

Action-oriented knowledge for sustainable management of organic soils in Finnish agriculture

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Agriculture is a contributing force to climate change due to unsustainable changes in land use with the usage of peatlands for food production in Finland. The use of organic soils in food production is a complex and politically driven issue, thus multistakeholder and participatory approaches to policy development, implementation and evaluation are essential. This study is integrating qualitative and quantitative methods in an iterative process to produce action-oriented knowledge for supporting actions to sustainably manage peatlands and reduce the enormous greenhouse gas emissions from agricultural peatlands. This study has engaged inter-disciplinary researchers and transdisciplinary actors in the Finnish food system via farmers, regional and ministry officials, food industry representatives along with education and research representatives to produce action-oriented knowledge for sustainability. The results indicate that actions are needed to develop a shared understanding between relevant actors and stakeholders in the food system to create activities and effective policy measures to remove peatlands from active production in Finland. Therefore, there is a necessity to identify and define incentives from both the public and private sectors to remove peatlands from food production, and thus reducing greenhouse gas emissions from agriculture. Interventions that account for local, regional, and national perspectives should be co-created among the inter-disciplinary researchers and transdisciplinary actors in the food system to generate transformative and system-wide change in the transition towards a low-carbon society.

Key words: peatlands, greenhouse gas emissions, food system, inter-disciplinary, qualitative method, quantitative method

Introduction

Humans with ingenuity, science and technology can adapt the environment to produce ever-increasing amounts of food to feed the growing population through various agricultural systems. However, more land than ever is dedicated to agriculture (Foley et al. 2005, Graham-Rowe 2011, Ramankutty et al. 2018), with higher resource intensity and overwhelming environmental impacts (Rockström et al. 2009), while diverting a large portion of crops to feed animals (Berners-Lee et al. 2018), biofuels (Fargione et al. 2008) and other non-food uses. To solve these challenges, tremendous progress should be made to halt agricultural land expansion, improve yields on underperforming lands, increase cropping efficiency, reduce food waste, and transition toward sustainable diets (Godfray et al. 2010, Foley et al. 2011, Huan-Niemi et al. 2020). In the effort to reduce greenhouse gas (GHG) emissions and mitigate climate change, notable progress can be made in Finland through sustainable management of peatlands or organic soils in agriculture.

More than half of the GHG emissions from Finnish agriculture is from the cultivation of organic soils, but the share of organic soils is only 11% of the cultivated land area in Finland (Kekkonen et al. 2019). Therefore, agriculture is a contributing force to climate change due to unsustainable changes in land use with the usage of peatlands for food production in Finland and agricultural peatlands emitting 9 million tonnes of CO₂ eq. per year (Statistics Finland 2021). According to Huttunen (2015), land clearing is an obvious solution that comes to mind for farmers when they are faced with the dilemma of acquiring more land, besides land purchase or leasing. Land clearing has a strong and ongoing cultural tradition in Finland (see Appendix). Among farmers and officials, land clearing is perceived as a normal way of developing a farm. Land clearing also provides a way of getting the much-valued own land, thus increasing independence and contributing to the prosperity of one's farm. Therefore, land clearance for new fields has increased cultivation on peatlands in Finland (Viitala et al. 2022). Furthermore, the Common Agricultural Policy (CAP) of the EU and its implementation in Finland have resulted in the increase of land prices and rents, thus land clearance has been considered as a competitive option to acquire new farmland compared to renting or purchasing farmland (Kässi et al. 2015). The increasing utilisation of agricultural peatlands is also

related to the higher national subsidy payments for dairy and beef production in the central and northern parts of the country. These subsidy payments have induced expanding milk production in Ostrobothnia and Northern Finland, where peatlands are relatively abundant. Some farmers who are located in Ostrobothnia and Northern Finland are concerned about the possible restrictions on the use of peatlands in agriculture because they have heavily invested in farming on peatlands (Puupponen et al. 2022).

The peatland question is connected to wider agricultural and agri-environmental policies (Huttunen 2015). Studies (Kivimaa et al. 2012, Mela et al. 2014) have claimed that land clearing is the combined result of strict environmental policies relating to water pollution that demand increasing land areas for manure spreading along with the economic need of farms to expand their production. The agri-environmental policies in Finland have concentrated on the implementation of water protection and biodiversity measures but decreasing GHG emissions have not been in the focus of the agri-environmental policies in Finland (Hyvönen et al. 2020).

The role of peatlands or organic soils in food production as well as a main source of GHG emissions from agriculture is a problematic issue among the actors in the Finnish food system. Puupponen et al. (2022) asserted that the use of agricultural peatlands is a politically sensitive question, as farmers perceive themselves as being in the most vulnerable situation in terms of carbon neutrality goals in Finland. If public policy restricts the use of peatlands, farmers also expect public compensation. Other food system actors tend to be sympathetic to farmers' needs and see that the solutions should not create additional burdens for farmers (Huttunen et al. 2022). From the perspective of reducing carbon emissions from the agricultural sector, the high emphasis on farmer livelihoods and securing food production in Finland complicates the identification of workable solutions via the food system.

Food systems are facing a triple challenge: providing food security and nutrition, supporting livelihoods for those working in the food supply chain, and contributing to environmental sustainability (OECD 2021). Better policies for the food system will require breaking down silos between agriculture, social, and environmental policies to overcome knowledge gaps, resistance from interest groups, and differing values. Action-oriented knowledge for sustainability is needed to develop better policies. Action-oriented knowledge emerges when integrated ways are utilised with many kinds of knowledge involved in the shared design (Caniglia et al. 2021). The objective of this study is to produce action-oriented knowledge for sustainable management of organic soils in Finnish agriculture by integrating qualitative method (stakeholder dialogues, focus groups, interviews) with quantitative method (modelling, cost estimations) together with assessing and developing the integrated knowledge in an iterative process by engaging stakeholders from across the food system. Currently, there are no explicit policy measures or actions in Finland for addressing the substantial GHG emissions from agricultural peatlands, thus action-oriented knowledge is needed to propel actions and create policy measures to reduce GHG emissions from agricultural peatlands.

Material and methods

A key feature of mixed methods research is its methodological pluralism, which frequently results in superior research compared to monomethod research (Johnson and Onwuegbuzie 2004). Therefore, the reasons for integrating the quantitative and qualitative methods are twofold: it can serve for the mutual validation of data and findings as well as to produce a more coherent and complete picture of the investigated domain than a single research method can yield (Kelle 2006). Sattar et al. (2017) utilised quantitative and qualitative approaches to study the adoption of sustainable agricultural practices. The quantitative approach provided data on whether variations have occurred because of introducing sustainable agricultural practices. The qualitative approach provided an in-depth understanding of farmer's behaviour about the uneven socio-economic factors, institutional features, perceptions and informational factors, resource endowments, and psychological factors. Gardner et al. (2021) combined quantitative and qualitative methodology to assess prospects for novel crops in a warming climate. Climate and crop models were used to identify environmental constraints to growing novel crops. Delphi methodology was used to understand non-climatic constraints on crop suitability and farming decisions. This study is combining qualitative and quantitative methods to investigate the possibility of reducing GHG emissions from agricultural peatlands, whereby the use of peatlands is a complex and politically driven issue among farmers and other stakeholders in Finland.

Integrating qualitative and quantitative methods in an iterative process to produce action-oriented knowledge

The qualitative and quantitative methods were integrated by creating feedback loops in a deliberate and innovative way for an iterative process to relay in depth information between the qualitative and quantitative methods for data evaluation, validation, and reflection (see Figure 1). Action-oriented research was utilised to adopt critical approaches that aim for improvements in acquiring knowledge for sustainable management of organic soils in agriculture (see Figure 2). The advantages of using action-oriented research are i) high level of practical relevance of the research; ii) qualitative data as well as quantitative data can be used; and iii) ability to gain in-depth knowledge about the problem. This study started with data collection from stakeholders in the food system with policy dialogue I & II as well as the conducted survey. Selected information concerning the usage and management of agricultural peatlands was analysed and used as the base for modelling three different scenarios to reduce GHG emissions from organic soils in Finland by 33% in 2035 and by 70% in 2050: i) voluntary measures, ii) organic soil is still used for grass production only, iii) no more food production on organic soils. The modelling results were discussed in one of the focus group discussions for land use management. The stakeholders in the focus group discussed and evaluated the modelling results. Feedback from the focus group discussion was analysed and used for the planning of the next action. The costs of the alternative management options for peatlands were estimated to serve as an input for policy dialogue III to evaluate the economic feasibility of implementing management options such as wet grassland and afforestation. After analysing the feedback from policy dialogue III, the general costs of the alternative management options such as wet grassland and afforestation were tailored for municipalities from regions containing the highest share of organic soils in Finland such as Northern Finland and Ostrobothnia. Finally, the cost estimations for wet grassland and afforestation were evaluated by farmers from Northern Finland in Posio and from Ostrobothnia in Perho via personal interviews to discover whether the estimated investment costs and subsidy payments would be politically and economically realistic to reduce GHG emissions from agricultural peatlands.

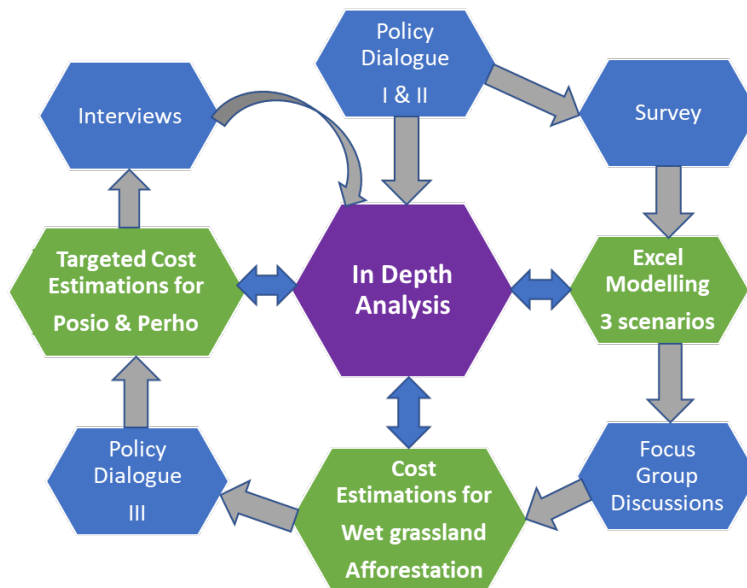


Fig. 1. Feedback loops in a deliberate and innovative way between the qualitative and quantitative methods for data evaluation, validation, and reflection

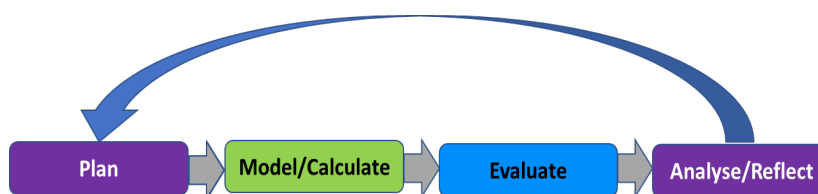


Fig. 2. Action-oriented research to adopt a critical approach that aims for improvements in acquiring knowledge for sustainable management of organic soils in agriculture

The feedback loops (see Figure 1) were important response mechanisms between the stakeholders from across the food system via the qualitative method (blue boxes) and the quantitative method (green boxes) for data evaluation, validation, and reflection. The iterative process (see Figure 2) with in-depth analysis (purple boxes) of the acquired information from the qualitative method by the inter-disciplinary researchers served as inputs for planning the Excel modelling of different scenarios and calculations for implementing wet grassland and afforestation. The acquired information from the quantitative method served as inputs for planning the focus group discussion on land use management, the policy dialogue to evaluate the economic feasibility of implementing the management options, and the interviews conducted with farmers at the municipal level in Posio and Perho. The feedback loops are not only to indicate the need of modelling results and cost estimations to get more targeted and detailed input from the stakeholders, but also to provide information to the stakeholders for a deeper understanding on the impacts and costs of the selected measures for sustainable management of agricultural peatlands. This will make the research outputs more practical, meaningful, and action-oriented towards sustainability.

Policy dialogue I and II (Qualitative Method)

The qualitative method with the involvement of stakeholders from the food system were conducted in consequential steps (see Table 1). All group discussions in the policy dialogues were recorded and transcribed. The transcribed texts were used as the source for qualitative content analysis. The content analysis focused on the participants' perceptions on policy means, their acceptability, and feasibility in utilising and managing peatlands.

Table 1. The consequential steps for the qualitative method with the involvement of stakeholders from across the food system

Event	Number of participants	Stakeholders represented by participants	Purpose	Type of data
1) Policy dialogue I & II 8.10.2019 & 29.10.2020	Three groups with 18 participants	Central government, NGO, interest or expert organization, food industry, education and research, farmers	Perceptions on just transition towards low- carbon food system, and identification of policy means for land use	Transcripts of group discussions (1.5–2h each)
2) Survey 20.1 – 2.2.2021	80 respondents	Representatives from food-related agencies, organizations and businesses	Effectiveness, feasibility, and fairness of policy means	Descriptive statistics and open-ended responses
3) Focus group discussions 26.2 – 7.5.2021	Four groups with 19 participants focusing on land use transition and related policies	14 farmers/ farmers' union representatives, 2 regional council officers, 1 from industry, ministry and educational institution	Perceptions on fairness of the policy means for land use transition	Transcripts of group discussions (2 h each)
4) Policy dialogue III 28.11.2021	One group focusing on peatlands with 4 participants	Central government, Farmer interest organization, expert organization, food industry	Perceptions on the use of peatlands in agriculture	Transcript of group discussion (1.5 h)
5) Interviews 10.2 – 2.3.2022	5 in Perho 4 in Posio	Farmers in Perho and Posio	Feasibility of the selected measures for peatlands	Transcripts of interviews (25–50 min each)

First, two policy dialogue workshops were organised for the food system actors. The workshops included separate agricultural production and peatland related discussions which set the ground for understanding stakeholders' perspectives regarding the utilisation of peatlands and related just policy measures. The contents of the group discussions were analysed by concentrating on the participants' perceptions on the usage and management of agricultural peatlands.

While the stakeholders recognised the issue of peatlands as crucial for reducing GHG emissions, they regarded peatlands as necessary for the livelihood of some farmers. Therefore, they considered the establishment of strict regulations on the usage of peatlands as challenging for farmers with high share of organic soils in their farms. The discussants preferred compensation measures and technical support for farmers, if restrictions or demands for actions would be imposed on the utilisation of peatlands. Furthermore, the discussants emphasised that solutions should be found from a broader food system level and farmers should not be blamed for owning and utilising peatlands.

Survey (Qualitative Method)

Policy dialogue I and II served as the base for the exploratory survey to map the more specific perceptions of food system actors on policy means for just food system transition. The survey included a separate section on policy means for land use transition. This survey consisted of a 5-scale questionnaire on the effectiveness and feasibility of given policy measures and an additional open-ended question concerning fairness of policy measures.

In the survey, there were two questions directly related to organic soils in the land use section. The respondents were asked to assess the effectiveness and feasibility (1 = low; 5 = high) of two given policy measures: “supporting peatland restoration and removing from cultivation by using public funding” received mean value of 3.58 for effectiveness and 3.03 for feasibility, whereas “restricting cultivation activities on peatlands” received mean value of 3.47 for effectiveness and 2.74 for feasibility. Hence, ‘a carrot’ is perceived as a more effective and feasible measure than ‘a stick’. In the open-ended question, the agglomeration of animal husbandry in certain peatlands dominated regions where livestock production has increased was seen as a problem. In addition, a long transition period for banning the use of peatlands and a funding mechanism for peatlands restoration especially for low-yield fields was suggested. From a just transition point of view, regional inequality was raised as a major issue.

Excel modelling (Quantitative Method)

Findings from the conducted policy dialogue I and II as well as the survey suggested that information and a support system would be needed for farmers to change the utilisation and management of agricultural peatlands, whereas strict regulations were perceived as unjust. Paludiculture, afforestation, and restoration were the suggested measures for sustainable management and usage of agricultural peatlands. These findings were utilised as the base for modelling three different scenarios: i) voluntary measures, ii) organic soil is still used for grass production only, iii) no more food production on organic soils.

The Finnish government program has very ambitious climate objectives: compared to the EU’s objective to be climate-neutral by 2050, Finland aims to be carbon neutral by 2035. Therefore, the inter-disciplinary researchers came up with the assumptions to reduce GHG emissions from agricultural peatlands by 33% in 2035 and by 70% in 2050, whereby the basis for the targets was roughly based on the feedback from the stakeholders.

The Excel based model is a simple spreadsheet used to simulate the necessary land use change with the aim to reduce GHG emissions from agricultural peatlands in Finland by 33% in 2035 and by 70% in 2050. Both reduction targets would require large changes in the usage of agricultural peatlands, thus only a small amount of land would be allocated for emission intensive activities and a large amount of land would be allocated to activities with low GHG emission intensity. Table 2 is showing the GHG emissions from the cultivation and other activities on peatlands.

Table 2. The GHG emission intensities for the different types of activities on peatlands

Activities	GHG emissions (CO ₂ eq. t ha ⁻¹ year ⁻¹)
Annual crops	35.1
Perennial crops/grasslands	25.3
Abandoned agricultural peatland	15.5
Wet grasslands, water table 30 cm below surface	14.9
Paludiculture, water table 5–10 cm below the surface	2.8
Restoration of agricultural peatland	2.8
Afforestation of agricultural peatland, first 20 years of afforestation	18.0
Afforestation of agricultural peatland, after 20 years of afforestation	3.0

Source: Kekkonen et al. 2019

The Excel model consists of GHG emission information (see Table 2) and the areas for all the different activities on agricultural peatlands in 2020: annual crops (cereals such as oats and barley, feasible to be grown on peatlands with low soil pH, total 93 000 ha), perennial crops (grass forage, grass covered set aside, total 162 000 ha), and abandoned agricultural peatlands not considered as forested land (total 67 000 ha). The data on the usage of agricultural peatlands in 2020 were extracted from the National GHG Inventory (Statistics Finland 2022a). In the modelling exercise, the areas allocated for all the activities included in Table 2 were based on year 2020 values, thus the simulated GHG emissions were changing annually from 2021–2050.

The purpose and function of the Excel model was to provide a tool for keeping track of the land use changes in relation to the reduction of GHG emissions, therefore all land allocations were determined exogenously in the model. The Excel model was utilised to analyse the assumed combinations of land allocation (three different scenarios) for the different types of activities (see Table 2) on agricultural peatlands from 2021 up to 2050 with the total area of agricultural peatlands remaining constant, hence simulating the total GHG emissions for the three different scenarios below.

i) Voluntary measures

Voluntary measures whereby “green farmers” are willing to take measures to mitigate GHG emissions from organic soils on their farmlands: 25 000 ha of wet grassland and 20 000 ha afforestation of abandoned organic soils.

GHG emissions from organic soils could only be reduced by 7% (0.6 million tonnes of CO₂ eq. per year) in 2035 and by 10% (0.9 million tonnes of CO₂ eq. per year) in 2050 (see Figure 3). This scenario could not achieve the aim to reduce GHG emissions from organic soils by 33% in 2035 and by 70% in 2050 with only voluntary measures by “green farmers” to reduce GHG emissions from their farmlands.

ii) Organic soil is still used for grass production only

Organic soil is still used for food production, but only providing grass for feeding dairy cows. 120 000 ha is used for wet grassland and another 120 000 ha is restored into wetlands, totalling 240 000 ha along with 50 000 ha afforestation of abandoned organic soils and 10 000 ha used for paludiculture.

GHG emissions from organic soils could be reduced by 33% (2.9 million tonnes of CO₂ eq. per year) in 2035 and by 63% (5.6 million tonnes of CO₂ eq. per year) in 2050 (see Figure 3). This scenario could achieve the aim to reduce GHG emissions from organic soils by 33% in 2035 but not by 70% in 2050. Grains are no longer cultivated on organic soils, but only wet grasslands would remain on peatlands for milk production as well as all peatlands no longer cultivated are restored and abandoned peatlands are afforested.

iii) No more food production on organic soils

No more food production on organic soils, whereby most of the organic soils are restored into wetlands: 240 000 ha is restored into wetlands as well as 50 000 ha afforestation of abandoned organic soils along with 10 000 ha used for paludiculture.

GHG emissions from organic soils could be reduced by 41% (3.6 million tonnes of CO₂ eq. per year) in 2035 and by 79% (7 million tonnes of CO₂ eq. per year) in 2050 (see Figure 3). This scenario could exceed the aim to reduce GHG emissions from organic soils by 33% in 2035 and by 70% in 2050. However, this is extremely challenging and hard to accomplish because peatlands are no longer used in agricultural production whereby 240 000 hectares (almost all) of agricultural peatlands would need be restored into wetlands.

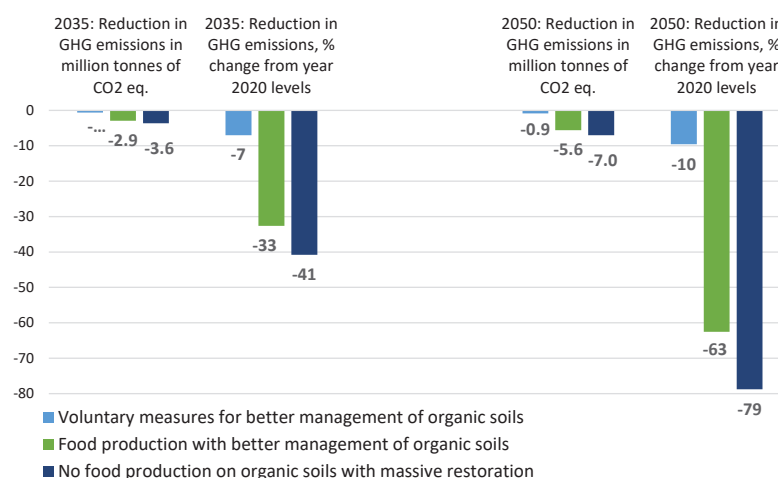


Fig. 3. The potential in reducing GHG emissions from organic soils in Finnish agriculture with three different scenarios (2035 and 2050)

Focus group discussions (Qualitative Method)

Four focus group discussions were conducted on land use transition to continue working with the policy measures for sustainable land management. Two groups discussed fairness of public policy measures, while the third group focused on private policies for sustainable land management in connection with dairy supply chains. In the last focus group, the participants were presented with information (projections) from modelling the potential to reduce GHG emissions from organic soils in Finland by 33% in 2035 and by 70% in 2050 with three different scenarios for land use. It should be noted that most of the participants in the focus groups were farmers or representatives of farmers' interest groups (see Table 1).

Findings from the focus groups strengthened the understanding provided by the policy dialogues (I & II) and survey: the role of organic soils in food production was seen as a problematic issue and strict regulations on the usage of organic soils would be difficult to implement. The focus group participants were reluctant to strongly regulate the use of organic soils in agriculture, which are highly important to livestock farmers, due to the need to produce animal feed and spread manure at the farm level. The participants highlighted the importance of private property (land) protection. They also indicated a need for more straightforward scientific communications and consistent research results due to the perceived measurement uncertainties and inconsistencies related to the role of organic soils and the accounting of GHG emissions from organic soils. Participants assessing the modelling results were sceptical about the fairness of strict regulations, but instead speculated on the potential of market-based mechanisms, which could provide market-based incentives for farmers to decrease GHG emissions from peatlands. Moreover, regional or farm-level policy measures were preferred instead of one-size-fits-all policy measures. Regionally or locally tailored economic incentives, advisory services, and support to agriculture were favoured over strict regulations. There was a consensus among production-oriented farmers that CAP subsidies should be paid for active food production instead of paying subsidies for "doing nothing" (i.e., maintaining the fields in good condition but not producing food or feed). In addition, participants highlighted the need to support collaboration between farms in terms of field exchanges and re-parcelling land areas. The focus group participants assessing the modelling results thought that voluntary measures could work in regions where the proportional share of peatlands is small. Participants thought that subsidy payments could promote wet grassland, paludiculture, and afforestation on organic soils, but were doubtful about the political and economic feasibility of the needed subsidy levels.

The cost estimations for wet grassland and afforestation (Quantitative Method)

The feedback from the focus group discussions was used for the planning of the next action. A need was identified to understand better the costs related to the different measures for sustainable management of agricultural peatlands. The costs for the alternative management options for peatlands were estimated to serve as an input for further stakeholder discussions (policy dialogue III) to evaluate the economic feasibility of implementing wet grassland and afforestation. The investment costs for installing the adjustable drainage system on peat soils for wet grassland were based on Pro Agria (2019) estimations along with the subsidy payment for the annual cost of maintenance from the Finnish Food Authority (2021). It was estimated that the investment costs for wet grassland would be 3 500 euros ha⁻¹ and the annual maintenance subsidy from the Finnish Food Authority would be 70 euros ha⁻¹. The afforestation cost of agricultural peatlands was based on Aro et al. (2020) estimations of the costs in growing Scots-pine trees on cutaway peatlands. It was estimated that the investment costs for afforestation would be 1 800 euros ha⁻¹.

Policy dialogue III (Qualitative Method)

In the last policy dialogue, the participants were presented with the alternative management options for peatlands with information about their effectiveness in terms of GHG emissions and biodiversity impacts as well as the cost estimations for implementing the different management options for peatlands such as wet grassland and afforestation. They were asked to use this information to evaluate the feasibility and acceptability of the alternative measures.

The participants overall agreed with the findings from the focus groups and emphasised voluntary actions and carrots for farmers in the effort towards a just transition in the food system. Regarding the cost estimations of the alternative measures, the participants underlined the need to know more about the wider environmental, economic, and social impacts in the affected regions. Especially, the impacts on local livelihoods and other sources of income besides farm income would need further consideration if food production would be significantly reduced on peatlands. More broadly, the participants emphasised the need to identify a workable set of different

measures rather than focusing on just one solution. Therefore, there would be a need for more specific information on the impacts at the farm-level for the most affected regions and the costs for implementing the alternative management options for peatlands at the local level.

The cost estimations with Excel spreadsheet (Quantitative Method)

After analysing the feedback from policy dialogue III, the general costs of the alternative management options such as wet grassland and afforestation were tailored for municipalities from regions containing the highest share of organic soils in Finland. Data at the municipal level from the Economic Development, Transport and Environment (ELY) centres (Luke 2021) are examined to extract municipalities from Northern Finland and Ostrobothnia with high shares of organic soils. The economic and socioeconomic statistics between the chosen municipalities (Posio and Perho) are compared to the national level by using data retrieved from Statistics Finland (2022b). Different type of investment costs and subsidies for changing the management of organic soils tailored to Posio in Northern Finland and Perho in Ostrobothnia are calculated to examine whether the investment costs and subsidies are economically feasible to be implemented at the farm level.

Posio and Perho were chosen to represent municipalities with low urbanization rates and high share of workplaces in primary production compared to the national level along with a large proportion of farmland consisting of peatlands. The intention was to examine whether farmers with poor production conditions and weak employment opportunities would be willing to change their farming practices with subsidy payments as the incentive to reduce GHG emissions from peatlands. Table 3 is showing the estimated levels of investment costs and subsidy payments for implementing wet grassland and afforestation as the selected options for sustainable management of peatlands.

Table 3. Different levels of investment costs and subsidy payments calculated for Posio (Northern Finland) and Perho (Ostrobothnia)

				WET GRASSLAND		AFFORESTATION	
	Peatland proportion	Farmland total 2019 hectares	Grassland total 2019 hectares	Peatland total 2019 hectares	Investment cost euros	Annual maintenance cost euros	Investment cost euros
POSIO	24.0%	1 421	1 405	341	3 500 euros ha ⁻¹ 1 193 500	70 euros ha ⁻¹ * 23 870	1 800 euros ha ⁻¹ 613 800
PERHO	34.7%	14 371	8 784	4 987	17 454 500	349 090	8 976 600

*Currently paid under the second pillar of the CAP agri-environmental scheme of subsidy payments

Interviews with farmers (Qualitative Method)

In order to gain in depth knowledge from regions containing the highest share of organic soils in Finland, five farmers in Perho (Ostrobothnia) and four farmers in Posio (Northern Finland) were interviewed to extract local farmers' perspectives on specific measures for managing peatlands in their farms and regions. The interviews were short thematic interviews focusing on farming method for wet grassland and afforestation of peatlands. A graphic demonstration of the alternative management options for peatlands were sent in advance to the farmers. It included GHG emissions and biodiversity impacts of the options as well as the estimated levels of investment costs and subsidy payments for wet grassland and afforestation. In the interviews, farmers were contemplating the feasibility of implementing the specific measures on peatlands in their farms. Eight of the interviewees have a dairy farm and one has a grain farm. The cultivated area varied from 80 to 170 hectares and the share of peatlands varied between 30 and 80 percent. The peatlands in Perho and Posio are mainly cultivated with grasslands. These municipalities are located in regions where dairy and beef production are based on grasslands and there are limited economically viable or competitive alternatives for agricultural production. The interviews were analysed by paying attention to the farmers' perceived ability to adopt the different management options and their reasoning behind the perceptions.

The interviews conducted at the farm level in Perho and Posio confirm the findings of the focus group discussions: regulation on the usage of organic soils would be problematic and difficult to implement. The results are rather similar to the study conducted by Virkkunen and Leppänen (2022) whereby 19 farmers (mostly livestock farms with a large proportion of peatlands) from different municipalities were interviewed in Ostrobothnia and Northern Finland. In general, the interviewed farmers felt that they are dependent on the peatlands. They need

area for farming, and they were concerned about the possible restrictions on the cultivation of peatlands. Some of the farmers have invested heavily in dairy production, thus increasing their dependence on the usage of peatlands. Concerning the feasibility of the different measures for peatlands, almost none of the interviewed farmers were interested in wet grassland farming; and there was no difference of opinions between the farmers in Perho and Posio. The farmers were sceptical regarding wet grassland farming, and they thought it is not a productive and suitable method for dairy farms. They said that the machineries are heavy, and they already have difficulties with the load capacity of the fields. Thus, they will encounter more problems with wet grassland farming. However, some of the farmers were not familiar with the method and there would be a need for more information and guidance. A couple of farmers were interested in the adjustable subsurface drainage method. Still, the interviewed farmers had difficulties in evaluating the feasibility of subsidy payments for wet grassland farming. Some of them said that they should get at least the same income compared to the current farming method, but the productivity of wet grassland was questioned. One of the interviewed farmers also suggested that farmers should get for wet grassland farming the same annual subsidy as for grasslands under the environmental protection zones (500 euros ha⁻¹ for protection zones in target area II).

Afforestation seemed to be the option that was slightly more realistic from the farmers' point of view, but only in certain circumstances. Nearly all the interviewed farmers said that they could afforest certain small areas that would be difficult to cultivate or are located in a far distance. However, farmers were not willing to afforest all their peatlands because they thought that the fields would be needed for food production. Similar to the wet grassland option, farmers found it difficult to evaluate what would be the realistic level of subsidies for afforestation. If a farmer would receive the full reimbursement for the investment costs (1 800 euros ha⁻¹), the subsidy payments may lead some farmers to afforest their peatlands, however the interviewed farmers did not consider this as an option for them. According to the farmers, afforestation is not possible to combine with dairy production because the fields are needed to produce feed for their livestock. The farmers in Posio also questioned the afforestation option because they thought that the trees would not grow due to the northern climatic conditions. Like the feedback from the farmers in the focus groups, the current subsidies paid according to the field area were seen in a negative way: subsidies prevent active farms from getting new fields because the CAP subsidy payments have caused the increase in land prices. According to the interviewed farmers, resembling the opinion of production-oriented farmers in the focus groups, the subsidy payments should be directed to active farms through transfers of subsidy payments between farms and land consolidations. Thus, the farmers saw themselves foremost as food producers. They would be willing to accept changes that would support better possibilities for food production in their farms, but the proposed management options for organic soils presented risks to their agricultural production.

Results and discussion

Farmers in the focus groups and interviews are clearly production oriented. However, the intensive use of peatlands will cause high GHG emissions. Stopping cultivation on peatlands would rapidly reduce GHG emissions from agricultural peatlands; and paying subsidies to stop cultivation and activities on organic soils could be a future policy measure. Another way to stop cultivation on peatlands could be buying agricultural peatlands from farmers via public or private initiatives. There is a need to identify a workable set of different measures rather than focusing on just one solution in reducing GHG emissions on peatlands, hence avoiding one-size-fits-all policy measures. Multi-functional solutions and angles are essential to support actions for the sustainable management of peatlands in agriculture and reduce the enormous GHG emissions from agricultural peatlands.

The aim to reduce GHG emissions from agricultural peatlands in Finland by 33% in 2035 and by 70% in 2050 could not be achieved because farmers at the farm level, especially in regions with high shares of peatlands, are not willing to change the usage or management of agricultural peatlands. In order to reach the reduction targets, almost all agricultural peatlands in Finland (240 000 ha) should be under restoration. Moreover, the costs for restoration cannot be estimated currently because there are no cases of restoring agricultural peatlands available in Finland. Only one case can be found in Finland whereby an abandoned agricultural peat field with grown bushes and small trees has been properly restored in Eastern Finland, nearby a protected area in Juuka (restoration handbook by Aapala et al. 2013). Even with the scenario that allows food production on agricultural peatlands, a huge amount of land (120 000 ha) would need to be restored and a lot of agricultural peatlands would be under the measure of wet grasslands farming (120 000 ha). Wet grasslands are not considered as an option for farmers due to the numerous difficulties face at the farm level. Moreover, the assumption for the voluntary measures is over ambitious because it would be very difficult to find farmers, who are owning 25 000 ha of agricultural peatlands, to volunteer for implementing wet grasslands in their farms. There is a clear distinction between the quantitative

and qualitative research outputs: the modelling exercise to reduce GHG emissions from agricultural peatlands gave the impression that it might be possible to have ambitious targets, however, the ambitious targets could not be achieved according to the farmers and stakeholders because changing farming practices for sustainable management of peatlands are extremely difficult at the farm level especially in regions and municipalities with high proportion of peatlands, poor production conditions, and weak employment opportunities.

The low feasibility among the interviewed farmers to reduce GHG emissions from agricultural peatlands via wet grassland farming and afforestation is not only applicable in Finland, but also applies to farmers in other high-income countries. Prokopy et al. (2015) studied across six sites – Scotland, Midwestern United States, California, Australia, and two locations in New Zealand – and found that a minority of farmers express support for adaptation or mitigation actions. In the context of agri-environmental policies, the conflict between food production and the need to reduce the environmental/climate impact of agricultural production has been connected to farmers' identities (Burton and Praghawewa 2011).

According to Burton (2004), the production-oriented roles symbolise both to farmers and to the country, the notion of “good farming” practice and enabled farmers to claim a high social position as caretakers of the nation's food supply. What are often identified as “good farming” ideals focus on high productivity and manifest via symbols such as high yields and farming skills. Farmers and stakeholders in the food system may have the notion that food production in Finland would be at risk if peatlands are not used for food production. However, food production in Finland would not be endangered by stopping the clearance of new fields from peatlands. Finland is self-sufficient in grains production, whereby dairy production's self-sufficiency rate has been slightly more than 100% and more than 90% for meat production in recent years (Latvala et al. 2021). Therefore, from the viewpoint of food production, no new land area is needed in Finland. The utmost important way to deter GHG emissions from peatlands is to avoid clearance of peatlands for new agricultural fields. An effective and economically efficient measure would be imposing a land clearance fee (Assmuth et al. 2022).

Burton and Paraghawewa (2011) propose that in order to culturally embed the environmental/climate values, beliefs, and knowledges that underlie such policies, policymakers need to devise approaches that allow the creation of cultural and social capital within farming communities rather than simply compensating for economic capital lost. They outline two possible ways of accounting for cultural capital in policy creation: either through the development of measures for cultural capital that enable its incorporation into contemporary policies or through a major revision to the way in constructing and applying the agri-environmental as well as climate policies. It is culturally embedded in farmers that they are the caretakers of the nation's food supply, but there is a need to create a new culture that farmers are also the nation's land managers, who are able to reduce GHG emissions from agricultural peatlands. Both public and private initiatives should be created to support farmers and local communities who are going through the difficult transition to a low-carbon society. Further research is needed to study the cultural aspect when designing new policy measures. In addition, more research is needed to breach the measurement uncertainties and inconsistencies related to the role of organic soils in the attempt to improve the accounting of GHG emissions from agricultural peatlands. The food system approach and dialogues to identify the points of friction can engage stakeholders together in defining the different angles and problems in the effort to find the multi-functional solutions. Future research needs not only an iterative process, but also a deliberative process with the aim to involve the public and local communities together with the most affected stakeholders in a practical, meaningful, and effective way for a shared understanding and decision-making in using agricultural peatlands for food production as well as the urgent need to reduce GHG emissions to fight climate change.

Conclusions

Currently, there are no explicit policy measures or actions in Finland for addressing the substantial GHG emissions from agricultural peatlands, thus action-oriented knowledge is needed to propel actions and create policy measures for reducing GHG emissions from agricultural peatlands. The use of organic soils in food production is a complex and politically driven issue in Finland. Therefore, multistakeholder and participatory approaches to policy development, implementation and evaluation are essential. This study is integrating qualitative and quantitative methods in an iterative process to produce action-oriented knowledge for supporting actions to sustainably manage peatlands in agriculture and reduce the enormous GHG emissions from agricultural peatlands. This study has engaged inter-disciplinary researchers and transdisciplinary actors in the Finnish food system via farmers, regional and ministry officials, food industry representatives along with education and research representatives to produce action-oriented knowledge for sustainability.

The limitations of the action-oriented research in this study were the long process needed for the iterative actions to engage the actors and stakeholders as well as the difficulty in framing the circular and iterative research process. The planning of the policy dialogues started in August 2019, and the iterative research process continued for three years along with in-depth analysis of the acquired information from the qualitative and quantitative methods by the inter-disciplinary researchers. The final results are analysed in this article, whereby the circular and iterative research process are framed and reported concisely. The reproducibility of this study is only possible if the feedback loops can be created in a deliberate and innovative way to relay in depth information between the qualitative and quantitative methods for data evaluation, validation, and reflection.

The action-oriented knowledge produced in this study could support actions and shared agency to mitigate climate change as well as the development of individual and collective capacities for sustainable management of organic soils. For example, the interventions for reducing GHG emissions from agricultural peatlands may be easier if regions with lower shares of agricultural peatlands are targeted first and there are possibilities for alternative livelihoods when agriculture would no longer be the main source of income for farmers and rural communities. Future research could set-up a living-lab to apply a participatory multi-actor approach with the aim to build a transformative learning community, consisting of multidisciplinary scientists with diverse expertise (social and natural sciences) as well as transdisciplinary actors and stakeholders with specific knowledge and motivations (e.g., farmers or landowners, extension service, food companies, consumers, policymakers, local communities, government agencies). This learning community could act as a knowledge transfer forum to create the momentum for a just food system with better acknowledgement of regional disparity in the transition towards a low-carbon society.

The results indicate that actions are needed to develop a shared understanding between relevant actors and stakeholders in the food system to create activities and effective policy measures to remove peatlands from active production in Finland. Therefore, there is a necessity to identify and define incentives from both the public and private sectors to remove peatlands from food production, and thus reducing GHG emissions from agriculture. Interventions that account for local, regional, and national perspectives should be co-created among the inter-disciplinary researchers and transdisciplinary actors in the food system to generate transformative and system-wide change in the effort to reduce GHG emissions and mitigate climate change.

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References

- Aapala, K., Similä, M. & Penttinen, J. 2013. A Guide to Restoring Drained Peatlands. Nature Conservation Publications Series B 188. Vantaa: Metsähallitus. (in Finnish).
- Aro, L., Ahtikoski, A. & Hytönen, J. 2020. Profitability of growing Scots pine on cutaway peatlands. *Silva Fennica* 54: 10273. <https://doi.org/10.14214/sf.10273>
- Assmuth, A., Lintunen, J., Wejberg, H., Koikkalainen, K., Uusivuori, J. & Miettinen, A. 2022. The climate impacts of deforestation and climate change mitigation measures in Finland. *Natural Resources and Bioeconomy Studies* 31/2022. Helsinki: Natural Resources Institute Finland. (in Finnish).
- Berners-Lee, M., Kennelly, C., Watson, R. & Hewitt, C.N. 2018. Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation. *Elementa: Science of the Anthropocene* 6: 52. <https://doi.org/10.1525/elementa.310>.
- Burton, R.J.F. & Paragahawewa, U.H. 2011. Creating culturally sustainable agri-environmental schemes. *Journal of Rural Studies* 27: 95–104. <https://doi.org/10.1016/j.jrurstud.2010.11.001>
- Burton, R.J.F. 2004. Seeing through the ‘good farmer’s’ eyes: towards developing an understanding of the social symbolic value of ‘productivist’ behaviour. *Sociologia Ruralis* 44: 195–215. <https://doi.org/10.1111/j.1467-9523.2004.00270.x>
- Caniglia, G., Luederitz, C., von Wirth, T., Fazey, I., Martín-López, B., Hondrila, K., König, A., von Wehrden, H., Schöpke, N.A., Laubichler, M.D. & Lang, D.J. 2021. A pluralistic and integrated approach to action-oriented knowledge for sustainability. *Nature Sustainability* 4: 93–100. <https://doi.org/10.1038/s41893-020-00616-z>
- Fargione, J., Hill, J., Tilman, D., Polasky, S. & P. Hawthorne, P. 2008. Land Clearing and the Biofuel Carbon Debt. *Science* 319: 1235–1238. <https://doi.org/10.1126/science.1152747>

- Finnish Food Authority 2021. The different levels of environmental compensation. (in Finnish). <https://www.ruokavirasto.fi/viljelijat/tuet-ja-rahoitus/ymparistokorvaus/ymparistokorvauksen-korvaustasot>
- Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P. C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D. & Zaks, D.P. 2011. Solutions for a cultivated planet. *Nature* 478: 337–342. <https://doi.org/10.1038/nature10452>
- Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patzl, J.A., Prentice, C., Ramankutty, N. & Snyder, P.K. 2005. Global Consequences of Land Use. *Science* 309: 570–574. <https://doi.org/10.1126/science.1111772>
- Gardner, A.S., Gaston, K.J. & Maclean, I.M.D. 2021. Combining qualitative and quantitative methodology to assess prospects for novel crops in a warming climate. *Agricultural Systems* 190: 103083. <https://doi.org/10.1016/j.agsy.2021.103083>
- Graham-Rowe, D. 2011. Agriculture: Beyond food versus fuel. *Nature* 474: S6–S8. <https://doi.org/10.1038/474S06a>
- Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. & Toulmin, C. 2010. Food Security: The Challenge of Feeding 9 Billion People. *Science* 327: 812–818. <https://doi.org/10.1126/science.1185383>
- Huan-Niemi, E., Kaljonen, M., Knuutila, M., Niemi, J. & Saarinen, M. 2020. The impacts of dietary change in Finland: food system approach. *Agricultural and Food Science* 29: 372–382. <https://doi.org/10.23986/afsci.95282>
- Huttunen, S. 2015. Farming Practices and Experienced Policy Coherence in Agri-environmental Policies: The Case of Land Clearing in Finland. *Journal of Environmental Policy & Planning* 17: 573–592. <https://doi.org/10.1080/1523908X.2014.1003348>
- Huttunen, S., Tykkyläinen, R., Kaljonen, M., Paloviita, A., Kortetmäki, T. & Puupponen, A. 2022. Framing justice in sustainable food system transition in Finland. Paper presented at the Nordic Environmental Social Sciences conference 7.–9.6.2022. Gothenburg.
- Hyvönen, T., Heliölä, J., Koikkalainen, K., Kuussaari, M., Lemola, R., Miettinen, A., Rankinen, K., Regina, K. & Turtola, E. 2020. Environmental and cost-effectiveness of agri-environmental measures (MYTTEHO): Final Report. *Natural Resources and Bioeconomy Studies* 12/2020. Helsinki: Natural Resources Institute Finland. (in Finnish).
- Johnson, R.B. & Onwuegbuzie, A.J. 2004. Mixed Method Research: A Research Paradigm Whose Time Has Come. *Educational Researcher* 33: 14–26. <https://doi.org/10.3102/0013189X033007014>
- Kekkonen, H., Ojanen, H., Haakana, M. & Latukka, A. 2019. Mapping of cultivated organic soils for targeting greenhouse gas mitigation. *Carbon Management* 10:115–126. <https://doi.org/10.1080/17583004.2018.1557990>
- Kelle, U. 2006. Combining qualitative and quantitative methods in research practice: Purposes and advantages. *Qualitative Research in Psychology* 3: 293–311. <https://doi.org/10.1177/1478088706070839>.
- Kivimaa, P., Huttunen, S., Hildén, M., Laturi, J., Lehtonen, H., Pohjola, J. & Virtanen, Y. 2012. Climate policy coherence. Conflicts and synergies in policies influencing the production of forest bioenergy and food chains. *The Finnish Environment* 34/2012. Helsinki: Finnish Environment Institute. (in Finnish).
- Kässi, P., Niskanen, O. & Lehtonen, H. 2015. Field procurement options, costs, and the functioning of the field market. *Natural Resources and Bioeconomy Studies* 30/2015. Helsinki: Natural Resources Institute Finland. (in Finnish).
- Latvala, T., Niemi, J. & Väre, M. 2021. Finnish agri-food sector outlook 2021. *Natural Resources and Bioeconomy Studies* 72/2021. Helsinki: Natural Resources Institute Finland. <http://urn.fi/URN:ISBN:978-952-380-292-6>
- Luke 2021. Economydoctor. Soil Class Information. Luke Soil Class Data. Assessed May 4 2022. https://portal.mtt.fi/portal/page/portal/economydoctor/soil_class_information/own_criteria/
- Mela, H., Huttunen, S. & Hildén, M. 2014. How different policies affect land clearing? *Maaseudun uusi aika* 3: 81–91. (in Finnish).
- OECD 2021. Making Better Policies for Food Systems. Paris, France: OECD Publishing. <https://doi.org/10.1787/dfbba4de-en>
- Pro Agria 2019. Investment support for drainage has risen. Assessed 23.04.2019. (in Finnish). <https://www.proagria.fi/ajankoh-taista/salaojituksen-investointituki-on-noussut-11623>
- Prokopy, L.S., Arbuckle, J.G., Barnes, A.P., Haden, V.R., Hogan, A., Niles, M.T. & Tyndall, J. 2015. Farmers and climate change: a cross-national comparison of beliefs and risk perceptions in high-income countries. *Environmental Management* 56: 492–504. <https://doi.org/10.1007/s00267-015-0504-2>
- Puupponen, A., Lonkila, A., Savikurki, A., Karttunen, K., Huttunen, S. & Ott, A. 2022. Finnish dairy farmers' perceptions of justice in the transition to carbon-neutral farming. *Journal of Rural Studies* 90: 104–112. <https://doi.org/10.1016/j.jrurstud.2022.01.014>
- Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M. & Rieseberg, L.H. 2018. Trends in Global Agricultural Land Use: Implications for Environmental Health and Food Security. *Annual Review of Plant Biology* 69: 789–815. <https://doi.org/10.1146/annurev-arplant-042817-040256>
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J.A. 2009. A safe operating space for humanity. *Nature* 461: 472–475. <https://doi.org/10.1038/461472a>
- Sattar, R.A., Wang, S., Muqadas, M., Ashraf, M.F. & Tahir, M.N. 2017. Qualitative and quantitative approaches to study adoption of sustainable agricultural practices: a research-note on mixed method approach. *International Journal of Agricultural Extension and Rural Development* 5: 539–544.
- Statistics Finland 2021. Greenhouse gas emissions in Finland 1990 to 2019. National Inventory Report under the UNFCCC and the Kyoto Protocol. Helsinki: Statistics Finland.
- Statistics Finland 2022a. Greenhouse gas emissions in Finland 1990–2020. National Inventory Report under the UNFCCC and the Kyoto Protocol. Helsinki: Statistics Finland. https://www.stat.fi/static/media/uploads/tup/khkinv/fi_nir_eu_2020_2022-03-15.pdf

Statistics Finland 2022b. Municipal Key Figures by Information and Region. Helsinki: Statistics Finland. https://pxnet2.stat.fi/PX-Web/pxweb/en/Kuntien_avainluvut/

Viitala, E.-J., Assmuth, A., Koikkalainen, K., Miettinen, A., Mutanen, A., Wall, A., Wejberg, H. & Lehtonen, H. 2022. The climate impacts of agricultural and forestry incentive schemes. *Natural Resources and Bioeconomy Studies 21/2022*. Helsinki: Natural Resources Institute Finland. (in Finnish).

Virkkunen, E. & Leppänen, J. 2022. Farmers' views on the reduction of greenhouse gas emissions from peat fields. *Suomen Maataloustieteellisen Seuran Tiedote Nro 40: Maataloustieteen Päivät 2022*. (in Finnish). <https://doi.org/10.33354/smst.115651>

Appendix: Historical development of peatlands used in Finnish agriculture

Before Finland's independence in 1917	1917–39	1940–59	1960–1995	1995–2020
In the 1800s mires were understood as wastelands, which should be taken into use. This view was greatly supported by literature. Authors like J.L. Runeberg in his poem "Saarijärven Paavo" created characters who cultivated mires, fighting against night frost, and with laborious labour finally succeeded (Lindholm and Heikkilä 2006).	As a result of the Land Acquisition Act (Lex Kallio) enacted in 1922 and land clearing subsidies, the arable area increased by around 660 000 ha by the end of the 1930s. The Act was repealed in 1938. The first inventory of the proportion and distribution of organic soils in 1920 showed that they represented 25% of the cultivated field area (Malm 1922), meaning a total area of 500 000 ha of organic soils (Myllys and Sinkkonen 2004).	An active era for peat soil drainage for agriculture were the years after the Second World War in 1950s and 1960s, when land was needed to compensate land losses to the Soviet Union. More than 300 000 ha of new arable land was cleared, spurred by the clearing incentives. Pessi (1966) calculated that the proportion of mire originated fields in 1950 was 29.7%, which equals approximately 720 000 ha, and 750 000 ha in 1960.	Clearing of arable land stopped in the 1960s and 1970s due to agricultural overproduction problems. There was a small amount of land clearing until the end of the 1980s, when a clearing fee was introduced, which practically stopped the clearing. Valmari (1982) has estimated that the total amount of mires cleared for agriculture would have been as much as one million hectares. Part of the organic soils changed first to mull soils and finally to mineral soil fields.	The clearance of peat soil for agriculture has continued in Finland and has been relatively extensive since 1990, totalling approximately 43 000 ha. According to the 2020 inventory of cultivated organic soils, the area of these soils was 260 000 ha, which is 11% of the total arable area. The proportion of organic fields is high in northern Finland (13-15%) and low in southern Finland (1-2%).
At the end of 1800s, Finnish Peatland Cultivation Association was established to promote mire cultivation.				

References

- Lindholm, T. & Heikkilä, R. 2006. Finland – land of mires. *The Finnish Environment* 23/2006. Helsinki: Finnish Environment Institute.
- Malm, E.A. 1922. Suot ja suoviljelys. [Peatlands and peatland farming] – In: Sunila, J.E., Nylander, H., Westermarck, B., Wuolijoki, W & Jutila, K.T. (eds.). *Suomen maatalous*: 418–427. WSOY, Porvoo. (in Finnish).
- Myllys, M. & Sinkkonen, M. 2004. Viljeltyjen turve- ja multamaiden pinta-ala ja alueellinen jakauma Suomessa. (Abstract: The area and distribution of cultivated organic soils in Finland). *Suo* 55: 53–60. (in Finnish).
- Pessi, Y. 1966. Suon viljely. (Peatland cultivation). WSOY, Porvoo-Helsinki. (in Finnish).
- Valmari, A. 1982. Cultivation of peatlands. In: Laine, J. (ed.). *Peatlands and their utilization in Finland*: 42–48. Finnish Peatland Society & The Finnish National Committee of IPS, Helsinki.