Vol. 72: 165–176, 2017
https://doi.org/10.3354/cr01462

CLIMATE RESEARCH
Clim Res

Published online May 29

Information needs, barriers and incentives to adopting climate change mitigation and adaptation actions in boreal agriculture

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ABSTRACT: Effective climate change mitigation and adaptation in agriculture requires farmers to gain sufficient information to plan and implement practical climate-related actions. Science-based knowledge that meets actors' needs supports proactive action taking. The aim of this study was to characterize the views of farmers and other rural stakeholders regarding farmers' climate change information needs, and to identify potential barriers to and necessary incentives for applying climate change mitigation and adaptation in practice. Data were collected by conducting an internet survey in Finland for which 340 responses from farmers, farm advisers and other rural stakeholders were received. Applying cluster analysis, 5 information need profiles were identified: 'information highlighters', 'globally and nationally oriented', 'livestock oriented', 'plant production oriented' and 'no interest'. Half of the respondents believed that climate change would affect their activities in the near future. Among respondent groups, farmers themselves perceived the information on climate change as most uninteresting. The complexity of the current climate change communication and potential economic costs associated with proactivity were found to hinder both mitigation and proactive adaptation actions. Based on our study, climate change communication needs to be practice-oriented and tailored to fit the needs of farmers representing different lines of agricultural production and regional locations. Such information, plus an integration of an assessment of the effects of proactive action taking on farm profitability, is needed to encourage climate change mitigation and adaptation actions on Finnish farms.

KEY WORDS: Climate change communication · Adaptation · Agriculture · Information need · Mitigation · Regional adaptation

1. INTRODUCTION

Agriculture is directly dependent on climate conditions, which makes food production sensitive to a rapidly shifting climate and variability in weather (Ray et al. 2015). Climate-induced changes in policy, increasing economic instability and changing food consumption patterns are increasingly influencing farm operations and rural livelihoods (Pachauri et al. 2014). In addition to having to adapt to climate change, agriculture is facing increased pressure to participate in mitigation efforts (McKinsey & Company 2009). Agriculture accounts for circa 13% of total global greenhouse gas emissions when emissions from land use, land-use change and the forestry sector are taken into account (WRI 2014), and expansion of farming to produce enough food and feed has caused circa 75% of global deforestation (Vermeulen et al. 2013). The need to develop agricultural practices so that mitigation of climate change and the ability to adapt are

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strengthened has elicited the desire to build climate-smart agriculture (Lipper et al. 2014). Actual adaptation and mitigation depend largely on how individual farmers adopt actions at the farm level, but factors determining climate actions are not well understood (Moore & Lobell 2014).

A variety of means of adapting to and mitigating climate change at the farm level have been proposed in the literature (e.g. Smith et al. 2008, Porter et al. 2014). Mitigation can be implemented by sequestering carbon in soil and vegetation, reducing emissions of CO_2, CH_4 and N_2O, and avoiding emissions by replacing on-farm fossil fuel with bioenergy and decarbonisation of agricultural machinery (Smith et al. 2008, Rimhanen 2016). The most prominent mitigation actions in agriculture are the management of cropland and grazing land, and the restoration of degraded and organic soils (Smith et al. 2008). Compared to many other sectors, agriculture represents a cost-effective mitigation option (McKinsey & Company 2009) that also delivers benefits in terms of food security (Kahiluoto et al. 2012, Rimhanen 2016). Regarding adaptation, the IPCC (e.g. Porter et al. 2014) and Finland's National Strategy for Adaptation to Climate Change (Marttila et al. 2005, Ministry of Agriculture and Forestry 2014) have proposed many options, such as increased genetic diversity of crop species, water management and improved pest and disease monitoring. However, adopting mitigation and adaptation actions that help slow down climate change and make farms more resilient to face its impacts (FAO 2013, Wheeler & von Braun 2013) is still in its infancy among most farmers, partly due to lack of knowledge (Lorenzoni et al. 2007).

Potentially useful information on climate change mitigation and adaptation often remains untapped (Lemos et al. 2012). Climate change information is most often driven by science, leading to a situation where the information may not meet users' needs (Lemos & Rood 2010, Lemos et al. 2012, Kirchhoff 2013). The usefulness of information has been argued to depend on political, organizational, behavioural, processional, cultural and institutional gaps between information providers and recipients (Adger et al. 2009, Lemos et al. 2012). Lemos et al. (2012, p. 789) proposed that a usability gap depends on 'users' perception of information fit, how new knowledge interplays with other kinds of knowledge that are currently used by users, and the level and quality of interaction between information producers and users'. Research has emphasized the need for information perceived by users as credible, salient and legitimate (Cash et al. 2003).

According to theory and empirical work by Hayami & Ruttan (1985), the adoption of new technologies and practices is dependent on economic opportunities, environmental regulation and scarcity (every resource is to some degree scarce). Sunding & Zilberman (2001) further developed the theory, and suggested that technical feasibility, new scientific foundation and knowledge are also necessary for new technologies or practices to be adopted. From a social perspective, Hyland et al. (2016) suggested that farmers' willingness to adopt mitigation and adaptation action is influenced by farmers' self-identity, degree of awareness of climate change and climate change risk perceptions. There is growing interest in understanding the obstacles and drivers to adopting climate change mitigation and adaptation practices at the farm level (Barnes & Toma 2012, Arbuckle et al. 2013, Gramig et al. 2013, Niles et al. 2015, Chen & Whalen 2016). For example, Arbuckle et al. (2013) found that farmers who were concerned about climate change showed positive attitudes towards adaptation and mitigation actions. Thus, farmers' personal views and experiences on climate change may induce proactivity. Barnes & Toma (2012) reported high heterogeneity in dairy farmers' attitudes towards climate change mitigation and adaptation. Such investigations are valuable both for designing effective and targeted climate change information provisioning and uptake by farmers in practice.

The views of farmers and rural stakeholders on whether climate change will affect them in the near future mirror their needs and motivations to prepare proactively for climate change. Their specific information needs and the barriers and incentives perceived to implementing mitigation and adaptation actions in practice could be crucial to effectively incorporate agriculture into climate change mitigation. Our study represents the first attempt to assess farmers' and rural stakeholders' climate change perceptions and information needs in a Nordic country. The following research questions were addressed:

(1) Which climate change mitigation and adaptation topics interest farmers the most, and which the least? Are there differences in these interests among Finnish regions and among different occupational groups in rural areas?

(2) Do farmers and other rural stakeholders believe that climate change will cause changes in their activities in the near future? If yes, what type(s) of changes?

(3) What are the main barriers to and necessary incentives for adopting mitigation and adaptation actions?

2. MATERIALS AND METHODS

2.1. Case description

The study was conducted in 15 administrative regions in Finland (Fig. 1). Finland is representative of the northern European climate and agriculture, with 91% of farmers registered under the Common Agricultural Policy (CAP) of the European Union (Niemi & Ahlstedt 2013). In 2013, among the Finnish farms receiving EU subsidies, 69% were crop farms and 25% were livestock farms, and of these, 87% were privately owned. Average farmland area was 38 ha, and the farms' average forested area was 51 ha. Crop production is the main farming activity in southern, central and western Finland. The share of dairy husbandry is higher in northern and eastern Finland.

2.2. Survey of farmers and rural stakeholders

Data were gathered through an internet survey in October 2011. The survey was sent to a sample of 1568 farmers and other rural stakeholders. The sample was drawn from different contact lists available from unions of nationwide comprehensive agricultural producers' organizations and regional forest management associations and rural communal developers responsible for agriculture and natural resources.

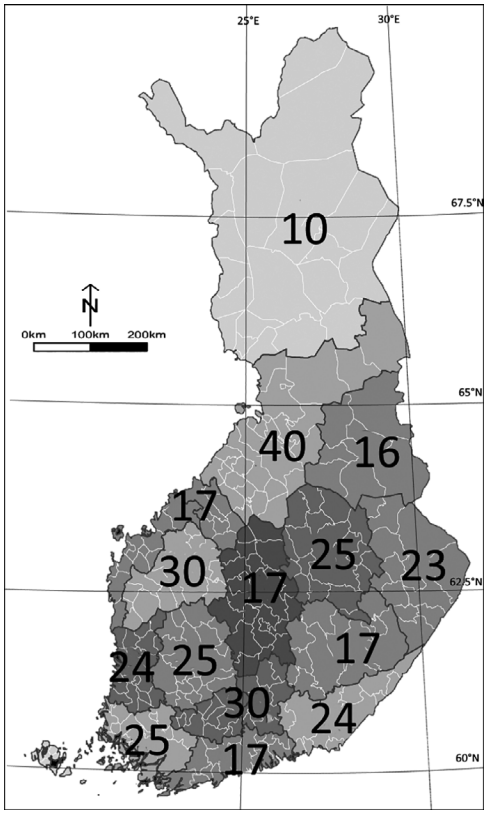

Fig. 1. Number of respondents (N) in each of the Employment and Economic Development Centre areas of Finland. Grey shades differentiate areas

The survey was created using Webropol 1.0 software. Demographic characteristics including age, occupational group and region (as classified by the Employment and Economic Development Centres within Finland) were acquired to categorize responses.

2.3. Assessing climate change information needs

The quantitative portion of the survey included a list of climate change related topics based on the literature (see Table S1 in the Supplement at www.int-res.com/articles/suppl/c072p165_supp.pdf). In total, 65 topic suggestions related to policy, economic, energy, social and production specific adaptation and mitigation actions were included. Participants were asked to rank the topics from the viewpoint of farmer information needs through a 4-point Likert-type scale, ranging from high information need (4) to no information need (1). Additionally, an 'I don't know if there is a need for more information' option was included.

2.4. Information needs profiles

Factor analysis (FA) was used to seek potentials underlying, unobservable (latent) variables called factors. Those factors are reflected in the observed variables. FA is related to principal component analysis (PCA), but in FA, total variance explained by variables is divided into common variance and error variance. In this study, we chose FA over PCA, because we sought to identify potentially underlying drivers influencing the views of farmers and other rural stakeholders with regards to climate change information. We also plan to use factor scores, extracted by FA, in further analysis. Factor scores are combination variables which provide information about a respondent placement on the factors.

Explanatory FA, using the maximum likelihood estimation method, was conducted on the 65 suggestions regarding climate change information needs. Three hundred and forty responses were obtained, and thus sample size requirements (5 observations per variable) were achieved (Comrey & Lee 2013). The sampling adequacy, tested with the Kaiser–

Melkin–Olkin (KMO) measure, was sufficient, with a KMO value of 0.94 (Kaiser 1970). An initial analysis was run to obtain eigenvalues for each factor in the data. Based on Kaiser's criterion of eigenvalues >1, 12 factors could have been used, but ultimately we selected 8. The decision was based on scree plots, the amount of variance explained and interpretability of factors. An orthogonal varimax rotation was used to achieve a more meaningful and interpretable solution. Eight factors explained 61% of total variance and 55% of common variance, corresponding to typical survey percentages (e.g. Dolnicar & Grun 2011).

Factor scores were calculated using the regression method (Thurstone 1935). Calculation of factor scores for every respondent requires that there be no missing values. Answers such as 'I don't know if I need more information' were thus replaced with the mean scores for that particular question. For comparison, FA was analysed based on the correlation matrix without replacements, and the chosen factor structure was found to be almost identical. This was expected because most of the respondents had only a few replacements.

Next we clustered the respondents based on their answers to information needs. The purpose was to identify groups of respondents that are similar to each other but different from respondents in other groups. Clustering was based on factor scores because of the large amount of such information-need variables. Formann (1984) recommended a sample size of at least 2^m, where m equals the number of clustering variables. Therefore, an 8-factor solution was the maximal m recommended for our sample. The respondents were clustered according to the method of Ward (1963), which is the most commonly used hierarchical clustering method. In Ward's method, at first all respondents belong to 1 cluster, and at each step the pair of clusters that leads to a minimum increase in total within-cluster variance after merging will be combined. In other words, Ward's method starts out with n clusters of size one and continues until all the observations are included into 1 cluster. There are multiple criteria which help us to choose the best amount of clusters. Another widely used clustering method, K-means, was also tested, but Ward's method was found to be more interpretable. The 5-cluster solution was based on the dendrogram and the pseudo t^2-criterion (Yeo & Truxillo 2005).

A chi-squared test was used to compare the means of information-need variables and factor scores within demographic and occupational variables. All analyses were carried out with SAS Enterprise guide 7.1 (SAS Institute).

2.5. Defining barriers to and incentives for climate change mitigation and adaptation actions

The qualitative portion of the survey was based on open-ended questions. The following questions were posed: 'Do you believe climate change will cause changes in your activities in the near future? What types of changes? What would help farmers take climate change into account in their everyday practical activities? What are the practical obstacles to taking an interest in climate change information from a farmer's point of view, and what are the obstacles for putting such knowledge into practice? Why?'

Respondents were divided into 3 groups according to their occupation: farmer, farm adviser and other rural stakeholders. The farm advisers were public or private intermediaries who pass information between scientists and farmers. Responses were coded by identifying aspects or ideas from a single word, sentence or phrase. Codes were then categorized into themes (Creswell 2013).

The answers to the question of whether respondents believed climate change would cause changes in their activities in the near future were categorized in 3 themes: 'No', ' Yes', and 'I don't know'. Inappropriate or vague responses were categorized as 'I don't know'. Responses that were categorized as 'Yes' were coded by identifying aspects or ideas from a single word, sentence or phrase regarding the types of changes in activity that the respondent believed climate change will cause in the near future. Codes were then categorized into themes. Responses in each category were quantified (Creswell 2013).

3. RESULTS

3.1. Characteristics of the respondents

We received 340 completed questionnaires, equal to a 21.8% response rate. We also received 3 questionnaires that were uncompleted. The largest age group, 32.3% of all respondents, was 41–50 yr; 32.0% of the respondents were 51–60 yr, and 19.3% were 31–40 yr old. Answers were received from all regions of Finland (Fig. 1). Most of the respondents were farmers (n = 129) and farm advisers (n = 87). Other respondents were decision makers or office-holders (n = 71), interest organization workers (n = 13), teachers or consultants (n = 2), researchers (n = 6), agricultural and forest specialists (n = 27), other workers (n = 6) and students (n = 2). These other

respondents are hereafter called other rural stakeholders.

3.2. Climate change information needs

Among the 65 specific climate change related suggestions, the respondents were most interested in how policy and the farm economy were influenced by climate change. The most highlighted single topics of information needs were: energy efficiency on the farm, heating solutions, bioenergy business opportunities and challenges, support for production of renewable energy, rural and agricultural policy in the next CAP, the effects of greening policy and new innovative business opportunities.

Eight main themes in terms of information needs (factors) were identified among the 65 climate change topic suggestions (Table 1): soil fertility, renewable energy, livestock production, crop production, food security, diversity, eco-efficiency and policy.

Information needs varied by region. In eastern Finland, information on 'livestock production' (theme 3 in Table 1) was emphasized, differing significantly ($p = 0.02$) from the information needs of respondents from southern Finland. In southern and western Finland, information related to 'crop production' (theme 4 in Table 1) topics was rated high, differing significantly ($p = 0.004$) from the information needs of northern Finland.

Five information uptake profiles (Table 2) were created based on differences in climate change information needs. Climate change information uptake profiles varied by occupation (Table 3). 'Information highlighters' consisted of respondents mostly from other rural stakeholders (i.e. office holders, decision makers, specialists), and they considered most of the themes of information needs as more important than did other profiles. The profile 'globally and nationally oriented' emphasized information regarding 'food security' and 'renewable energy' and considered 'soil fertility' less important than did other profile types. This profile included mostly respondents from the other rural stakeholders (Table 3). Farmers fit mostly (73%) into the following profiles: 'livestock oriented', 'globally and nationally oriented' or 'no interest'. The 'livestock oriented' respondents were likely to engage with specific information about livestock production (e.g. livestock protein feeding, targeting animal breeding), policy and soil fertility (e.g. maintenance

Table 1. Contribution of key variables to the themes in the factor analysis. CAP: Common Agricultural Policy

Theme	Key suggestions	Loadings
1 Soil fertility	Maintenance of soil organic matter	0.66
	Soil water management and extreme weather events	0.62
	Plant cover in winter time	0.61
	Fertilization and timing of extreme weather events	0.61
	Crop rotation	0.61
2 Renewable energy	Bioenergy business: opportunities and challenges	0.77
	Biomass recycling and re-use on the farm	0.73
	Production of biogas	0.69
3 Livestock production	Livestock protein feeding	0.77
	Ruminant feeding	0.76
	Targeted animal breeding	0.62
4 Crop production	Novel pests and need for pesticides	0.79
	Enhanced pest observation	0.75
	Plant disease management	0.71
5 Food security	Food supply and security	0.77
	Global food security	0.72
	Domestic food production	0.68
6 Diversity	Diversity of crop species at the farm level	0.66
	Diversity of crop cultivars	0.62
	Functional diversity of cropping system	0.61
7 Eco-efficiency	Food carbon footprint	0.68
	Comprehensive eco-efficiency in the food chain	0.68
8 Policy	Agricultural policy in the next CAP	0.88
	Rural policy in the next CAP	0.83

Table 2. Standardized factor scoring coefficients and contributions of information-uptake profiles to climate change information themes. **Bold:** statistically significant differences (α = 0.05); the strongest anomalies are underlined. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Profile	N	Theme							
		Soil fertility	Renewable energy	Livestock production	Crop production	Food security	Diversity	Eco-efficiency	Policy
Information highlighters	51	**0.32*** **	**0.31***	**0.37*** **	−0.07	**0.43*** **	**0.33****	**0.43*** **	**−0.85*** **
Globally and nationally oriented	76	**−0.49*** **	**0.62*** **	**−0.34*** **	−0.23	**0.59*** **	−0.04	0.10	**0.41*** **
Livestock oriented	91	**0.46*** **	**−0.22***	**0.65*** **	−0.07	0.09	−0.11	**−0.23****	**0.51*** **
Plant production oriented	66	0.01	0.06	−0.04	**0.35*** **	**−0.96*** **	−0.05	**0.23***	0.04
No interest	56	**−0.39***	**−0.84*** **	**−0.89*** **	0.08	−0.19	−0.01	**−0.42****	**−0.66*** **

Table 3. Number (parentheses: percent share of cluster) of respondents in each clustered profile by occupation. The occupations of respondents differed significantly for the profiles (p = 0.004)

Occupation	Profile					
	Information highlighters	Globally and nationally oriented	Livestock oriented	Plant production oriented	No interest	Total N
Farm advisers	14 (27)	14 (18)	27 (30)	24 (36)	8 (14)	87
Farmers	11 (22)	28 (37)	34 (37)	23 (35)	31 (55)	127
Other	26 (51)	34 (45)	30 (33)	19 (29)	17 (30)	126
Total N	51	76	91	66	56	340

of soil organic matter, soil water management and extreme weather events). Other farmers, by contrast, appeared to be very globally and nationally oriented and thus called for more food security and renewable energy related information. The 'no interest' profile differed significantly in most cases from the other profiles in terms of lack of interest towards practically all of the suggested climate change themes (Table 3). Farm advisers primarily stressed the importance of farm-level information and fell into the 'livestock oriented' and 'plant production oriented' profiles.

3.3. Views on impacts of climate change in the near future

Among the respondents, 55% believed that climate change would affect their activities in the near future. One-third (34%) of respondents did not see that climate change would affect their activities, and 11% were uncertain. A total of 40 responses from farmers, 37 responses from farm advisers and 30 responses from other rural stakeholders were categorized as 'Potential for agriculture', 'Risks for agriculture', 'Potential in terms of energy options' and 'Energy conservation' (Fig. 2). Examples of the responses are shown in Table S2 in the Supplement.

Farmers anticipated that new possibilities and benefits for agricultural production would be brought about by climate change, while farm advisers and other rural stakeholders considered the effects in terms of increasing risks for production (Fig. 2). The production potential was considered to improve due to the extended and more physiologically effective thermal growing season that would increase the yields of current crops and increase the yield capacities of novel crops. The main concerns of farmers related to challenging produc-

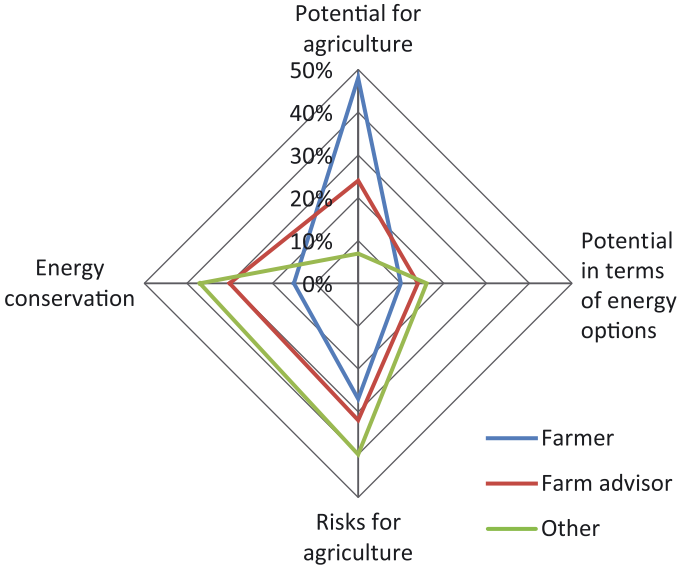

Fig. 2. Radar diagram showing the percentage share of entrusted effects of climate change in the near future presented for the different occupational groups. Potential in terms of energy options, energy conservation and efficiency and potential and risks in terms of agricultural production were emphasized in the responses

tion conditions, such as increases in plant diseases and pest incidence due to climate change. Some considered adaptation practices to already be urgent. In this regard, improved nutrient cycling or transition to organic production were mentioned. Farm advisers believed that providing their advisory services would be more challenging in the future, and therefore emphasized the need for training, in particular regarding new crop species, soil structure and pest and disease management. The respondents from other rural stakeholders thought their work would be more challenging due to worsening environmental problems.

Climate change was projected by the respondents to increase farm energy costs, energy price volatility and the unpredictability of input availability. Respondents believed that the use of renewable energy and the energy efficiency of agriculture would increase. They also found increasing energy self-sufficiency as a necessity in preparing for the impacts of climate change, both in individual farms and nationally. However, farmers expected improvements in energy efficiency to stem from reductions in energy consumption, rather than on-farm energy production or use of renewable energy sources. Farm advisers and other rural stakeholders anticipated that renewable energy would become the focus of project and consultancy work, although putting this into practice on farms was seen as challenging. The respondents from other rural stakeholders considered reducing the use of fossil fuels in their everyday life. Several respondents assumed climate change impact would not intensify until much later in the future.

3.4. Perceptions of barriers to and incentives for engaging in climate change actions

Responses of farmers (n = 140), farm advisers (n = 100) and other rural stakeholders (n = 130) regarding the barriers to and necessary incentives for taking action on climate change on farms were categorized as: 'Concreteness of communication', 'Economic opportunities', 'Reliability of communication' and 'Economic losses' (Fig. 3). Examples of the responses are shown in Table S3 in the Supplement.

Respondents criticized the lack of concreteness of climate change communication. The overload of information and the lack of intelligible, locally usable and practically applicable information were perceived as the main obstacles to engaging in actions to prepare for climate change. The communication channels were considered to be inconsistent and characterized by abstract targets. In addition, the general focus of climate communication on international aspects made it seem distant from farm-level action. Respondents asked for information based on farm-level experiments and face-to-face advice. They also hoped to gain information with consistent connections between farm-level measures and their significance in terms of climate change adaptation or mitigation.

Respondents were suspicious regarding the reliability of climate communication, particularly due to the questionable credibility of the information itself, and to the multiple goals of climate communication, both leading to inconsistencies. According to respondents, the reliability of climate change information had been weakened by manipulation and politicization, as in the case of the manipulation of science for political gain. There was also confusion due to the contradictory information received from, and cases of exaggeration by, the mass media. Climate change research was also criticized due to the partial evidence and controversy with respect to research results. Contradictory policy measures, such as a lack of political incentives for farm-level businesses, and multiple and ever-changing environmental goals, raised doubt regarding the veracity of the idea that climate issues are important at the farm level.

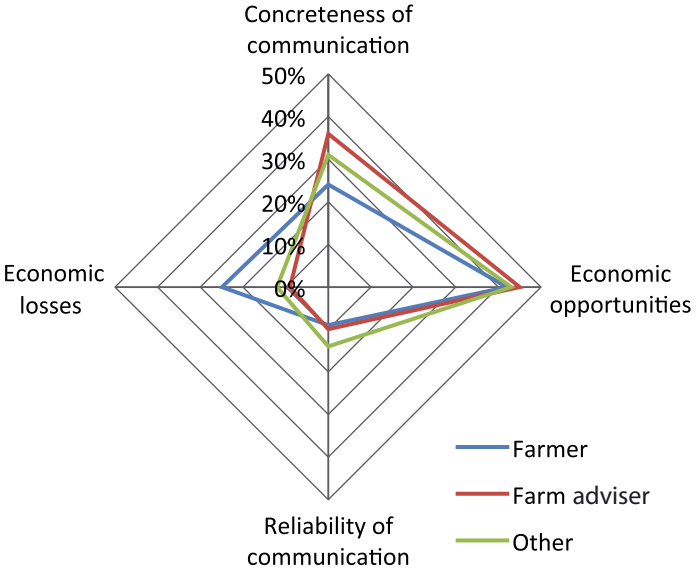

Fig. 3. Radar diagram showing the percentage share of perceptions of barriers and required incentives to putting climate change adaptation and mitigation measures into practice. Respondents emphasized the concreteness and the reliability of communication as well as the economic losses and opportunities

Farmers were the most concerned group in terms of how climate change would impact economic profitability. Obstacles to farm-level engagement in proactive climate actions were mostly linked to the low current profitability of farming, shortage of time or potential increases in costs. A portion of the respondents anticipated climate change solely as a threat that might, for example, lead to tightening mitigation policy and thus input price increases, and therefore they were unwilling to be proactive. These respondents were unwilling to consider climate issues unless there was a direct financial impact on the farm business. In turn, a portion of the farmers was highly interested in acting proactively if the economic and communication barriers were solved. Respondents called for monetary incentives for proactive climate change preparedness. Various suggestions were offered for generating interest in climate change issues on farms. These suggestions included, for instance, markets for climate-friendly products and urgent reforms to the current farm-scale bioenergy business environment through investment support or better market channels. Nutrient recycling and reduced input use interested respondents, although not directly due to willingness to prepare or to voluntary mitigation measures, but because they were perceived rather as an obligatory path for survival in the current economic situation. Some of the actors thought the effects of climate change would guide food systems in more climate-friendly directions, without any significant incentives

A few respondents externalized responsibility, for example to consumers or other countries, while others regarded themselves as already active in an environmentally friendly way, in which case no further action was considered necessary. The lack of the effectiveness of actions was also mentioned as a perceived barrier: farm-level or Finnish national actions to mitigate greenhouse gas emissions were seen as negligible when compared to the scale of emissions from other countries. According to farm advisers and other professionals, a lack of interest, a passive attitude and strong prejudices create a challenge for engagement in climate change preparedness among farmers. Other respondents mentioned that the media portrays an unfair and exacting picture of agriculture, which may reduce the enthusiasm for climate change actions. For instance, it was perceived that agriculture was often blamed as a driver of environmental problems, while the mitigation or adaptation potential in rural areas received hardly any attention in the media.

4. DISCUSSION

4.1. Climate change communication and the usability gap: information uptake profiles in developing more targeted and effective communication

Our study revealed a diversity of profiles with regard to climate change information needs of farmers, ranging from production-specific interests to globally and nationally oriented respondents and information highlighters. The information needs varied among regions. This finding coincides with earlier reported patterns, e.g. among Australian (WIDCORP 2009), Indian (Kumar 2011) and west African (Ingram et al. 2002) farmers. Thus, tailored communication based on the profiles can be used to more effectively address farmers' needs, improve the effectiveness of climate communication and help increase farmer interest in climate actions.

Occupation constituted a key determinant in the profiles of perceptions of climate change information. This may be explained by the differences among farmers, farm advisers and other rural stakeholders (including decision makers, office holders) in terms of awareness of mitigation and adaptation actions that is influenced by accumulated knowledge (Hyland et al. 2016). Farmers may think in terms of localized perspectives and shorter timeframes than the other respondents (Roncoli 2006). This may explain our findings regarding the low interest ratings among farmers towards abstract issues, such as the topics related to policy or diversity as a buffer. However, the profiles presented also reflected that some respondents saw it as highly relevant to provide farmers more national and global climate change information. Such knowledge may empower farmers to participate more in national or international climate debates (Williams et al. 2015).

A quarter of the farmers were not strongly interested in any of the climate change themes. This represents a challenge for climate communication, as it indicates merely passive adaptation (occurring as late as possible) and hinders effective mitigation. A similar reluctance among farmers regarding climate actions has been reported for instance in Australia (WIDCORP 2009) and Scotland (Barnes & Toma 2012). The fact that other rural stakeholder respondents regarded the need for climate change information among farmers as more imperative than did the farmers themselves reflects the challenge of engaging farmers in pursuing proactive farm-level actions.

The low interest rating obtained by the theme 'diversity' as a buffer towards climate change (including diversity of crop species at the farm level, diversity of crop cultivars, functional diversity of the cropping system), mostly highlighted by other rural stakeholders, indicates skepticism among farmers and farm advisers regarding the practicality and effectiveness of diversity in adapting to climate change. Although diversity in many forms has been suggested as a key determinant in strengthening resilience in agriculture to face climate change (Lin 2011), similar suspicion among farmers has been reported in the UK (Turner et al. 2006) and in the EU (Gorton et al. 2008). Thus, diversification seems to be rather a theoretical, abstract and region- or nation-specific issue, presenting a typical challenging topic for climate change communication.

4.2. Actor perceptions guide engagement in climate change actions on farms

Our findings are in line with previous literature, both in terms of perceived future potential opportunities and risks in agriculture from climate change (Pachauri et al. 2014, Peltonen-Sainio et al. 2016), and regarding attitudes to energy options and savings (Smith et al. 2008). Half of the respondents believed that climate change would affect their activities in the near future. Several studies conducted previously have shown that people in northern Europe have not been highly concerned about climate change, and have thus to date been unwilling to prepare, or have been uninformed in terms of preparing (Gallup Organization 2007, Lorenzoni et al. 2007). Reasons for such perceptions have been proposed in the literature, and may also explain our findings. According to Poortinga & Pidgeon (2003), the importance of climate change falls below that of personal and social issues (finance, health, etc.), and the remoteness of climate change in time and space makes it difficult to relate to (Moser 2010). Furthermore, the confusion regarding perceived responsibility (Moser 2010), a low sense of the perceived risks (Hyland et al. 2016), and tension with other environmental issues hinder engagement with climate issues (Lorenzoni et al. 2006).

In our study, the principal perceived barriers to proactive climate-related action were a lack of economic incentives and failed climate communication. Earlier studies with similar findings have been conducted among the general public (Lorenzoni et al. 2007, Doulton & Brown 2009) and among farmers (Sunding & Zilberman 2001, Fleming & Vanclay 2011). The lack of concreteness of information, information overload and sometimes contradictory messages, as well as a lack of connection to — and demonstration of — practical climate actions have also been discerned by several studies (Moser 2010, Fleming & Vanclay 2011). These studies emphasize how the availability and provision of information is not a guarantee for changes in behaviour (Fleming & Vanclay 2011). Putting information into practice on farms is also weakened by doubts influenced by the media (Härtel & Pearman 2010, Kim 2011), government and policy (Compston & Bailey 2008, Moser 2010) and science (Moser 2010). Earlier studies have revealed how a high level of interaction (or co-production of information) among scientists, policy makers, farm advisers and farmers can encourage farm-level action on the multifaceted issue of climate change (Lowrey et al. 2009, Lemos et al. 2012). Importantly, according to our findings, information received from other farmers or farm advisers may be more easily adopted than information from scientists.

Economic barriers were seen as important by our respondents, which coincides with results reported by Fleming & Vanclay (2011): costs of actions were perceived as high and the effectiveness of measures as unproven and ultimately as a threat to competitiveness. Our findings emphasize the need for climate communication to be more closely linked with the farm economy, future costs and financial potential, which may increase the general willingness to be proactive. Similar findings have been reported by Lorenzoni et al. (2007), Hyland et al. (2016) and Fleming & Vanclay (2011). The latter authors discussed how profit-oriented farmers could be motivated towards climate actions by informing them about how others, including government, industry and consumers, are responding to climate change. The challenge in engaging in climate activities also relates to policy: long-term commitment and incentives play a crucial role (Lemos et al. 2012). Although regulation is linked to adoption of new practices (Sunding & Zilberman 2001), little regulation exists regarding mitigation or adaptation in agriculture. The high dependence of Finnish farmers on CAP should also be noted, as it may either critically restrict or support the possibility of taking proactive climate actions. Communication with, and engagement of, farmers in designing future CAP support actions that connect with climate change mitigation and adaptation targets are also a way to support the early adoption of climate actions by farmers in the future.

Our results indicate that tailored climate communication that considers regional specifications and farm economics, and offers practical information on mitigation and adaptation actions, are likely to help bring about earlier planning and adoption of climate actions. Farmers are open to information delivered through practical observation and trials. Participatory approaches involving dialogue among farmers and other rural stakeholders, allowing learning from different perspectives, may be an effective way for such purposes (Roncoli 2006). When the information generated is produced with farmers' needs in mind, it will help build credibility and legitimacy (Crane et al. 2010). As an example, a policy initiative by the Scottish Government called 'Farming for a Better Climate', that is based on farmer discussion groups 'to find practical ways to move towards a more profitable, low carbon future, adapt to a changing climate and secure farm viability for future generations' (www.sruc.ac.uk/climatechange/farmingforabetterclimate/) represents one way to enhance climate-smart actions. In terms of climate actions that mainly benefit the public good, too little regulation regarding adaptation and mitigation and a lack of economic incentives hinder the adoption of actions (Sunding & Zilberman 2001).

4.3. Generality and reliability of the study

Because the information-need profiles were created for a northern country, viz. Finland, which has specific agronomic characteristics such as a short growing season and a high proportion of organic soils, their value may be limited in terms of targeting climate communication in more southern countries. Although climate change mitigation and adaptation are pressing issues globally, climate actions connect to local conditions and operating environments, which is why such case study approaches are needed. However, our approach of gathering perceptions to develop profiles that allow more targeted communication could be applicable to other regions as well. The survey sample was well representative of Finnish farmers in terms of age distribution of the respondents (the average age of Finnish farmers receiving agricultural support was 52 in 2012; Niemi & Ahlstedt 2013). Furthermore, the use of contact lists of different unions to gather the sample contributed to the reliability of the study in terms of representativeness for the occupational groups and regions of Finland. However, use of the union lists may have led to a higher frequency of more societally active farmers (involved in union actions) being invited compared to more passive ones.

5. CONCLUSION

Our study reveals the necessity of developing more targeted climate change communication for farmers, as information needs vary by region. The perceptions of whether climate change will have an impact on operations in the near future also varies by region and between farmers, advisers and other rural stakeholders. From actors' opinions, practical, production-specific information that takes into account farm typology and potential effects on farm profitability is needed to raise the interest and encourage climate change mitigation and adaptation actions on farms. As a solution, characterizing information needs and uptake profiles and strengthening the connection between science-based knowledge and farm practices can help identify critical knowledge gaps and facilitate more effective and tailored climate communication for farmers. Given the rapidly changing climate, there is an urgent need for more customized, practical and effective communication means to encourage the trialing and development of case-specific climate actions on farms.

Acknowledgements. Research data collection was enabled by the European Union and Rural Development Programme for Mainland Finland via the 'Climate change and countryside' (ILMASE) climate communication project which was allocated by The Centre for Economic Development, Transport and the Environment (ELY Centre) of Häme. The study was finalized with support from the Natural Resources Institute Finland (and former MTT Agrifood Research Finland). We thank Riitta Savikko for constructive comments on the manuscript.

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Editorial responsibility: Gerrit Hoogenboom, Gainesville, Florida, USA

Submitted: August 25, 2016; Accepted: February 20, 2017
Proofs received from author(s): May 19, 2017