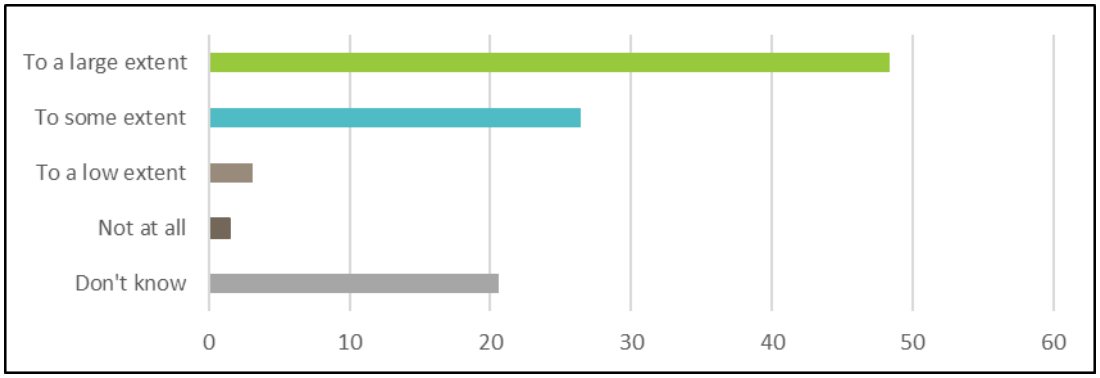


Figure 146: To what extent does SOC improve soil workability (Danish farmers)

To what extent does SOC improve soil biodiversity

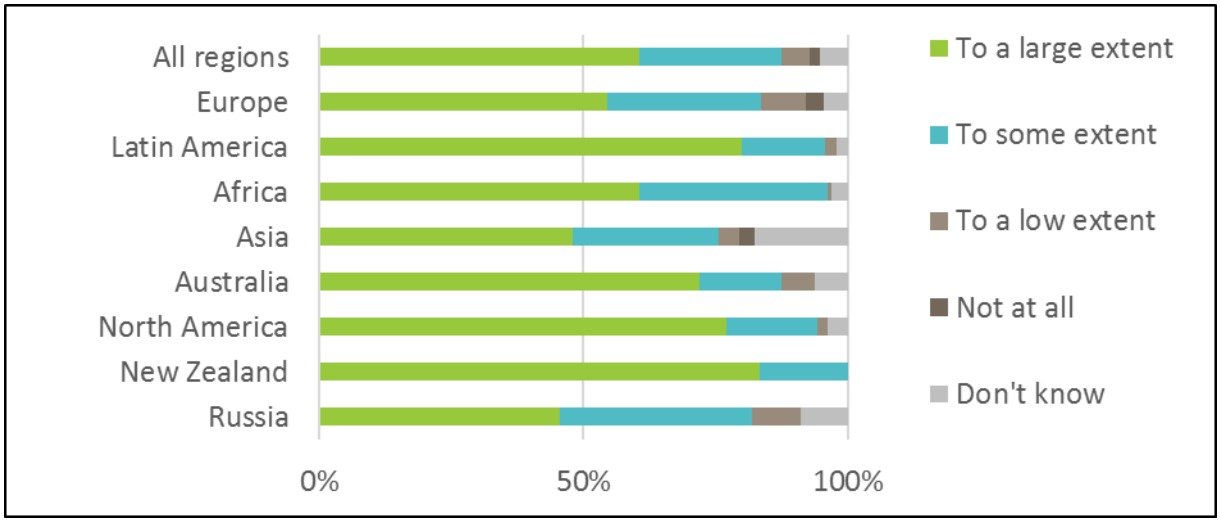


Figure 147: To what extent does SOC improve soil biodiversity (Global)

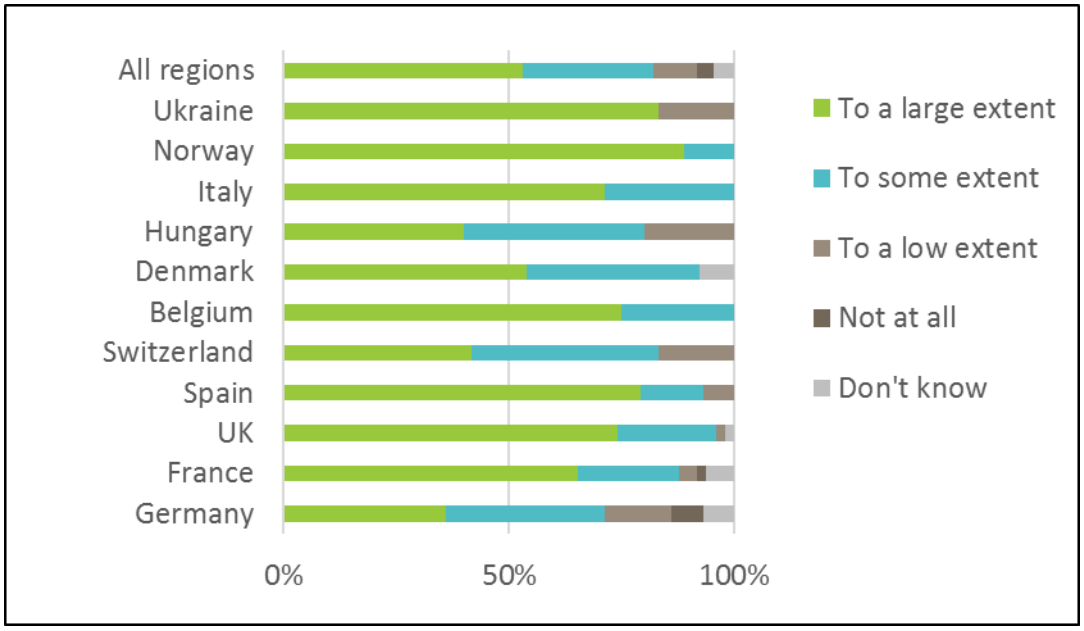


Figure 148: To what extent does SOC improve soil biodiversity (Europe)

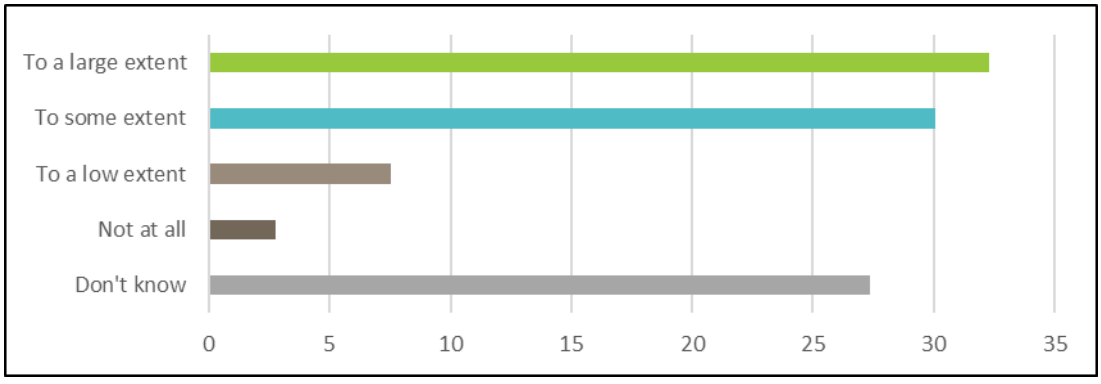


Figure 149: To what extent does SOC improve soil biodiversity (Danish farmers)

To what extent does SOC improve soil water holding capacity

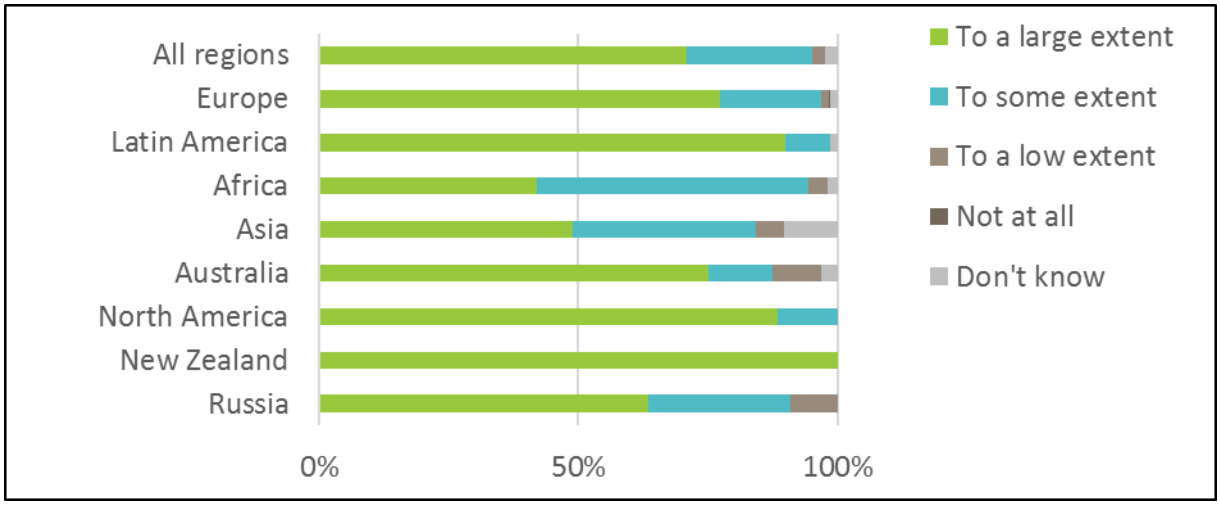


Figure 150: To what extent does SOC improve soil water holding capacity (Global)

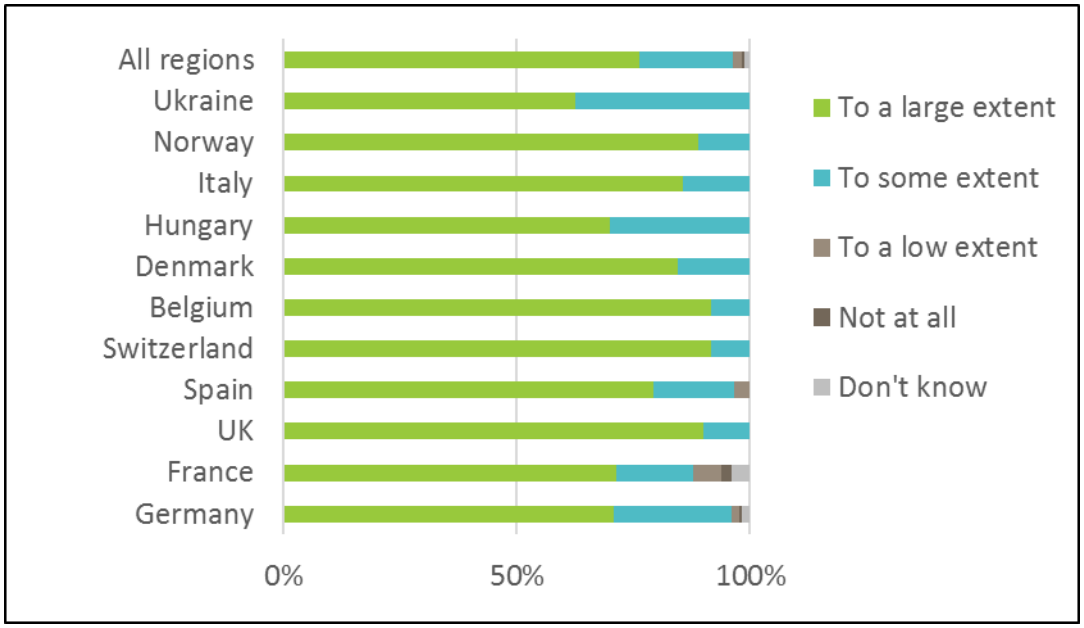


Figure 151: To what extent does SOC improve soil water holding capacity (Europe)

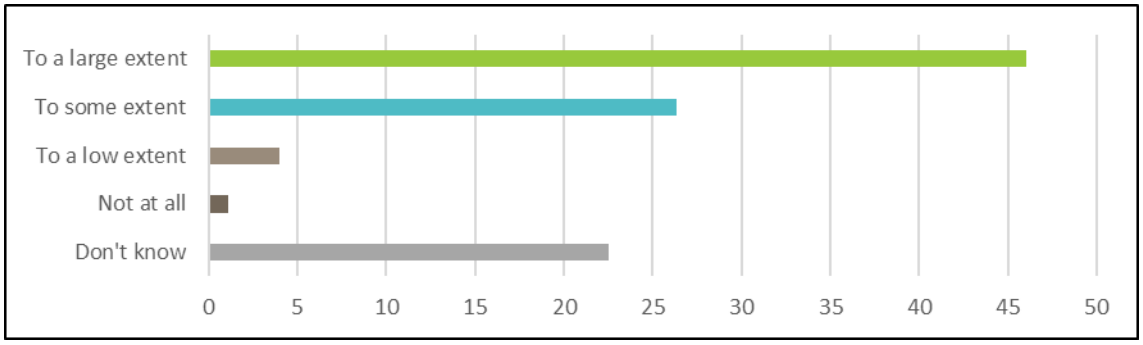


Figure 152: To what extent does SOC improve soil water holding capacity (Danish farmers)

To what extent does SOC improve water infiltration and drainage

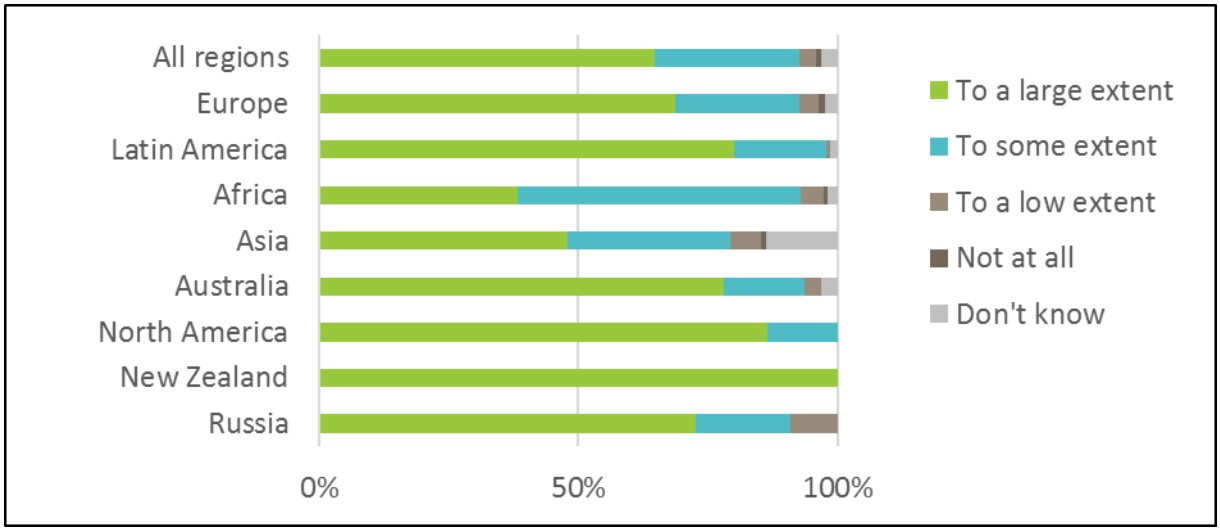


Figure 153: To what extent does SOC improve water infiltration and drainage (Global)

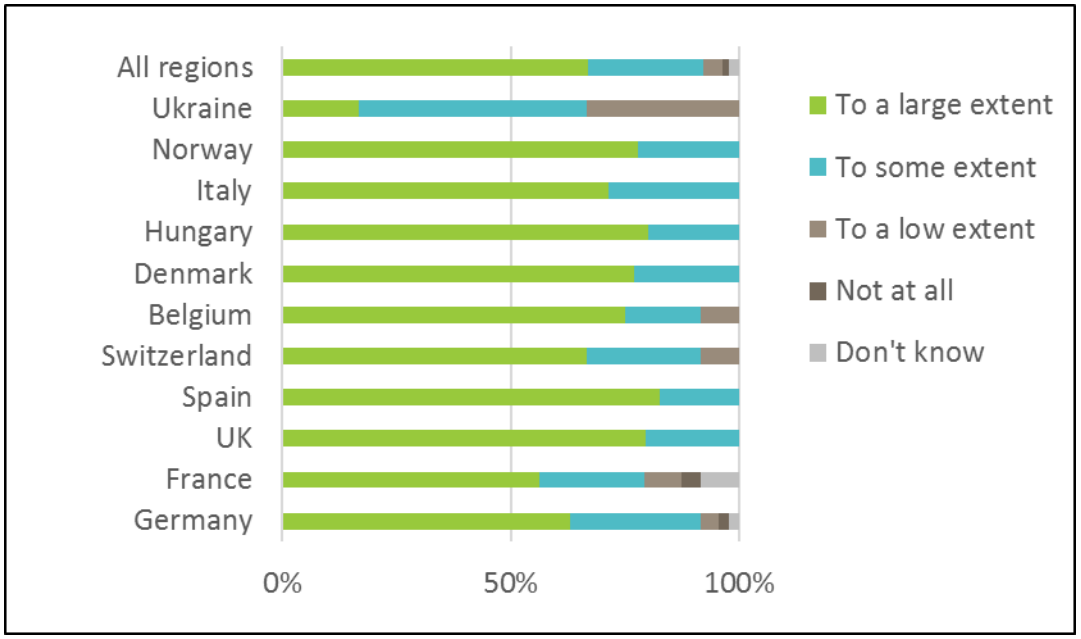


Figure 154: To what extent does SOC improve water infiltration and drainage (Europe)

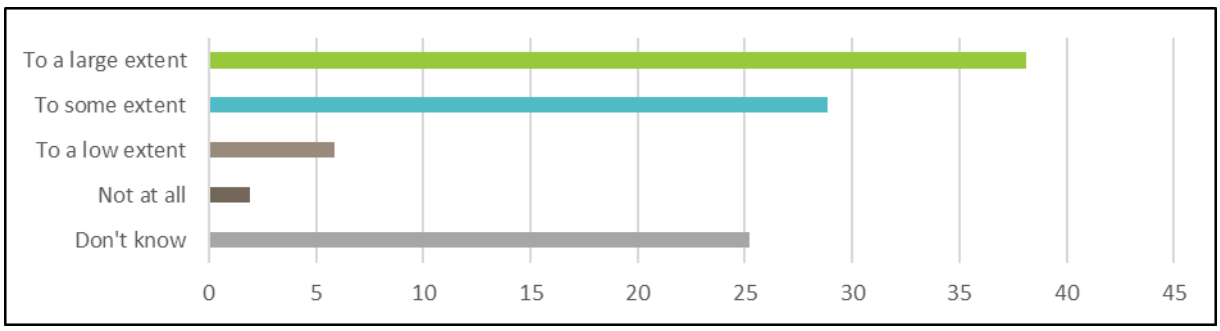


Figure 155: To what extent does SOC improve water infiltration and drainage (Danish farmers)

To what extent does SOC prevent soil erosion

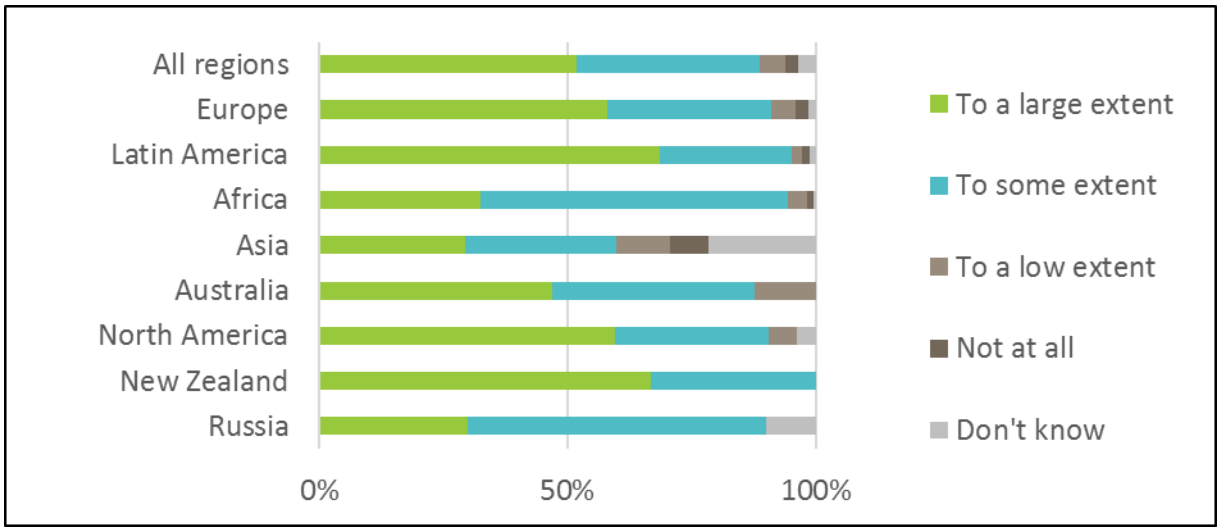


Figure 156: To what extent does SOC prevent soil erosion (Global)

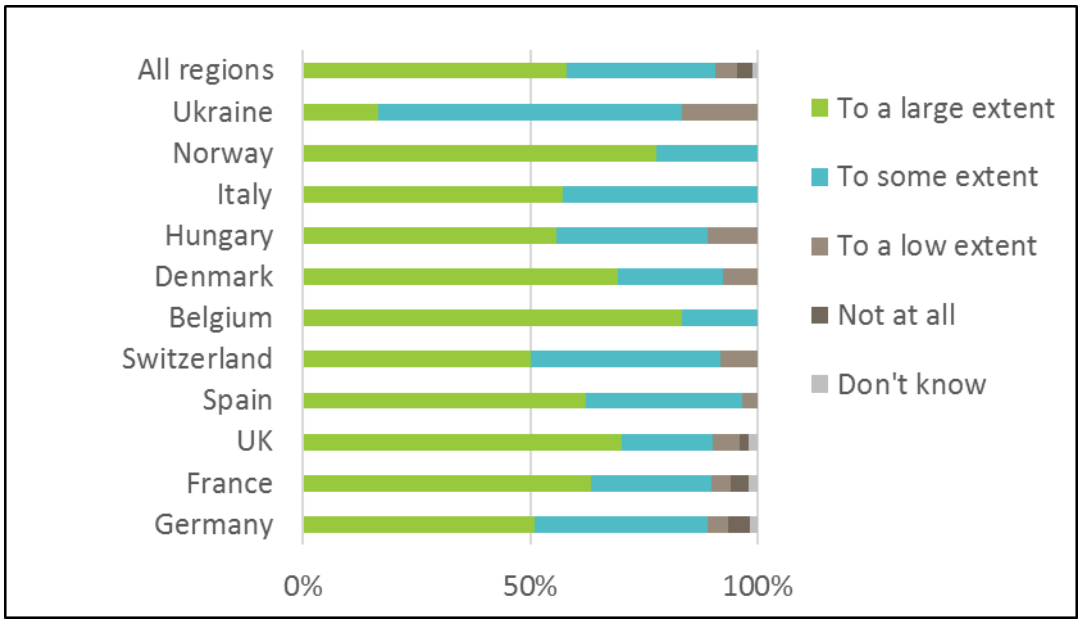


Figure 157: To what extent does SOC prevent soil erosion (Europe)

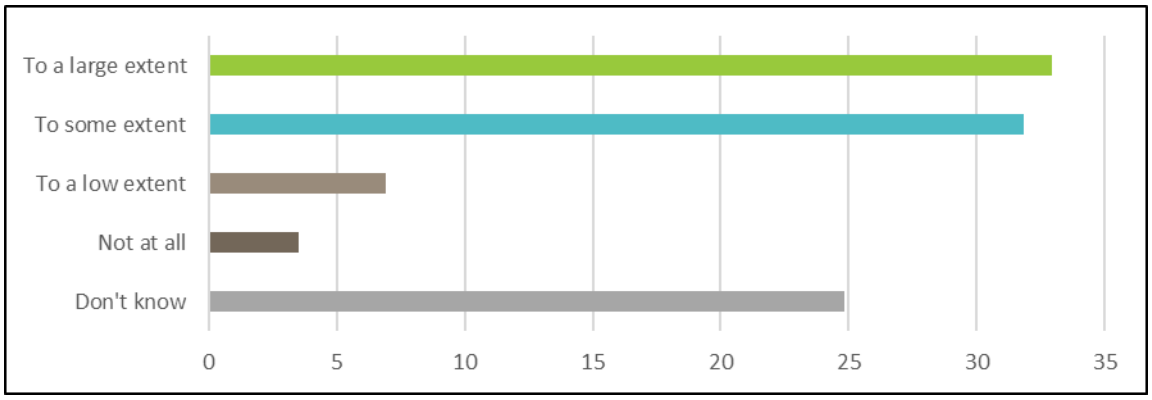


Figure 158: To what extent does SOC prevent soil erosion (Danish farmers)

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