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Finnish farmers' views towards fluctuating and changing precipitation patterns pave the way for the future

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A R T I C L E I N F O

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A B S T R A C T

At high latitudes of Europe climate change is projected to alter the risk of flooding and drought depending on the season. Farmers are the ones who decide how and when to adapt to excess, scarcity, and even to extreme precipitation events in agriculture. To understand farmer's views on the needs and means to manage future changes in precipitation, a farmer survey was organized in 2018 with 4401 respondents and a follow-up survey in 2020 with 2000 respondents. The aims were: (1) to understand farmers' views on future changes in precipitation patterns, (2) to gain an insight into farmer views on prioritization of the potential key adaptation measures (irrigation, drainage and maintenance of soil conditions) to future floods and drought episodes and thereby, (3) to be better able to support farmers in their primary task of food production in a sustainable manner in a changing climate. This study highlighted that farmers need financial support, but also more information about the costs and benefits of the measures to cope with changing precipitation patterns—not least due to the many uncertainties in projecting future precipitation patterns. As fluctuating precipitation have many environmental impacts in addition to those on production per se, costs and investments of adaptation to climatic constraints should not be payable only by the farmers. Farmers prioritized the soil organic content (SOC) and well-functioning subsurface drainage as the main objects of their attention, and these were clearly ahead of future use of irrigation. Taking care of subsurface drainage, soil structure, SOC and functionality is the long-term means to maintain and improve sustainability and productivity, while the implementation of irrigation is a more flexible, one-off measure that requires short-term reactivity as an adaptation option.

1. Introduction

Global warming is projected to advance the thermal spring in the northern Europe, delay the onset of autumn, increase the length of the summer period by one month and shorten the thermal winter by as much as up to two months by the mid-century (Ruosteenoja et al., 2019). As climatic conditions have already changed, the northward shift of agro-climatic zones has been evidenced across Europe, and an accelerated pace of change is expected to take place in the near decades (Ceglar et al., 2019). Consequently, large zonal and temporal shifts in crops towards northern growing regions have already been demonstrated in Finland since 1996 (Peltonen-Sainio and Jauhiainen, 2020). Since the 1950s there has, however, been a tendency of increased drought in many regions of the world (Wang et al., 2018). Drought is projected to become more severe in the forthcoming decades and may thereby, cause higher yield losses in Europe (Webber et al., 2018). In addition to the higher risk of more severe drought episodes in Europe, heavy precipitation is projected to change towards more extreme daily rainfall events, though regions differ in the expected increase in intensification (Scoccimarro et al., 2015). Thereby, extreme precipitation events and fluctuating periods with limited and excess precipitation may be more challenging for crop production in the future.

In the high-latitude conditions of Europe, both flooding and drought risks are projected to change depending on the season (Lehtonen et al., 2014; Ruosteenoja et al., 2017). Precipitation may increase especially in the autumn and winter (Ruosteenoja et al., 2016). Reductions in precipitation and droughts may again become more common in the spring and early summer. Towards the end of the growing season rains may be more frequent, which is detrimental rather than beneficial for maturing crop stands (Peltonen-Sainio et al., 2018). In Finland, the distribution of precipitation during the crop's growth cycle is opposite to the requirements, i.e., steady and balanced water availability

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(Peltonen-Sainio et al., 2016b, 2016c), but it might be even more so in the future. Early summer drought is common (Peltonen-Sainio et al., 2011) and it takes place at the most critical developmental stages of seed producing crops (Rajala et al., 2009, 2011) causing 7–20% annual yield losses (mean across 30 years) depending on the region (Peltonen-Sainio et al., 2011). Furthermore, despite quite a high diversity of response identified among barley cultivars which have adapted to high-latitude conditions, no response diversity to drought or excess rain has been observed (Hakala et al., 2012).

Any shift towards more severe drought in Finland would challenge the rainfed crop production and call for consideration of irrigation (Peltonen-Sainio et al., 2015a, 2016a). Finland has abundant water reserves and one third of the fields are located next to waterways, and 50% of them are only 100 m from a water source (Peltonen-Sainio et al., 2015b). Climate projections concerning changes in precipitation are, however, uncertain compared temperature changes (Ruosteenoja et al., 2016). Nonetheless, recent projections suggest strong seasonal differentiation in precipitation patterns. Depending on the climatic model, summer precipitation is projected to increase, increase substantially, decrease, or remain the same as in recent decades (Ruosteenoja et al., 2016). The latter two cases would be especially challenging for crop production. However, plants may suffer from more severe drought despite a moderate increase in precipitation (Ylhäisi et al., 2010) because of temperature elevation, the consequent higher pressure for evapotranspiration, but also because later maturing and higher yielding future cultivars are likely to require more water. However, the elevated atmospheric CO_2 concentration decreases crop water demand through increase in crop water-use efficiency (Deryng et al., 2016). In the case that the rains come in sudden downpours instead of even precipitation, they will be less beneficial for crop production due to surface runoff (Puustinen et al., 2007; Warsta et al., 2014). Not to mention the short and long-term risks that flooding may cause, such as total crop failure, deterioration of crop quality, problems with harvesting, high energy costs for drying seeds, soil compaction, nutrient leaching, and erosion (Peltonen-Sainio et al., 2016c).

Taking care of the existing drainage systems and switching from rainfed to irrigated crop production systems are both effective and straightforward means to cope with the future projected fluctuations in precipitation. However, geographical differences in the future changes in precipitation as well as differences among irrigated crops (conventional and emerging) in water use efficiency may contribute to the general usefulness and extent of the implementation of irrigation systems (Okada et al., 2018). As a country with emerging potential for irrigation, Finland can benefit from all the advances in agricultural technology so far that have enabled the adoption of water-efficient irrigation methods (Zohaib and Choi, 2020). Complexity in considering all the future coinciding trends of changes coupled with the profitability of adaptation measures may, however, cause confusion rather than confidence among farmers. Uncertainty may be attributable to: (1) changes in the likelihood of periods of drought and excess water that may vary in severity depending on the location and time of the growing season, (2) high investment costs (and in the case of irrigation non-experiential understanding of them), (3) volatile commodity prices as well as (4) uncertainties about future subsidies and the Common Agricultural Policy of the European Union. Furthermore, public discussion may have further blurred farmers, as climate change related news in the Finnish media has dramatically increased since early 2000s (Lyytimäki et al., 2020) and they may be discordant. The role of agriculture was brought up in these discussions more frequently. Anticipated climate change opportunities for agriculture (e.g., longer growing season, novel crops, more diverse land use and higher yields) alongside with the emerging production risks (extreme weather events) and the need for farm-scale climate change mitigation actions may cause confusion among farmers contemplating their actions. The public discussion especially around the agricultural use of peatlands has blamed farmers for environmental degradation. Some farmers have responded by, e.g., underrating climate change and required actions in agriculture. Nonetheless, majority of Finnish farmers acknowledge this connection and feel responsibility for both adaptation and mitigation (Peltonen-Sainio et al., 2020, Sorvali et al., 2021a).

In the end, farmer is the one who decides how and when to adapt to climate change by considering the payback periods of investments and the economic returns as the outcome. Two farmer surveys were organized, first in 2018 and a follow-up survey in 2020 with additional specified questions to obtain farmers' views on the issue of managing future precipitation conditions. The aims of this study were: (1) to understand farmers' views on future changes in precipitation patterns, (2) to get an insight into farmer views on prioritization of the potential key adaptation measures, irrigation, drainage and maintenance of soil conditions to manage the future changes in precipitation patterns, (3) to assess farmers' preparedness to adapt considering both sides of precipitation, i.e., the risks of flooding and drought and thereby, (4) to be better able to acknowledge farmer's understanding when considering future means to support their primary task of producing food in a socially, economically and environmentally sustainable way.

2. Materials and methods

In 2018 when the first farmer survey was carried out in Finland, 38,091 farmers, whose email-addresses was available in the registry of the Finnish Food Authority, received the survey via email. At that time, the total number of farmers was 47,688 and the survey reached 80% of them. 4401 farmers answered the survey, which corresponded to a 12% response rate of the farmers contacted and 9% of all Finnish farmers overall. The person principally responsible for the decision making at the farm was asked to be the respondent. As reported by Peltonen-Sainio et al. (2020) and Sorvali et al. (2021b), no significant distortions of representativeness were found for age, geographical area, farm type, farm size and the level of education. According to a non-response analysis, including a possible coverage error, our data was interpreted as a representative sample of the Finnish farmer community. A follow-up survey was carried out in 2020, but it was sent only to the farmers who had answered the first survey in 2018. Out of the 4401 who had responded to the first survey, 2000 farmers replied in 2020, thereby the response rate was 45%. The 2020 survey repeated some of the questions that were asked in the 2018 survey, included some new questions and some which were specified on the basis questions asked and answered in 2018. The basic structure and logistics of the survey were the same in both years.

There were two groups of questions which were examined in 2018 survey only: (1) *In the 2000s have you already experienced changes in your farm or region* with two structured statements (SS) and (2) *How important or unimportant are the following measures* with four SS. The SS and the

Table 1
Structured principle statements providing an understanding of the farmers' views as background information surveyed in 2018 (N = 4401). Alternative answer choices and the statements are in the order they were in the questionnaire.

In 2000s have you already experienced changes in your farm or region?	How important of unimportant are the following measures?
1 = Not at all	1 = Unimportant
2 = Rarely	2 = Quite unimportant
3 = Occasionally	3 = Neither nor
4 = Frequently	4 = Quite important
5 = All the time	5 = Important
Increased damaged caused by drought	Taking care of basic soil conditions
Increased damaged caused by heavy rains.	Taking care of the drainage systems on the field and local scale
	Taking care of the subsurface drainage system
	Preparing for the implementation of irrigation

alternative answer choices are shown in Table 1. There were another group of questions which were examined first in 2018 survey and then repeated in 2020 survey. These were: (1) *What do you think about the following statements* with six SS (Table 2). The latter primary question was also examined only in the 2020 survey with 16 additional, specified SS (Table 3).

The background information that was not requested in the survey was available in the registry of the Finnish Food Agency. After linking the datasets, the respondents were grouped for statistical analyses according to: (1) the farm size (<30, 30–49, 50–99 and ≥100 ha), (2) farming system (organic and conventional), (3) farm type (horse/sheep, cattle, crop, pig and poultry farm), 4) age of the farmer (≤30, 31–50, 51–70 and >70 years), (5) education (unidentified, basic, vocational and university) and (6) geographical area (representing 16 Centers for Economic Development, Transport and the Environment, ELY Centers).

First the 2018 survey data (N = 4401) was used to assess differences in the farmers' answers to the SS (Table 3) depending on the farm and farmer characteristics. The differences between the means of the respondent groups were analysed using a one–way analysis of variance (ANOVA). Pairwise comparisons of the means were tested using the Tukey's honest significant difference (HSD) test with a significance level of $\alpha = 0.05$. New specified questions of the 2020 survey data (N = 2000) were analysed similarly. Thereafter, the changes in the farmers' views were analysed by including only data of the same 2000 respondents from both years, by subtracting the answer of 2018 from corresponding answer from 2020 for each SS.

All question groups were measured on a 5-point Likert scale. Although the scale is ordinal, a parametric ANOVA was used in the analysis. Both ANOVA and HSD are based on the assumption of a normal distribution of observations and equal variances of the groups, but the risk of violating these assumptions was significantly reduced, due to the large sample size (N = 4401 in 2018 and N = 2000 in 2020). The analyses were performed using the ANOVA and MEANS procedures specified by the SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. General views

According to the 2018 survey, farmers agreed that in the forthcoming years winters will be milder, heavy rains more frequent, floods more severe and that drought periods will last longer. However, the farmers mostly disagreed or neither agreed nor disagreed (Fig. 1) on the likely consequences of these changes, such as higher risks of soil erosion and nutrient leaching into waterways. Two years later the views of the farmers had changed in sense that more of them strongly agreed with the statements on drought periods and heavy rains. By 2018 ca. 40% of farmers had already frequently or regularly experienced increased damage caused by heavy rains, though only occasionally or rarely by drought (Fig. 2). Only 10% of farmers had frequently or constantly experienced damage caused by drought.

Table 2
Structured principle statements providing an understanding of the farmers' views on future changes in precipitation events and their possible impacts that were surveyed both in 2018 (N = 4401) and 2020 (N = 2000). Alternative answer choices and the statements are in the order they were in the questionnaire.

What do you think about the following statements?
1 = Fully disagree
2 = Disagree
3 = Neither agree nor disagree
4 = Agree
5 = Fully agree
Heavy rains will be more frequent in the future.
Floods will be more severe in the forthcoming years.
Drought periods will last longer in the forthcoming years.
Nutrient loads in waterways will increase in the forthcoming years.
Soil erosion will be more severe in the forthcoming years.
Winters will be milder in the forthcoming years.

Table 3
Structured principle statements providing an understanding of the farmers' views on irrigation-related statements in the 2020 survey (N = 2000). Alternative answer choices and the statements are in the order they were in the questionnaire.

What do you think about the following statements?
1 = Fully disagree
2 = Disagree
3 = Neither agree nor disagree
4 = Agree
5 = Fully agree
Well-functioning subsurface drainage is important for the soil structure and the maintenance of soil conditions
Subsurface drainage will become more important because of climate change
Additional subsidies should be allocated to the maintenance of subsurface drainage
My subsurface drainage system needs basic construction
The maintenance of subsurface drainage is too expensive on my farm
Climate change will increase the need for irrigation
Climate change will reduce the need for irrigation
The need for irrigation involves too many uncertainties
Irrigation systems are too expensive
Finland does not have enough expertize or business activities related to irrigation
The need for irrigation only covers a limited part of my fields
The need for irrigation only covers a limited part of my crops
The amount of organic matter is important for the soil structure and the maintenance of soil conditions
Adding different organic soil improvement agents is too expensive
Additional subsidies should be allocated for the addition of organic matter and for carbon farming
I cultivate my fields in a way that retains C in the soil.

3.2. Basic measures according to 2018 survey

Regarding measures that farmers considered to be important or unimportant according to 2018 survey, taking care of the basic soil conditions was valued most as 92% of farmers considered it to be important or quite important (Fig. 3). Taking care of the subsurface drainage system as well as the drainage systems on the field and local scale were also considered important or quite important by close to 90% of the farmers. On the other hand, preparing the implementation of irrigation was regarded as mostly unimportant or quite unimportant for the farmers.

3.3. 2020 survey on soil organic content (SOC)

Based on the replies to the 2018 survey, additional specified statements were prepared for the 2020 survey to gain a more comprehensive understanding of the farmers considerations on the topic of possible measures or factors with impacts on plant and soil water conditions. The farmers agreed most with the statements that the organic content is important for the soil structure and the maintenance of soil conditions (Fig. 4). However, only 33% agreed that they were concerned about the organic content in their fields. Organic producers, female farmers, and farmers with large or very large farms (≥50 ha) and a university education agreed more than their counterpart farmer groups with the statement concerning the importance of the SOC (Table 4). Most farmers considered that additional subsidies are needed to support the addition of organic matter to the soil and for carbon farming (Fig. 4). Organic and female farmers agreed slightly more than conventional and male farmers (Table 4). The farmers often considered adding different organic soil improvement agents to be too expensive (Fig. 4), more so by conventional than organic producers (Table 4). Almost 70% of farmers agreed that they cultivated their fields in a way that retains carbon in the soil (Fig. 4) and this was especially true for organic producers, but also for farmers with medium, large or very large farms compared to those with small farms (Table 4).

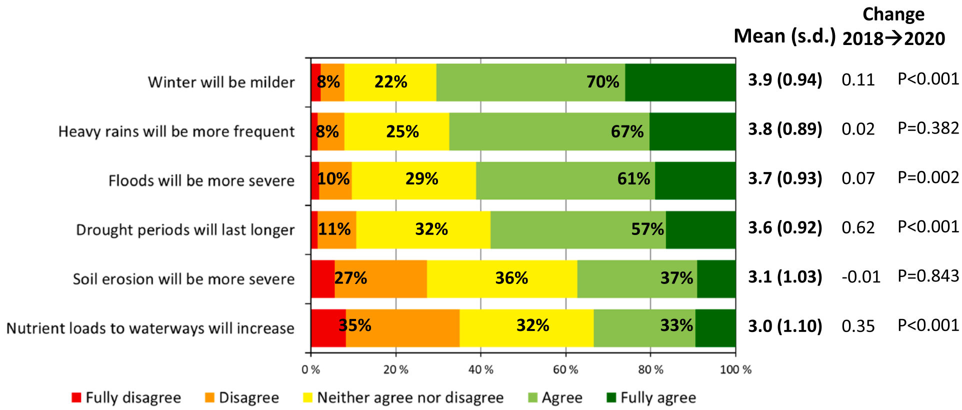

Fig. 1. The distribution, mean and standard deviation (s.d.) of farmers' answers (N = 4399) in the 2018 survey to the principal question *What do you think about the following statements* regarding changes in the forthcoming years. The answer choices were: 1 = fully disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = fully agree. The shares of responses are shown within each horizontal bar as follows: sum of shares of fully disagree and agree responses (left), share of neither agree nor disagree responses (middle) and sum of shares of agree and fully agree responses (right). The questions and statements were repeated in 2020 and the change compared to 2018 is shown on the righthand side (N = 1966).

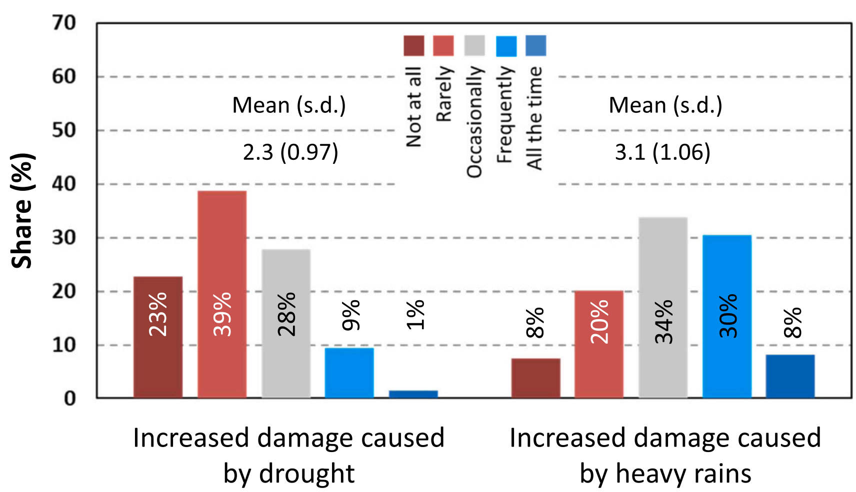

Fig. 2. The distribution, mean and standard deviation (s.d.) of farmers' answers (N = 1971) in the 2018 survey to the principal question *In 2000s have you experienced?* The answer choices were: 1 = not at all, 2 = rarely, 3 = occasionally, 4 = frequently and 5 = all the time. The share of response is shown next to each bar.

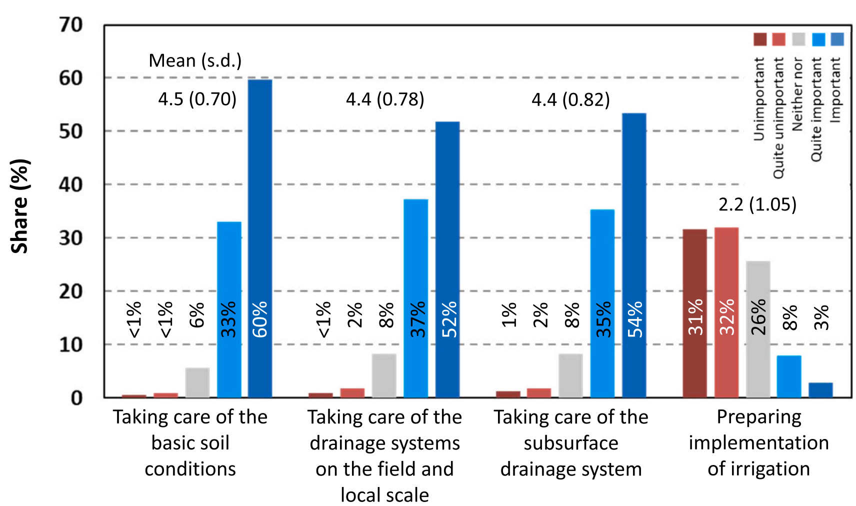

Fig. 3. The distribution, mean and standard deviation (s.d.) of farmers' answers (N = 1971) in the 2018 survey to the principal question *How important or unimportant are the measures?* The answer choices were: 1 = unimportant, 2 = quite unimportant, 3 = neither nor, 4 = quite important and 5 = important. The share of response is shown next to each bar.

3.4. 2020 survey on drainage

Regarding statements on drainage, farmers agreed most with the statement that well-functioning subsurface drainage is important for soil structure and the maintenance of soil conditions (Fig. 4). Farmers with farms ≥50 ha agreed more than those with smaller farm sizes as did pig and crop production farms compared to horse/sheep farms (Table 5). Farmers with small farms disagreed more frequently than those with

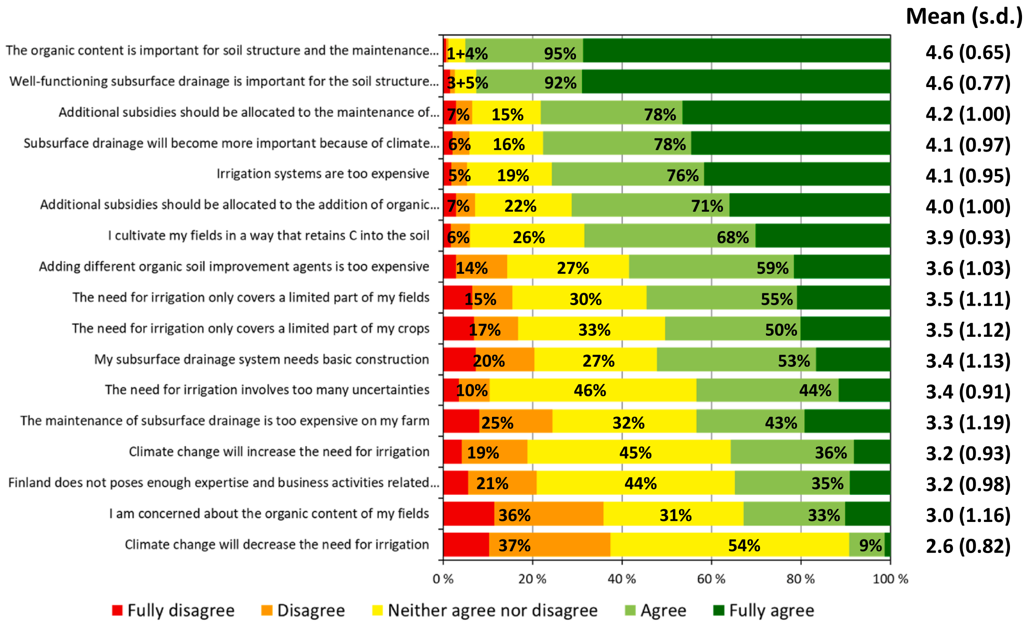

Fig. 4. The distribution, mean and standard deviation (s.d.) of farmers' answers (N = 2000) in the 2020 survey to the principal question *What do you think about the following statements?* The answer choices were: 1 = fully disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = fully agree. The shares of responses are shown within each horizontal bar as follows: sum of shares of fully disagree and agree responses (left), share of neither agree nor disagree responses (middle) and sum of shares of agree and fully agree responses (right). See full statements in Table 3.

Table 4
Farmers' views on adding organic matter to the soil depending on the farm and farmer characteristics. Means with the same letter do not differ significantly from each other (at $P \leq 0.05$). Triple dots indicate a non-significant difference. The alternative answer choices are shown in Table 3.

Farm/farmer characteristic[a]	N	Adding organic matter to the soil: The amount of organic matter is important for the soil structure and the maintenance of soil conditions.		Adding different organic soil improvement agents is too expensive.		Additional subsidies should be allocated for the addition of organic matter and for carbon farming.		I cultivate my fields in a way that retains C in the soil.	
Farm size:									
0–29 ha	775	4.6	b	…	…	…	…	3.8	b
30–49 ha	432	4.6	ab	…	…	…	…	4.0	a
50–99 ha	502	4.7	ab	…	…	…	…	4.0	a
≥100 ha	231	4.7	a	…	…	…	…	4.1	a
Farming system:									
Organic	288	4.8	a	3.5	b	4.1	a	4.4	a
Conventional	1678	4.6	b	3.7	a	4.0	b	3.8	b
Gender:									
Female	217	4.7	a	…	…	4.1	a	…	…
Male	1749	4.6	b	…	…	3.9	b	…	…

[a] Farmers with a university education (4.7, N = 526) agreed more frequently that the amount of organic matter is important for the soil structure and the maintenance of soil conditions than those with a basic or unidentified education (4.4 for both).

large and very large farms that subsurface drainage will become more important because of the changing climate. Pig farmers were more positive towards this statement than poultry and horse/sheep farmers. According to majority of farmers their subsurface drainage systems need basic construction (Fig. 4) and especially so in large and very large farms, and according to young farmers and those with university education (Table 5). However, for some 43% of farmers its maintenance was too expensive (Fig. 4): more so on smaller farms and more so for conventional than organic producers (Table 5). Hence, almost 80% of farmers considered that additional subsidies are needed for the maintenance of drainage systems in the farm (Fig. 4) and more so the larger the farm (Table 5). No differences between genders were found concerning any of the statements on drainage.

The share of the field area with subsurface drainage was dependent on the region, farming system and farm type (Fig. 5). In southern and western parts of Finland the area ranged from 62% to 78% of the field area while in inland regions it was 55–58% and elsewhere 16–47% with the lowest shares in the north-east Finland. The drainage area was higher on conventional (62%) than in organic farms (54%), and on crop production farms, poultry, and pig farms (69–70%) compared to cattle farms (51%) and horse/sheep farms with only a 42% subsurface drainage area (Fig. 5).

3.5. 2020 survey on irrigation

Only <10% of farmers fully agreed that climate change would increase the need for irrigation (Fig. 4). On the other hand, <10% agreed that climate change would decrease the need for irrigation. In general, when farmers did not agree with a statement, not only the share of disagreements tended to increase, but also that of "neither agree nor disagree". This was especially the case with statements on climate change impacts on need for irrigation. This indicated lots of uncertainties (Fig. 4). Nonetheless, organic and female farmers were slightly more positive that climate change would increase the need for irrigation, while farmers with horse/sheep farms agreed more on the opposite statement in contrast to those with poultry farms (Table 6). 76% of farmers agreed that irrigation systems are too expensive (Fig. 4)—for smaller farms less so than for larger ones. 55% of them agreed that the need for irrigation covered only a limited part of their fields and 50% a limited part of their crops (Fig. 4). 44% of farmers

Table 5
Farmers' views on subsurface drainage depending on the farm and farmer characteristics. Means with the same letter do not differ significantly from each other (at $P \leq 0.05$). Triple dots indicate a non-significant difference. The alternative answer choices are shown in Table 3.

Farm/farmer characteristic[a]	N	Subsurface drainage system: Well-functioning subsurface drainage is important for the soil structure and the maintenance of soil conditions.		Subsurface drainage will become more important because of climate change.		Additional subsidies should be allocated for the maintenance of subsurface drainage.		My subsurface drainage system needs basic construction.		The maintenance of subsurface drainage is too expensive on my farm.	
Farm size:											
0–29 ha	775	4.5	b	4.0	b	4.0	b	3.2	c	3.4	a
30–49 ha	432	4.6	b	4.1	ab	4.2	ab	3.5	b	3.3	a
50–99 ha	502	4.7	a	4.3	a	4.2	a	3.6	ab	3.3	ab
≥100 ha	231	4.7	a	4.3	a	4.3	a	3.7	a	3.1	b
Farm type:											
Horse/sheep farm	56	4.3	b	3.9	b	…	…	…	…	…	…
Cattle farm	487	4.6	ab	4.1	ab	…	…	…	…	…	…
Crop farm	1008	4.6	a	4.2	ab	…	…	…	…	…	…
Pig farm	87	4.7	a	4.4	a	…	…	…	…	…	…
Poultry farm	30	4.6	ab	3.9	b	…	…	…	…	…	…

[a] Conventional farmers agreed more frequently that additional subsidies should be allocated for the maintenance of subsurface drainage (mean = 4.2, N = 1678) and that the maintenance of subsurface drainage is too expensive on their farm (3.3) when compared to organic farmers (4.0 and 3.2, respectively, N = 288). The youngest farmers agreed more frequently that their subsurface drainage system needs basic construction (3.8, N = 42) than did age groups of 51–70 and >70 years (3.3 and 3.2, respectively), as did farmers with a university education (3.5, N = 526) when compared to those with an unidentified education (3.1, N = 34). No differences were found in any of the statements depending on gender.

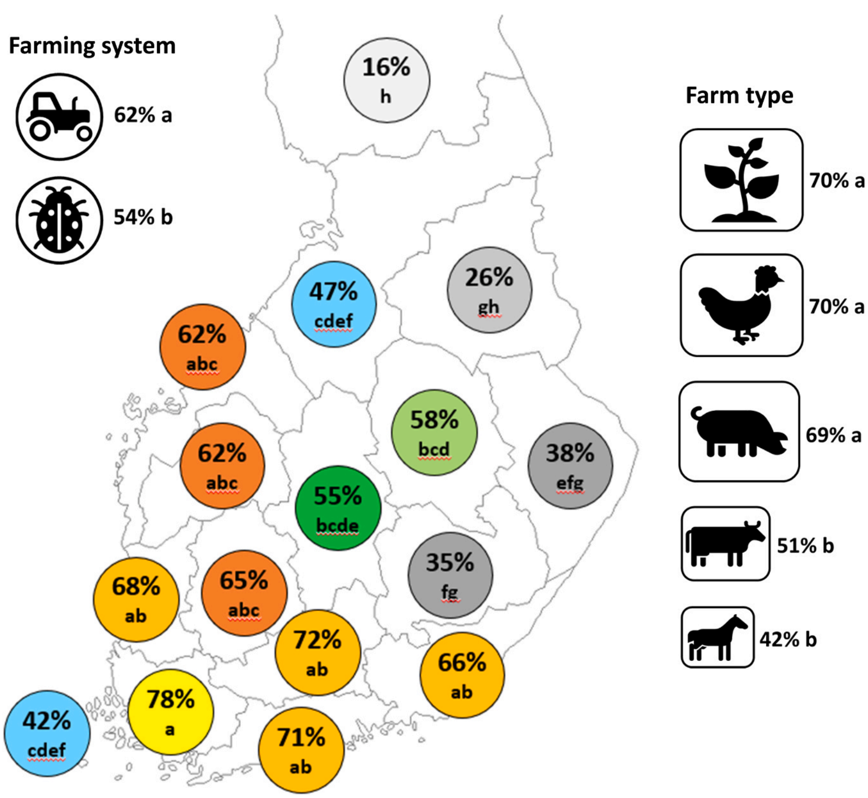

Fig. 5. The geographical differences in the share of the field area with subsurface drainage (%) according to 2020 survey. Regions with the same letter do not differ significantly from each other (at P ≤ 0.05) and the regions with identical letters are shown with same color. On the right-hand side, differences between farm types in the share of the field area with subsurface drainage are shown in order of crop, poultry, pig, cattle and horse/sheep farms (downwards). On the left the difference between farming systems is shown in order of conventional and organic farms. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

considered need for irrigation to be too uncertain—more frequently on very large farms, by young farmers and farmers with a university education (Table 7). 35% of farmers agreed that there is uncertainty whether Finland has sufficient expertize and business activities related to irrigation (Fig. 4).

4. Discussion

Farmers were in general aware (i.e., 58–70% agreed in the 2018 survey) of major forthcoming changes in growing conditions caused by global warming, such as shifts towards milder winters, more frequent downpours and floods and more severe and longer lasting drought periods (Lehtonen et al., 2014; Ruosteenoja et al., 2016, 2017, 2019) (Fig. 1). Despite anticipation of such changes in climatic conditions, farmers were not equally convinced that environmental risks, soil erosion and nutrient leaching will become more severe problems in the future. This does not necessarily mean that farmers overlooked the environmental risks related to climate change. This may be attributable

Table 6
Farmers' views on the future need for irrigation depending on the farm and farmer characteristics. Means with the same letter do not differ significantly from each other (at $P \leq 0.05$). Triple dots indicate a non-significant difference. The alternative answer choices are shown in Table 3.

Farm/farmer characteristic	N	Future need for irrigation: Climate change will increase the need for irrigation.		Future need for irrigation: Climate change will reduce the need for irrigation.	
Farming system:					
Organic	288	3.3	a	2.5	b
Conventional	1678	3.2	b	2.7	a
Farm type:					
Horse/sheep farm	56	…	…	2.9	a
Cattle farm	487	…	…	2.6	ab
Crop farm	1008	…	…	2.6	ab
Pig farm	87	…	…	2.8	ab
Poultry farm	30	…	…	2.5	b
Gender:					
Female	217	3.5	a	…	…
Male	1749	3.2	b	…	…

Table 7
Farmers' views on irrigation opportunities depending on the farm and farmer characteristics. Means with the same letter do not differ significantly from each other (at $P \leq 0.05$). Triple dots indicate a non-significant difference. The alternative answer choices are shown in Table 3.

Farm/farmer characteristic	N	Irrigation opportunities: The need for irrigation involves too many uncertainties.		Irrigation opportunities: Irrigation systems are too expensive.	
Farm size:					
0–29 ha	775	3.3	b	4.0	b
30–49 ha	432	3.4	b	4.0	b
50–99 ha	502	3.5	ab	4.2	a
≥100 ha	231	3.6	a	4.2	ab
Age of farmer:					
≤30	42	3.6	a	…	…
31–50	812	3.5	ab	…	…
51–70	1063	3.4	ab	…	…
>70	49	3.2	b	…	…
Education:					
Unidentified	34	3.1	b	…	…
Basic	123	3.2	b	…	…
Vocational	1283	3.4	ab	…	…
University	526	3.5	a	…	…

to the possibilities to manage such weather conditions, although changes in precipitation events per se may put the environment at risk in the future. Cover crops and buffer strips in fields next to waterways were examples of measures which were familiar to farmers for the mitigation of negative impacts of weather conditions (Aronsson et al., 2016). As autumns are projected to become warmer and wetter, the establishment, growth, and nutrient uptake of cover crops will be favoured, which may increase their power in the future in hindering erosion and nutrient loss into waterways (Peltonen-Sainio et al., 2018).

Farmers had some experience of increased damage caused by weather constraints according to the 2018 survey, however, more frequently due to heavy rains than drought (Fig. 2). The summer of 2017 which preceded the 2018 survey was cool and rainy, while the next two growing seasons were warm and dry. It appeared that according to 2020 survey, farmers were more conscious of the risks of drought and the nutrient load on waterways compared to the preceding survey (Fig. 1). Thereby, recent experience seemingly increased the farmers' awareness of the manifold impacts of climate change. On the other hand, Finnish farmers have always been forced to cope with weather variability and extreme events which are typical for high-latitude conditions (Peltonen-Sainio and Niemi, 2012; Peltonen-Sainio and Jauhiainen, 2014).

4.1. Irrigation—the ignored though straightforward means to cope with drought

Farmers were conscious of climate warming induced changes in water conditions and availability, and they even agreed more in the 2020 than in 2018 survey that the risk of longer lasting, more severe drought would increase in the future. However, they were not interested in being prepared for irrigation (Fig. 3). Irrigation is the most direct means to cope with water scarcity, and the premises for irrigation are excellent in Finland in the sense that water resources are vast and are located near the field parcels (Peltonen-Sainio et al., 2015b). On the other hand, farmers do not have irrigation systems and they are not accustomed to irrigating their field crops: irrigation is used for horticultural crops and early potatoes are the sole niche field crop.

Farmers agreed that climate change will increase rather than reduce the need for irrigation with slight differences in their views depending on the farming system, farm type and gender (Table 6). The majority of farmers considered irrigation systems to be too expensive (especially on larger farms) and agreed that the need for irrigation covers only a limited part of their fields and/or crops (Fig. 4). Only 10% of farmers considered irrigation not to involve uncertainties. Uncertainties were more frequently mentioned concerning very large farms, by young farmers and farmers with a university education (Table 7). In order to support changes in farmers' attitudes towards more openness to irrigation as a future adaptation measure, reliable and comprehensive understanding of the costs and benefits of implementation are needed. This means acknowledging: the frequency of growing seasons with drought at the critical developmental phase, yield losses caused depending on severity of drought (Peltonen-Sainio et al., 2016c; Rajala et al., 2009, 2011), differences in crops in their responses, i.e., crop competitiveness to irrigation (Okada et al., 2018), the impacts of climate change on the frequency of the future precipitation patterns (Lehtonen et al., 2014; Ruosteenoja et al., 2016), shifts in crop choices and cultivation areas (Peltonen-Sainio and Jauhiainen, 2020), as well as investment and running costs, and prices for crop yields (Peltonen-Sainio et al., 2021). Uncertainty, however, also challenges these estimations, although this uncertainty may be reduced by sensitivity analyses and scenarios of possible ranges of changes. Nonetheless, a thorough assessment, pinpointing the likely payback period for an investment in irrigation in Finland is urgently needed to support farmer's decision making, i.e., whether to invest or not in irrigation and if yes, when. Such support for farmers is essential as there were some concerns as to whether Finland has sufficient knowhow and business infrastructure related to irrigation after a long history of only rainfed cropping systems (Fig. 4).

A recent study will give comprehensive support for farmer's decision making on irrigation, when largely grown, currently rainfed spring cereals were considered as the target crops for irrigation (Peltonen-Sainio et al., 2021). According to past (1991–2020) weather and yield loss data, self-propelled irrigation and stationary irrigation systems were both found to be economically feasible but only for larger farm units and in the case of high farm yield levels. Projected changes in future precipitation were not substantial for the critical yield determination phase of spring cereals and hence, the change in precipitation per se does not necessarily encourage farmers to invest in irrigation in the future. However, further expanding farm size and higher future cereal yields available due to longer growing seasons in future climates, might act as additional incentives. Furthermore, Peltonen-Sainio et al. (2021) concluded that irrigation proved to be a key measure to reduce production uncertainties and high yield variability typical for high-latitude conditions, although early summer droughts are not necessarily increasing significantly. Thereby, farmers uncertainty, whether need for irrigation is increasing or not, in changing climate (Fig. 4) seems well justified.

4.2. Maintaining and improving soil structure and conditions

Contrary to the farmer's lack of interest in irrigation, taking care of basic soil conditions was an important or quite important measure for most farmers (Fig. 3). By and large, the farmers agreed that the organic content is important for soil structure and the maintenance of soil conditions and functioning (Fig. 4) (Lal, 2015; Autret et al., 2016). Almost 60% of the farmers who responded considered that they cultivated their fields to retains carbon in the soil (Table 5). However, in another part of the 2020 survey, majority of farmers agreed with the false statement that if crop residues are left on the field the humus content of the soil will not decrease (Sorvali et al., 2021a). This sort of measure with the dominant, monotonously sequenced crops, such as cereals (Peltonen-Sainio and Jauhiainen, 2019), that cover about one out of 2.5 million hectares of agricultural land is not sustainable considering the maintenance of SOC (Heikkinen et al., 2013; Francaviglia et al., 2019). Hence, farmers may have an overly positive idea of the measures that truly enhance soil humus content (Hansen et al., 2015; Autret et al., 2016; Jat et al., 2019). Not least as only 33% of farmers were concerned about the organic content in their fields: organic producers, female farmers, and farmers with large and very large farms ($\geq$50 ha) and a university education were the most conscious groups of farmers (Table 4). Hence, this finding highlights the need for comprehensive knowledge sharing with farmers on the key measures in carbon farming to roll back the current trend of decline in soil carbon in Finnish cropland soils (Heikkinen et al., 2013). Such measures include conservation tillage, shifting from monotonous cereal sequencing towards diverse crop rotations preferably with leguminous crops, replacing mineral fertilizers with organic ones (Francaviglia et al., 2019), and adding external organic amendments, e.g., biochar that may also improve the water holding capacity of the soil (Karhu et al., 2012). The efficiency of each measure is, however, dependent on region (Francaviglia et al., 2019).

The identified contradiction between the farmers' views on the importance of SOC and the means and even need to act and change cultivation practices to maintain and increase soil carbon emphasizes the necessity to provide further support for farmers. Farmers considered that adding organic soil improvement agents would be too expensive—although this concern was voiced more frequently by conventional than organic producers. Therefore, most farmers considered that additional subsidies would be needed to support the addition of organic matter to soil and to assist carbon farming. Organic and female farmers agreed slightly more with this statement than conventional and male farmers. Many different types of soil amendments are, however, available for farmers differing in their impacts and duration of the effect. There are traditional amendments such as crop residues as well as green and farmyard manure from your own or a neighbouring farm (Karhu et al., 2012). Commercial soil amendments such as wood-based by-products from the forest industry are also increasingly available for farmers to "uplift the soil environment in one go" (Soilfood, 2020). Impacts on then soil conditions due to changes in microbial community and functionality vary depending on the amendment (Lucas et al., 2014; Martínez-García et al., 2018).

4.3. Maintenance of drainage systems to cope with excess water—a neglected tradition?

On the respondents' farms, a high share of field parcels was subsurface drained in the prime crop production region of Finland with a reducing share towards the eastern and northern parts of the country (Fig. 5). The situation on the respondents' farms were well in line with the general knowledge that more than two thirds of the total drained area is drained via subsurface drainage (Anon, 2002). Subsurface drainage was slightly more frequent on conventional than organic farms and on crop production, poultry, and pig farms. Organic farmers are likely to be more conscious of the value of heterogeneous landscapes for biodiversity and ecosystem services (Isaacs et al., 2009; Smukler et al., 2010; Riho et al., 2013, 2014) and thereby, also appreciate open in-field drainage, between strips of cultivated land, as these may serve as niches for natural enemies of insect pests. A well-functioning drainage system was considered important for the soil structure and the maintenance of soil conditions (Fig. 4). This was especially emphasized by farmers with farm sizes of $\geq$50 ha and by those with pig and crop production farms (Table 5). According to the farmers, the role of subsurface drainage will become more important in the future, with anticipated increases in seasonal differences in precipitation patterns, which agrees with the projected changes in future precipitation (Ruosteenoja et al., 2016). Higher precipitation in the autumn calls for functional drainage to efficiently channel the overwhelming water and avoid surface run-off as erosion and nutrient leaching risks are likely to increase in the forthcoming decades (Puustinen et al., 2007; Warsta et al., 2014). The latter is likely if nutrients have not been fully exploited by the crops during the summer, e.g., due to drought (Peltonen-Sainio and Jauhiainen, 2010). Hence, cover and catch crops should belong to the toolkit of every farmer's best practice and are a necessity to counter the envisaged problems concerning soil conditions and functioning (Aronsson et al., 2016; Peltonen-Sainio et al., 2018). Up to now functional drainage has been essential to enable early sowing after the snow melt in the very short growing season of Finland and to channel excess water at the end of the season. In the future climate, the operational time of drainage systems may, however, expand from the present conditions as winters are becoming milder, precipitation is increasing and rains will change from snow to water (Ruosteenoja et al., 2016, 2019).

Majority of the respondents agreed that a high share of drainage systems need maintenance in Finland (Anon, 2002), and according to the respondents, their subsurface drainage systems need basic construction (Fig. 4). This was especially true on large and very large farms, pig farms, and crop production farms and according to young farmers and those with a university education. Renovation loans for drainage systems have cumulated since the 1990s: the share of leased land with short-term contracts has substantially increased, as have also a general reluctance to make investments in farms due to their economically challenging situation (Pouta et al., 2012). This study highlighted the farmers' concerns that the maintenance of drainage systems is too expensive: more so on smaller farms and for conventional than organic producers. Hence, farmers understandably often agreed that additional subsidies are needed for the maintenance of the drainage systems on farms, and they agreed more frequently the larger the farm was (Table 5).

5. Conclusions

The farmer surveys arranged in 2018 and 2020 emphasized the manifold needs that farmers have not only regarding financial support, but also concerning the need for a better understanding of costs and benefits when making decisions on measures to cope with future changes in precipitation patterns. This may be attributable to the challenges and uncertainties in projecting future changes in precipitation, especially considering frequency and timing of periods of drought and excess rain, both of which may constrain crop production even within the same growing season. However, fluctuating precipitation does not only impact agricultural production per se but may have many environmental impacts. Thereby, farmers may feel that the costs of such a battle against climatic constraints should not solely rest on their shoulders. Nonetheless, from the three key-themes included in this study, farmers prioritized SOC and well-functioning subsurface drainage to be the main objects of their attention—ahead any future need for irrigation to cope with possibly lengthening periods of severe drought. Taking care of subsurface drainage, soil structure, SOC and functionality are the long-term means for farmers to maintain and improve the sustainability and productivity of agricultural land, which in the end is the primary capital on a farm. The implementation of irrigation is again more of a one-off measure to cope with emerging droughts requiring short-term reactivity when compared to the long-term maintenance of soil conditions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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