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The need for non-climate services – Empirical evidence from Finnish municipalities

Aleksi Räsänen [a,b,*], Alexandra Jurgilevich [a], Simo Haanpää [c], Milja Heikkinen [a], Fanny Groundstroem [a], Sirkku Juhola [a,c]

[a] Department of Environmental Sciences, University of Helsinki, P.O. Box 65, FI-00014 University of Helsinki, Finland
[b] Department of Geography, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway
[c] Department of Built Environment, Aalto University, P.O. Box 22000, FI-00076 Aalto, Finland

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ABSTRACT

There is a call for climate services to facilitate climate risk assessment and management. Local governments are major actors in managing climate risk but there is less research on what kind of information is needed and used by municipalities. With the help of a quantitative survey and a post-survey workshop, we analyze the status of climate risk assessment and management in Finnish municipalities, evaluating key information sources and assessing the main barriers to climate risk work. Our results show that municipalities have generally been slow in implementing climate risk management, and that has mostly been concentrated on managing flood risks. They use and need various sources of information, such as experts, a range of networks, as well as data and tools related to climate and weather. Those municipalities that have been more active in climate risk management consider public sector experts and networks to be more important than do less active municipalities. There are significant barriers to managing climate risk, which include the usability of climate information and a lack of such information, a lack of resources, institutional arrangements and constraints both within municipalities and between municipalities and other organizations. In particular, those municipalities that have been less active in climate risk management need more networking, strengthening of their capacity and know-how to assess and manage climate risks as well as access to usable information, whereas more active municipalities are more readily able to digest climate information. We discuss how climate risk management could be linked to overall risk management in municipalities and how networks of municipalities could facilitate climate risk management. Finally, our results imply that, in addition to climate services, those less active municipalities in particular need non-climate services, i.e. services that explain how to use information that is not directly related to climate.

* Corresponding author at: Department of Environmental Sciences, University of Helsinki, P.O. Box 65, FI-00014 University of Helsinki, Finland.
E-mail addresses: aleksi.rasanen@helsinki.fi (A. Räsänen), Alexandra.jurgilevich@helsinki.fi (A. Jurgilevich), Milja.e.heikkinen@helsinki.fi (M. Heikkinen), fanny.groundstroem@helsinki.fi (F. Groundstroem), Sirkku.juhola@helsinki.fi (S. Juhola).

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1. Introduction

Irrespective of the efforts to mitigate it, climate change will have widespread impacts on societies (IPCC, 2014). The IPCC (2014) has conceptualized the possible impacts of climate change with a climate risk framework that consists of a combination of hazards (climatic events and trends), exposure (the presence of valued elements in locations that can be adversely affected) and vulnerability (the propensity of exposed elements to be adversely affected). To deal with climate risks, risks and their elements should be understood (Ribot, 2014), assessed (McDowell et al., 2016) and managed (Jones and Preston, 2011). Furthermore, it has been argued that risk management (i.e. exploring, making and acting on decisions in an uncertain future) should guide adaptation to climate change (Jones and Preston, 2011).

To inform climate risk management, the concept of climate services has emerged (Asrar et al., 2012; Hewitt et al., 2012; Vaughan and Dessai, 2014; WMO, 2011). Climate services are often defined as decision-relevant, actionable, science-based information that different stakeholders can act upon. The concept of climate services has also been criticized for being too supply-driven; in other words, it has been argued that demands of climate information users have not been widely considered when producing climate services (Lourenço et al., 2016). Therefore, to facilitate demand-driven climate services, it is necessary to know what kind of information is used and needed by various actors and for what purposes it is to be used. Early studies on climate services and their use, have concentrated, for instance, on boundary organizations (Briley et al., 2015; Kirchhoff et al., 2015a,b) and on useful and usable information (Dilling and Lemos, 2011; Kirchhoff et al., 2013a; Lemos and Rood, 2010), thus addressing the long-established question on how to make science useful in decision-making.

This issue of the science-policy interface is not new, neither is it solely an issue for the climate change adaptation community but it touches on wider academic and societal debates. On the one hand, studies have explored the ways to overcome the "loading-dock approach to science", to translate science into decision-making, and to bridge the gap between supply, demand and the process of production between the two (Cash et al., 2006; Dilling, 2007; Sarewitz and Pielke, 2007). On the other hand, studies have concentrated on the users of the science, particularly the institutions that are the decision-making actors. It has been proposed that these institutions may have their own path-locks, traditions, responsibilities, accountability procedures and even conflicting agendas (Krieger, 2013; Kuhlicke et al., 2016; Porter and Demeritt, 2012; Rothstein et al., 2006).

More broadly, risks have become a cornerstone of governance in many fields of public policy, and risk assessments and management are common tools in policy planning (Rothstein, 2006). The way in which risks are managed depends not only on the scientific evidence, but also on the institutional context (Krieger, 2013; Rothstein, 2006). From this perspective, it is vital to produce not just supply-driven science to be used in decision-making, but demand-driven science that can be used by executive and legislative institutions. In demand-driven science, the producer of knowledge needs to be aware of the user of the knowledge and its institutional context, the process of such knowledge (co)-production and the use of the knowledge (Rothstein, 2006; Rothstein et al., 2006). In other words, there is a need not only for scientific evidence to support decision-making, but also science to support institutions that are engaged in the process of decision-making. It has been stated that this is particularly relevant for the actors involved in climate risk management, as this policy field deals largely with the consequences of climate change impacts, or prevention thereof, thus placing an emphasis on the accountability of the institutions involved (Tang and Dessai, 2012). Thus, we argue that from the perspective of climate risk management, this would translate into the need not only for climate services (e.g. climate projections), but also non-climate services (e.g. spatial distribution and socio-economic aspects of climate risks, as well as risk management options).

Climate services and information are used by various actors who undertake climate risk management. While multi-level governance is needed for effective climate risk management, many of the practical measures are carried out by local governments (Measham et al., 2011; Næss et al., 2005; Nalau et al., 2015). Barriers that hinder, or conversely the conditions that enable the success of these local measures are now widely documented in the literature (Carlsson-Kanyama et al., 2013; Hamin et al., 2014; Lawrence et al., 2015; Measham et al., 2011; Rauken et al., 2015; Shi et al., 2015). However, research has paid less attention to what kind of climate information and services are used and needed by municipalities (Archie et al., 2014; Porter et al., 2015).

Here, we (1) analyze the status of climate risk assessment work in Finnish municipalities, (2) evaluate key information sources, and (3) assess what are considered to be the main barriers and ways to improve climate risk assessment and management. We answer these points with the help of a quantitative survey and a post-survey workshop.

2. Climate services and needs in municipal climate risk management

2.1. Climate services

According to WMO (2011), climate services are defined as a range of activities dealing with the generation and provision of information that is linked to the past, present and future climate and its impacts on natural and human systems. In other words, "[C]limate services may be defined as the provision of timely, decision-relevant, actionable, science-based information, and guidance on climate variability and change, and the associated environmental and social impacts, to assist decision-makers (users) in the public and private sector in the development of responses to manage their climate risks" (Bowyer et al., 2015, p. 534). The concept of climate services has mostly been used to refer to the provision of and accessibility to climate information (Goosen et al., 2014; Hewitt et al., 2012; Vaughan and Dessai, 2014), even though climate impacts are contingent on various societal and geographical factors (i.e. vulnerability and exposure), which vary significantly across locations (IPCC, 2014).

It has therefore been argued that climate services should include information on the impacts of climate change and assessment of vulnerability, together with the costs and benefits of different climate risk management options (Lourenço et al., 2016). Goosen et al. (2014) have thus suggested that this broader concept should be titled "climate adaptation services" in contrast to a narrower definition of the supply side of climate services. This suggestion has been justified by the argument that the knowledge of vulnerabilities and climate change impacts on human well-being is less advanced than the knowledge of climate systems (Goosen et al., 2014).

Indeed, the mainstream view on climate services often builds on scientific framings of climate change, where society is seen as an external box that drives changes in climate and experiences the impacts (O'Brien et al., 2007). There are, however, other discourses of climate change; most notably the human security framing posits that people are affected by climate change in various ways and the climate is in continuous interaction with multiple change processes (O'Brien et al., 2007). Although there has been a shift in focus towards a human security framing in studies related to assessing and understanding vulnerability (McDowell et al., 2016; Räsänen et al., 2016), and towards differentiating vulnerability and user needs in climate services for development practices (Carr and Owusu-Daaku, 2015), this shift is yet to happen in climate services (Lourenço et al., 2016).

2.2. Usability of information

A distinction between useful and usable information has emerged in the literature, with the former referring to functionality and desirability, and the latter to application and fit. In other words, useful information is regarded as functional in decision-making primarily by the producer, and usefulness is a necessary condition for usability. Usable information should directly target users' needs and be accessible to the user, thus, usability is defined primarily by the user (Lemos and Rood, 2010). According to the extensive review by Dilling and Lemos (2011), readily usable information should be produced in an iterative co-productive process between users and producers. Therefore, when processes are only supply-driven or only demand-driven, they are seldom sufficient for creating usable information and it has been found that there are serious institutional barriers between the scientists who produce the information and the users of information (Kirchhoff et al., 2013a).

It has been argued that various actors need develop the capacity to increase climate literacy and to understand climate service information (Asrar et al., 2012). Kirchhoff et al. (2013a) suggest that groups of users with similar needs would facilitate the creation of usable information. In a similar vein, there is evidence that networks can facilitate climate risk management (Archie et al., 2014; Kalafatis et al., 2015; Romsdahl, 2011; Tribbia and Moser, 2008), and colleagues are an important source of information (Archie et al., 2014; Tribbia and Moser, 2008). There is also widespread literature on boundary organizations (Briley et al., 2015; Feldman and Ingram, 2009; Kirchhoff et al., 2013b) and chains (Kirchhoff et al., 2015a,b) that act between climate information producers and users. The use of boundary organizations is not the only way to bridge the gap between information producers and users. Déandreis et al. (2014) show that a dedicated portal could perform the same task, and Lemos and Rood (2010) argue that climate information should be integrated with other kinds of knowledge so that climate risk management could be mainstreamed into decision- making. Finally, learning-by-doing and reflecting on one's work are needed for effective climate risk management (Orderud and Winsvold, 2012).

2.3. Barriers and enablers of municipal climate risk management

Municipalities and other public sectors need a variety of information, and the lack of both climatic and non-climatic information can be a barrier to climate risk management (Lawrence et al., 2015). However, it has been found that the lack of technical information, such as short-term climate projections, is among the less important barriers (Archie et al., 2014; Hamin et al., 2014; Porter et al., 2015). While some studies point to municipalities' need for locally-specific climate information in guiding climate risk management, they also regard knowledge on how to assess vulnerabilities as important (Archie et al., 2014; Tribbia and Moser, 2008).

There are also other barriers apart from information. Numerous studies point out that the most important barrier is a lack of resources (Archie et al., 2014; Porter et al., 2015; Tribbia and Moser, 2008), although some disagree (Hamin et al., 2014). Other barriers cited include a lack of political will (Archie et al., 2014) and leadership (Hamin et al., 2014; Measham et al., 2011), a lack of political support from central government (Dannevig et al., 2013; Porter et al., 2015; Wejs et al., 2014), competing priorities and other institutional constraints (Measham et al., 2011), the size of the municipality (Dannevig et al., 2012; Takao, 2012), and conflicting values and beliefs (Hamin et al., 2014). It has also been shown that barriers change over time; e.g. in Britain, a lack of usable information is no longer regarded as such an important barrier as it was in the early 2000s (Porter et al., 2015).

The enablers of climate risk management are usually considered to be the opposite of barriers: they include, for instance, political will and institutional arrangements (Dannevig et al., 2013; Lawrence et al., 2015; Shi et al., 2015), resources (Dannevig et al., 2013, 2012; Shi et al., 2015), and a variety of information (Lawrence et al., 2015). Some have discussed how climate risk management could be mainstreamed into municipal decision-making (Juhola et al., 2010; Rauken et al., 2015; Wamsler and Brink, 2014), including the need for vertical (across levels in public administration) and horizontal (across sectors in a municipality) policy integration (Rauken et al., 2015; van den Berg and Coenen, 2012). In particular, smaller municipalities need capacity-building in climate risk management (Takao, 2012) and local leadership is needed for effective climate risk management (Wejs et al., 2014). Overall, according to recent scientific literature, municipalities need both information and other support to be effective in climate risk management. Hence, climate services, as they are currently framed, constitute only a small portion of what is needed by municipalities.

3. Methods

To evaluate Finnish municipalities' climate risk management, we carried out an online survey in November–December 2015. The survey was sent to 122 municipalities (Fig. 1) that have been active in climate change planning and 33 answered (response rate 27%). We received a list of municipalities that have published a climate strategy or are in a process of writing one from the Association of Finnish Local and Regional Authorities. We then added municipalities that are currently included in a project about carbon neutral municipalities (Finnish Environment Institute, 2017). As we wanted to have one general view from each municipality, we sought the person who is responsible for climate issues or was responsible for the climate strategy. If we did not find that information, we targeted the survey at the head of environmental or technical administration. The online link for the survey was sent via email to the selected individual on November 30th 2015. We allowed them to forward the link to a person who knows most about municipal climate risk management. We allowed two weeks (until December 13th) to respond and sent two reminder emails about the survey to those municipalities that had not answered. The timing of the survey was planned so that it could be answered before the holiday season.

From each municipality, we received a maximum of one answer. In some municipalities, one person filled the entire survey, whereas in other municipalities, several officials were consulted when answering. As climate risk management is often co-ordinated between municipalities, three answers were given by regional organizations representing several municipalities. The respondents were municipal or regional officials either from environmental or technical administrations, mostly

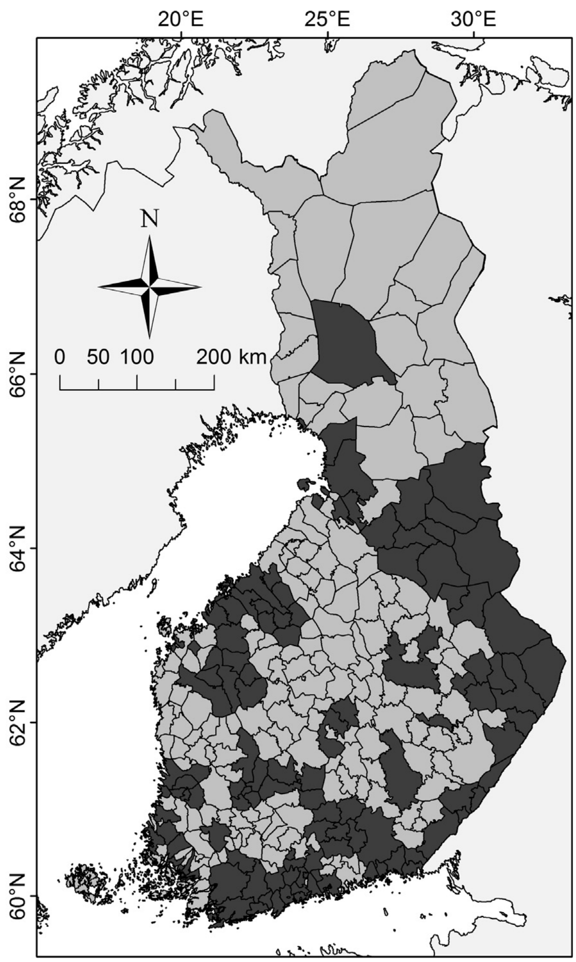

Fig. 1. Map of Finnish municipalities. The survey was sent to municipalities drawn in dark gray while the remaining municipalities are drawn in light gray.

with long work experience in their field (76% with over 10 years of work experience). Responses were received both from small and relatively large municipalities, with 40% of them having more than 50,000 and 36% less than 20,000 inhabitants.

In the survey, we asked for example, if municipalities have planned for climate change adaptation and assessed climate risks, how risks were assessed, what are considered to be the main climate hazards, what are considered to be useful information sources, what are the barriers in risk assessment/management, and how the assessment/management could be improved. The answers were analyzed using Microsoft Excel 2013 (Microsoft, Redmond, WA, USA) and IBM SPSS Statistics 22 (Armonk, NY, USA) software. In parts of the analysis, different groups of respondents were compared using the non-parametric Kruskal-Wallis H Test of identical distributions.

After the survey, we organized a two-hour follow-up workshop with nine participants, including three survey respondents. We invited all those respondents to the workshop who had answered that they were interested in a post-survey workshop. The workshop was part of a larger workshop about Finnish climate risk management, and invitations to the larger workshop were sent to key stakeholders in Finnish climate risk management, from business, public administration and civil society. In the larger workshop, there were two parallel sessions and participants could decide if they wanted to attend the municipal workshop or the other session. The workshop was organized on January 27th 2016. The municipal workshop was divided into three phases. First, we presented the initial survey results and discussed what kind of thoughts they raised. Second, we had a more general discussion about municipal and regional climate risk management. Third, we suggested and discussed a framework for how regional climate risk assessments could be undertaken. Three of the authors (AR, AJ, SH) made notes during the workshop to validate the survey findings.

4. Findings

4.1. The status of climate risk management in Finnish municipalities

According to the survey responses, climate risk assessment, management, and adaptation planning has been quite modest in Finnish municipalities (Fig. 2). This point was also emphasized in the open answers of the survey, in the workshop and in the climate strategy documents. Overall, most of the climate change planning is concentrated on mitigation. In the survey, we asked respondents if their municipality had considered adaptation in its climate strategy, if they had assessed climate or weather hazards, and if they had analyzed the risk of exposure to climate or weather in their municipality (Fig. 2). Based on the answers to these questions, we constructed four comparisons to find out whether the answers differed between municipalities that had been more, and those that had been less, active in climate risk management. In all comparisons, a municipality could only be in one group.

Most of the climate risk management is carried out as part of other work in the municipalities (73%), although consulting companies have been involved (42%) and workshops organized (39%). Both long- and short-term climate risk assessments have been carried out in municipalities (Table 1). The key drivers in climate risk management have been the functionality of the municipality, infrastructure, and well-being of inhabitants. This goes well in line with Finnish municipal law, which states that it is municipalities' duty to promote well-being and sustainable development. Nevertheless, the workshop participants argued that perceived vulnerabilities in an area hardly ever drive municipal climate risk assessment and management.

Climate risk assessment has so far mostly concentrated on flood risks, although respondents considered storm winds and heavy rains as more serious threats (Table 2). On the one hand, flood risks have been assessed in the municipalities that are in flood-risk areas, partly due to the EU Floods Directive (European Commission, 2007). On the other hand, storms are potential hazards in all municipalities. Municipalities are mostly concerned about future sudden weather events and changes in overall climate; current weather events and the weather and climate abroad are of less concern. Nevertheless, the increase in climate refugees was raised as a concern by some respondents.

4.2. Key information sources

Many different information sources were regarded as useful by the respondents and the differences in rating information sources were generally small. Most useful sources consisted of contacts with different experts and tools that illustrate climate change and its impacts. Media and historical datasets were considered to be the least useful sources (Fig. 3). The municipalities that have been active in adaptation gave both higher and lower ranks to different information sources but differences were typically small and not statistically significant. Nevertheless, municipalities that had planned adaptation measures or considered exposure regarded experts in the public sector and networks in their own field as more useful than did those municipalities that had been less active (Table 3).

We also asked if the municipalities have used some of the most well-known Finnish information sources related to weather and climate. The most used information sources were the Finnish Meteorological Institute's long-term climate forecasts, and different Internet-sources of climate information and impact modeling. The least used sources were official hazard announcements (Fig. 4). Nonetheless, it was speculated in the workshop that these should be used in municipal rescue services but this source of information is not widely known in the technical and environmental administration. This was partly

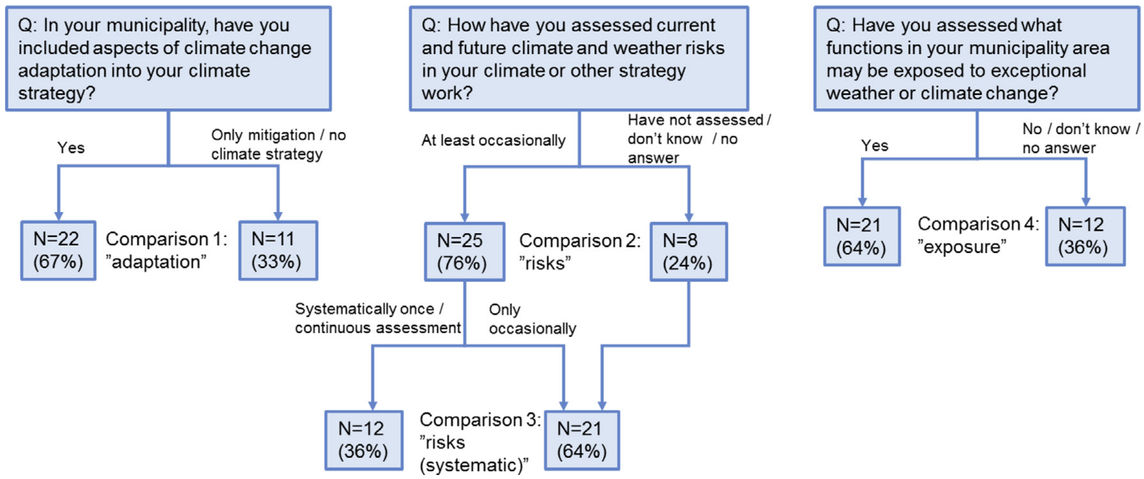

Fig. 2. In the survey, we asked three questions about the status of climate risk management in Finnish municipalities. Based on the answers to these questions, we constructed four comparisons, in which we compared more active municipalities against less active municipalities.

Table 1
Answers to the survey question "On which time scale did you assess climate and weather risks?" Percentages do not total 100% as respondents could choose multiple answers.

Time scale (years)	% of municipalities
<5	9
5–10	21
10–20	45
20–50	21
>50	21

Table 2
Answers to the survey question "Which are the most harmful weather phenomena with regard to your municipality's business sector, services and inhabitants welfare?" Respondents could pick a maximum of three phenomena in their answers.

Hazard	Municipalities (%)
Storm winds	76
Heavy rains	70
Floods	39
Excess snow	27
Drought	12
Freeze	12
Heat	9
No snow	9
Lack of frost heaving	9
Lighting strikes	6
Freezing rain	3
Frost heaving	3

confirmed in comparisons between groups: active performers in adaptation had used these information sources more; but then again, they had used all information sources more (Table 4).

While unusual weather conditions can often act as triggers for climate risk management (Dannevig et al., 2013; Shi et al., 2015; van den Berg and Coenen, 2012), only 15% of municipalities collect information about their impacts. In the workshop, it was emphasized that the information on impacts and consequences would be extremely useful in climate risk management. Furthermore, it was highlighted that impacts and vulnerability to those impacts are more meaningful to well-being than the causes and biophysical implications of climate change, yet impacts and vulnerability often get too little attention.

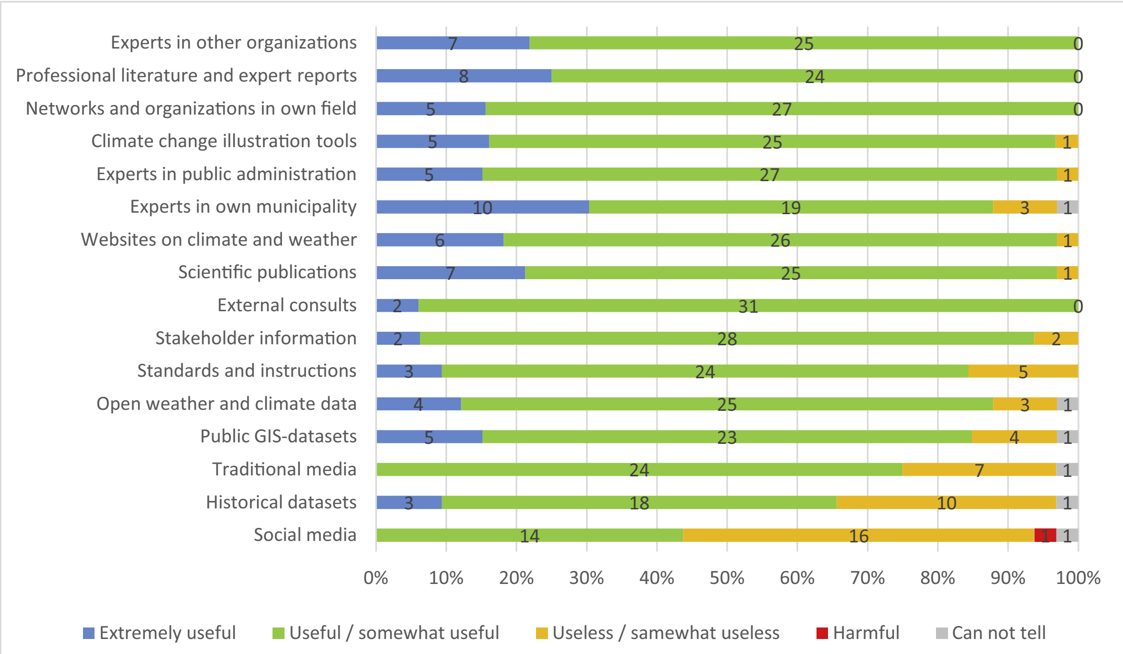

Fig. 3. Answers to the survey question "Assess the usefulness of the following information sources in developing climate and weather risk assessment or in adapting to climate and weather risks."

Table 3
The differences between groups in ranking the usefulness of information sources (see Fig. 3) according to Kruskal-Wallis H. The column adaptation refers to municipalities that have been involved in adaptation planning, the columns risks and risk (systematic) to municipalities that have assessed climate risks at least occasionally and systematically respectively, and the column exposure to municipalities that have considered exposure (see Fig. 2). To all groups two columns are given: direction shows if the information source is regarded as more useful (↑) or less useful (↓) by the respective group and p is the p-value of H (if $p < 0.1$ then *, if $p < 0.05$ then **).

Information source	adaptation		risks		risks (systematic)		exposure	
	direction	p	direction	p	direction	p	direction	p
Experts in own municipality	↑	0.452	↑	0.264	↑	0.773	↑	0.061^{*}
Experts in public administration	↑	0.047^{**}	↑	0.293	–	0.967	↑	0.06^{*}
Experts in other organizations	–	0.872	–	0.696	–	0.684	–	0.708
External consults	↑	0.451	–	0.464	↓	0.817	↑	0.786
Networks and organizations in own field	↑	0.078^{*}	↑	0.236	↑	0.506	↑	0.042^{**}
Stakeholder information	↑	0.294	↑	0.3	↑	0.797	↑	0.557
Professional literature and expert reports	↓	0.611	↓	0.171	↓	0.383	↓	0.156
Scientific publications	↓	0.87	↓	0.425	↓	0.508	↓	0.232
Social media	↓	0.378	↑	0.51	↓	0.373	↑	0.104
Traditional media	–	1	↑	0.361	↓	0.054^{*}	–	0.777
Websites on climate and weather	↑	0.324	–	0.852	–	0.324	↓	0.776
Standards and instructions	↓	0.628	↓	0.515	↑	0.68	↑	0.364
Climate change illustration tools	↑	0.394	–	1	↑	0.636	↑	0.248
Historical datasets	–	1	–	0.947	↓	0.524	↓	0.501
Public GIS-datasets	↑	0.158	↑	0.747	↓	0.743	↑	0.646
Open weather and climate data	↑	0.233	↓	0.391	↓	0.493	↓	0.778

4.3. Key barriers and proposals for improvement

The most significant barrier to climate risk management was the lack of resources both in terms of time and money. Other key barriers related to decision-making, lack of information about impacts and lack of usable climate information (Fig. 5). There was noteworthy dispersion in answers and many different barriers were regarded as significant. Nevertheless, climate information providers were mostly considered trustworthy. The municipalities that have been active in climate change planning regarded most of the barriers as less significant but the differences were usually small and not statistically significant. The barriers concerning limitations in suitable data, individual expertise, lack of contacts with climate information producers, insufficient information on climate and weather impacts, unclear liability distribution, diverging risk views

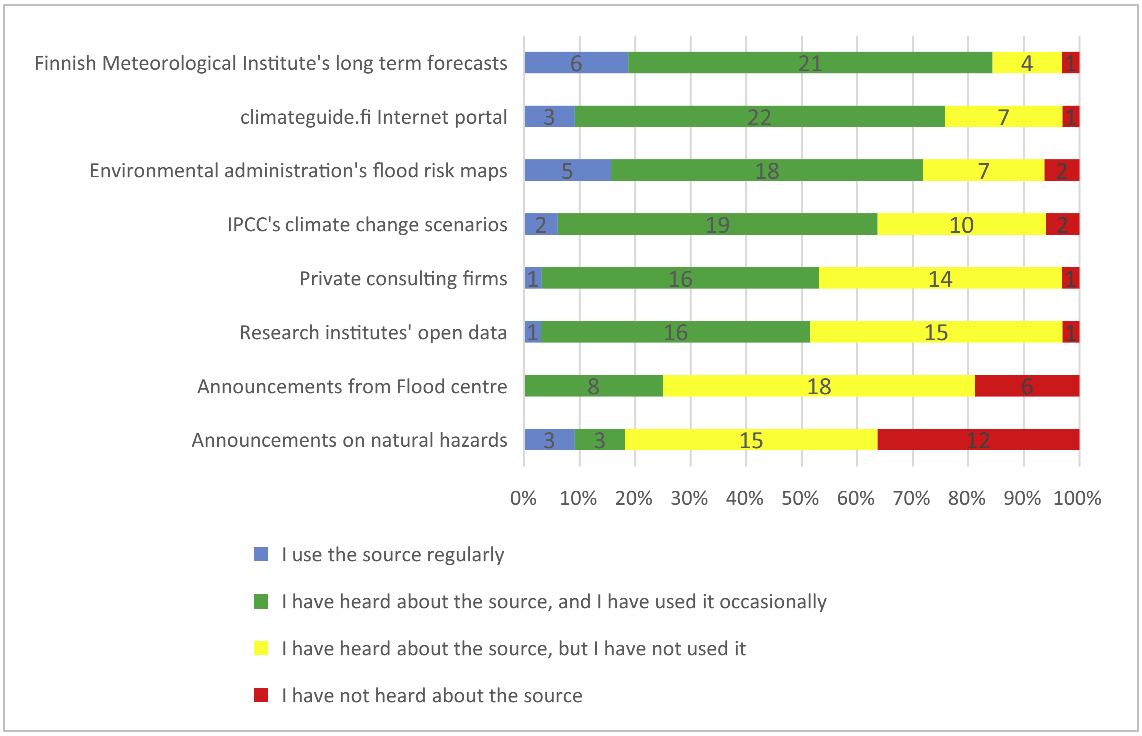

Fig. 4. Answers to the survey question "Are you aware of or have you used the following climate and weather information sources?".

Table 4
The differences between groups in the use of information sources (see Fig. 4) according to Kruskal-Wallis H. The column adaptation refers to municipalities that have been involved in adaptation planning, the columns risks and risk (systematic) to municipalities that have assessed climate risks at least occasionally and systematically respectively, and the column exposure to municipalities that have considered exposure (see Fig. 2). To all groups two columns are given: direction tells if the information source is used more (↑) or less (↓) in the respective municipalities and p is the p-value of H (if $p < 0.1$ then *, if $p < 0.05$ then **).

Information source	adaptation		risks		risks (systematic)		exposure	
	direction	p	direction	p	direction	p	direction	p
climateguide.fi Internet portal	↑	0.114	↓	0.808	↓	0.544	↑	0.893
Announcements from Flood centre	↑	0.329	↑	0.02^{**}	↑	0.074^{*}	↑	0.009^{**}
Announcements on natural hazards	↓	0.853	↑	0.059^{*}	↑	0.146	↑	0.512
Finnish Meteorological Institute's long term forecasts	–	0.423	↑	0.399	–	0.712	↑	0.137
Environmental administration's flood risk maps	↑	0.298	↑	0.083^{*}	↑	0.072^{*}	↑	0.001^{**}
Research institutes' open data	↓	0.368	↑	0.023^{**}	↑	0.377	↑	0.052^{*}
IPCC's climate change scenarions	–	0.697	–	0.756	–	0.735	↑	0.196
Private consulting firms	↑	0.841	↑	0.663	↓	0.358	↓	0.7

and separation between decision-making and climate risk management, were all considered less significant barriers ($p\text{-value} < 0.05$) in some comparisons (Table 5). This may point to the fact that municipalities that have neither assessed climate risks nor planned adaptation probably need more help in building contacts, focusing their own work and strengthening their expertise.

In the workshop, it was argued that climate information is often too technical and it lacks practicality. At the same time, it was acknowledged that some new biophysical illustration tools could be useful. According to the survey results, guides and more usable climate information would improve climate risk assessment and management. On the other hand, improvement in the spatial and temporal aspects of climate information was not considered as useful. However, all of the proposals for improvement were considered extremely significant by some respondents (Fig. 6). In the open answers, participants discussed whether guides and usability of information would help in overcoming the barrier of lack of time. Furthermore, municipalities that are active in climate change considered almost all improvement methods as less significant than did less active municipalities. In particular, improvements in information usability and in municipal know-how were not seen as important improvement methods ($p < 0.05$) in some comparisons (Table 6). This could indicate that there should be more effort to strengthen expertise in municipalities that have not yet started planning adaptation measures and climate risk assessments.

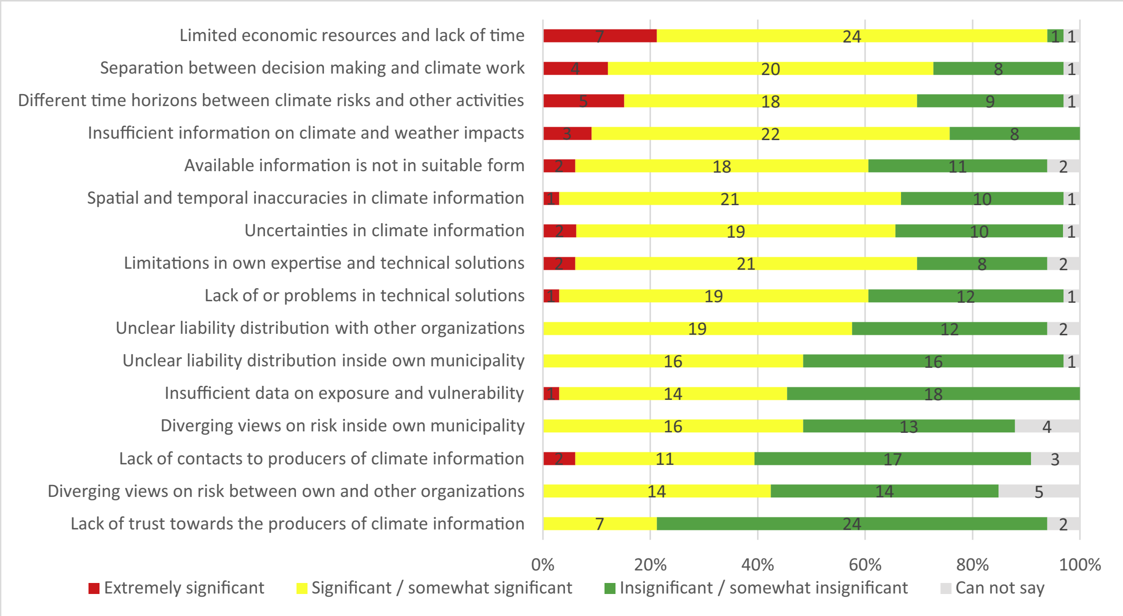

Fig. 5. Answers to the survey question "Here are listed barriers that may inhibit weather and climate risk management. Assess their significance in your climate work."

Table 5
The differences between groups in the considered significance of barriers to climate risk management (see Fig. 5), according to Kruskal-Wallis H. The column adaptation refers to municipalities that have been involved in adaptation planning, the columns risks and risk (systematic) to municipalities that have assessed climate risks at least occasionally and systematically respectively, and the column exposure to municipalities that have considered exposure (see Fig. 2). To all groups two columns are given: direction shows if the barrier is considered more (↑) or less (↓) significant in the respective municipalities and p is the p-value of H (if p < 0.1 then *, if p < 0.05 then **).

Barrier	adaptation		risks		risks (systematic)		exposure	
	direction	p	direction	p	direction	p	direction	p
Uncertainties in climate information	↓	0.333	↓	0.462	↓	0.218	↓	0.086*
Spatial and temporal inaccuracies in climate information	↓	0.113	↓	0.268	↓	0.069*	↓	0.12
Available information is not in suitable form	↓	0.806	↓	0.522	↓	0.369	↓	0.031**
Lack of contact with producers of climate information	↓	0.236	↓	0.073*	↓	0.033**	↓	0.01**
Lack of trust towards the producers of climate information	↓	0.32	↑	0.282	↓	0.712	–	0.78
Limitations in own expertise and technical solutions	↓	0.069*	↓	0.193	↓	0.006**	↓	0.014**
Limited economic resources and lack of time	↓	0.1	↓	0.407	↓	0.097*	↓	0.252
Insufficient information on climate and weather impacts	↓	0.222	↓	0.43	↓	0.039**	↓	0.041**
Insufficient data on exposure and vulnerability	↑	0.747	↓	0.17	↓	0.167	↓	0.07*
Lack of or problems in technical solutions	–	0.685	↑	0.228	↓	0.334	↓	0.752
Unclear liability distribution inside own municipality	↓	0.131	↓	0.86	↓	0.017**	↓	0.244
Unclear liability distribution with other organizations	↓	0.043**	↓	0.737	↓	0.204	↓	0.23
Different time horizons between climate risks and other activities	–	0.725	↓	0.893	↓	0.563	↓	0.204
Diverging views on risk inside own municipality	↓	0.092*	↓	0.043**	↓	0.085*	↓	0.069*
Diverging views on risk between own and other organizations	↓	0.351	↓	0.629	↓	0.059*	↓	0.096*
Separation between decision making and climate work	↓	0.334	–	0.913	↓	0.017**	↓	0.062*

In the workshop, it was highlighted that climate issues are usually co-ordinated by the environmental administration, whereas other risks are managed by the central administration. Therefore, one of the key avenues in enhancing climate risk management would be to integrate it into overall risk management rather than climate change mitigation. Furthermore, as Finnish municipalities are quite small in size, it was suggested that climate risk management could be co-ordinated regionally.

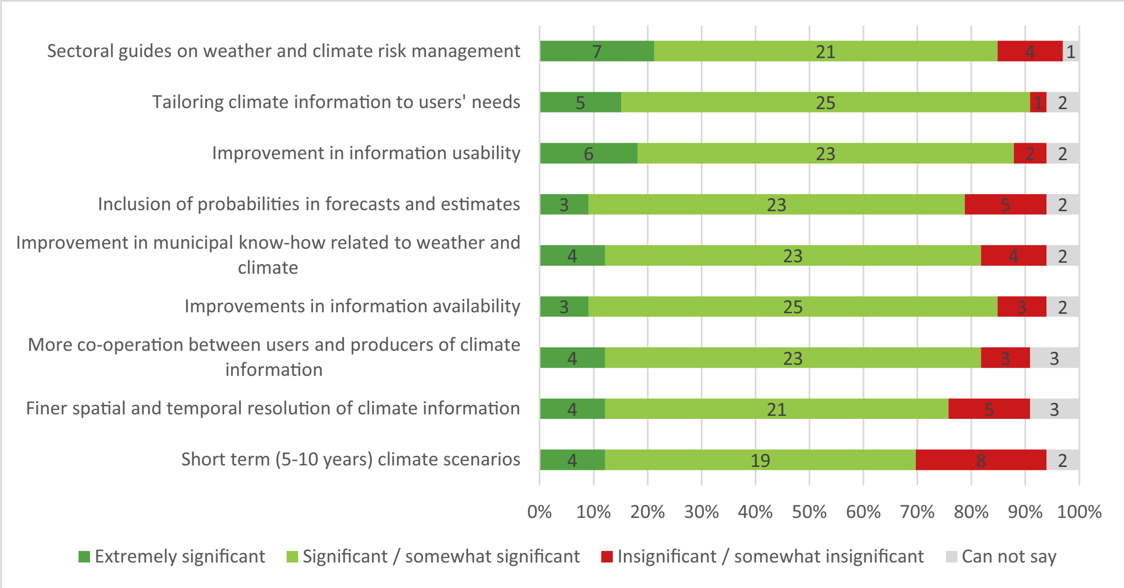

Fig. 6. Answers to the survey question "Here are listed different methods for improving weather and climate risk management. Assess their significance for your climate work."

Table 6
The differences between groups in the considered significance of improvement methods of climate risk management (see Fig. 6), according to Kruskal-Wallis H. The column adaptation refers to municipalities that have been involved in adaptation planning, the columns risks and risk (systematic) to municipalities that have assessed climate risks at least occasionally and systematically respectively, and the column exposure to municipalities that have considered exposure (see Fig. 2). To all groups two columns are given: direction shows if the improvement method is considered more (↑) or less (↓) significant in the respective municipalities and p is the p-value of H (if $p < 0.1$ then *, if $p < 0.05$ then **).

Improvement method	adaptation		risks		risks (systematic)		exposure	
	direction	p	direction	p	direction	p	direction	p
More co-operation between users and producers of climate information	↓	0.166	↓	0.279	↓	0.614	↓	0.599
Tailoring climate information to users' needs	↓	0.19	↓	0.801	↓	0.231	↓	0.365
Improvements in information availability	↓	0.206	↓	0.495	↓	0.156	↓	0.118
Improvement in information usability	↓	0.05^{**}	↓	0.497	↓	0.061^{*}	↓	0.052^{*}
Improvement in municipal know-how related to weather and climate	↓	0.176	↓	0.429	↓	0.004^{**}	↓	0.098^{*}
Finer spatial and temporal resolution of climate information	↓	0.075^{*}	↓	0.533	↓	0.206	↓	0.237
Short term (5–10 years) climate scenarios	↑	0.93	↑	0.974	↓	0.071^{*}	↓	0.565
Inclusion of probabilities in forecasts and estimates	–	0.912	↑	0.854	–	0.773	↓	0.207
Sectoral guides on weather and climate risk management	↓	0.983	–	0.953	↓	0.067^{*}	↓	0.12

5. Discussion and conclusions

Our findings show that: a) progress in climate risk management has been modest in Finnish municipalities; b) municipalities use and need various sources of information; c) there are numerous barriers to, and enablers of, climate risk management.

We focused only on those municipalities that have been active in climate change planning. This resulted in a relatively small sample, even though the response rate was rather typical for this kind of study (Archie et al., 2014; Porter et al., 2015; Shi et al., 2015). The small sample size is a possible limitation of the study and similar studies in other countries could be conducted to find out if results can be generalized. Another possible limitation of this study is that we did not ask the respondents about their personal attitudes and beliefs about climate change, which might have been the reason for answering the survey and may also affect the answers given (Hamin et al., 2014). However, the survey was designed to gather information about the views of the organizations, not individuals. In a previous inquiry among municipality officials, 70% of the respondents believed that municipalities could have very important roles in mitigating climate change (Kerkkänen and Savikko, 2012). This probably reflects a more general belief about climate change as an important issue. Also, we studied municipalities that have been active in climate change planning, so it is reasonable to think that the respondents believe that climate change should be addressed.

5.1. Climate risk management in municipalities and its mainstreaming

According to our findings, municipalities have mostly been active in mitigating climate change, whereas fewer municipalities have been planning for adaptation and climate risk management. These results are supported by the surveys conducted by the Association of Finnish Local and Regional Authorities (AFLRA). Mitigation in the form of reduction of GHG emissions has long been on the agenda, with an emphasis on the energy sector. However, adaptation has increased in recent years, partly because of the extreme weather events that have been experienced (Parviainen, 2015). The amount of municipalities that have included both mitigation and adaptation in their climate strategies has varied between 77% (Mattsson, 2012) and 63% (Parviainen, 2015). It should be noted that the lower figure in the latest survey is probably because of different respondents. This expected finding is consistent with earlier research in other countries (Hoppe et al., 2014; Measham et al., 2011; Wamsler and Brink, 2014) and shows that the adaptation turn (Wamsler and Brink, 2014) is in the process of taking place or has not yet taken place in Finland.

Climate risk management has mostly concentrated on floods, although other hazards may be more prominent in Finland. It has also been found that, while there has been progress in climate risk management in the water sector, progress in other sectors has been slower. This can be related both to EU policy demands and to the fact that climate change is often considered a water issue that manifests either in floods or storm-water (Rauken et al., 2015; van den Berg and Coenen, 2012). Furthermore, climate risk management has mainly been carried out by emergency rescue services, and partly by technical and environmental administrators in Finnish municipalities. Therefore, the nature of the work is fragmented and not all sectors are involved. In the AFLRA surveys, cross- sectoral co-operation was seen as one of the challenges of adaptation planning (Kerkkänen and Savikko, 2012; Parviainen, 2015). In addition, adaptation is often based on individual short-term projects, which increases the fragmented nature of the work (Parviainen, 2015).

The discussion on sector-based climate risk management is related to vertical and horizontal mainstreaming. For instance, Rauken et al. (2015) show that vertical sector-based mainstreaming works well in the early phases of climate risk management but that horizontal mainstreaming across sectors is needed in the long run to include climate risk management in all relevant sectors. Nevertheless, in our study, municipalities that have been active in climate risk management emphasized vertical mainstreaming: they considered networking with public administration and within their own field more important than did less active municipalities. On the other hand, our results also pointed to the other direction. Municipalities that have been more active in climate risk management considered diverging views and unclear liability distribution as less of a significant barrier than did the less active municipalities, which might imply that these municipalities have succeeded in horizontal mainstreaming. However, both horizontal and vertical mainstreaming might be insufficient as such. In other words, climate risk management should be integrated into all municipal decision- making. One possible way forward which our findings support, could be the integration of climate risk management into municipal risk and vulnerability analysis, as suggested by Sonnek et al. (2013). This point highlights the need for both climate and non-climate services and enabling the use of non-climate related information in the support of institutions making decisions on climate risk management.

The mainstreaming of climate risk management is key in the use of networks, multi-level governance, and boundary organizations. Our results show that, especially in the case of municipalities that have been more active in climate risk management, the importance of networks was emphasized. In earlier studies, Dannevig and Aall (2015) argue that regional administrations can be boundary organizations for facilitating climate risk management, and Archie et al. (2014) emphasize that networks of municipalities and other actors are needed to disseminate information effectively. In Finland's case, many of its climate strategies are either planned by regions or municipal networks, but climate risk assessment and management is scarce, and co-operation is not always easy. Some municipalities claim that regional strategies do not take into account local circumstances, and municipalities were much less content with the level of co-operation with regional councils in general: only 50% of the municipalities considered such co-operation to work well or very well, against 85% from the regional councils' side (Parviainen, 2015). Problems in regional co-operation are not the only bottleneck, and there are other issues that need to be added to the list of ranked barriers. Hence, there is still a need to build co-operation on climate information and overcoming other barriers related to climate risk management.

5.2. Barriers and the need for climate and non-climate services

Lack of resources was ranked as the most critical barrier. This finding is largely consistent with earlier studies (Archie et al., 2014; Porter et al., 2015; Tribbia and Moser, 2008) and also with the earlier inquires made in Finnish municipalities (Parviainen, 2015). However, our findings suggest a more nuanced picture of many interconnected triggers and barriers.

First, many different enablers and barriers were ranked as significant by the municipalities and there was generally little difference in the rankings among them. This suggests that problems in advancing climate risk management are multifaceted, and are related to resources, institutional arrangements and constraints, as well as information. In the previous AFLRA surveys, this multifaceted nature was also evident, with the list of barriers encompassing general attitudes, insecurity, and lack of resources and knowledge (Kerkkänen and Savikko, 2012; Parviainen, 2015).

Second, we grouped municipalities according to their level of engagement in climate risk management. With these comparisons, we were able to show how barriers and enablers differ, depending on the level of municipalities' activity in climate risk management. This means that municipal needs are not uniform, as is also suggested by Rauken et al. (2015) and Takao (2012). In particular, inactive municipalities need more help in capacity building, and they are possibly not in a situation where more climate information would enable larger involvement in climate risk management. These municipalities would possibly benefit more from boundary organizations and networks, as opposed to more active municipalities that could be more capable of digesting even technical climate information. However, the problems are no less onerous in the active municipalities, because those municipalities have already carried out the easy actions. The remaining actions are those that are harder to put into practice (Parviainen, 2015). An increasing number of aspects have to be taken into account when the actions move from relatively simple win–win solutions to more complicated projects that require bigger changes in the daily life of the municipalities. Also, there is a need to further identify what type of information is needed at different phases, and what type of information enables risk management to become a feature of institutions.

Earlier, many have argued that higher spatial resolution information and near-future climate scenarios are also needed by the users (Dunn et al., 2015; Srinivasan et al., 2011; Vincent et al., 2015). Our findings do not necessarily support this but are more in line with the research by Archie et al. (2014), who argue that short-term climate scenarios are not among the most desired information. Nevertheless, our findings do not imply that climate information is not needed by the municipalities. On the contrary, they ranked barriers and triggers related to information quite highly. Furthermore, the lack of technical information is a notable barrier and the need for usable and tailored information is seen as a key enabler in climate risk management. Thus, there is a need to increase usability of information and knowledge on how it could be used in municipal decision-making.

Our findings show that, especially in the case of those municipalities that have been less active in climate risk management, help is needed in evaluating their exposure and vulnerability to climatic hazards, as well as how these can be managed. More active municipalities also need such guidance. This seems surprising, since it could be assumed that municipalities are aware of the location and characteristics of inhabitants, elements and assets. Nevertheless, as Briley et al. (2015) discuss, there is a need to integrate municipal know-how into decision-making. In other words, municipalities may have the required knowledge about vulnerabilities and exposures but they do not know what kind of knowledge could be used and how it can be linked to climate risk assessment and management. There is thus a wider need for climate adaptation services (Goosen et al., 2014) and boundary organizations that can help with disseminating climate information (Briley et al., 2015), and it seems that the traditional climate-driven view of climate services is outdated (Lourenço et al., 2016). Overall, there is a pressing need for understanding climate risk and vulnerabilities and possible climate change impacts in municipalities. To tackle these needs, non-climate services, i.e. services that are related to providing information on the non-climatic factors that affect the impacts of climate change, are needed to supplement climate services. Finally, there is a need for further research on what kind of information on non-climatic factors is used and needed by different actors.

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