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ASSEMBLING CLIMATE KNOWLEDGE

The role of local expertise

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This paper investigates the use and production of relevant knowledge for climate adaptation activities. The analysis is based on a case study of so-called local area experts that are involved in the day-to-day practical operations of assessing the risk of avalanches in a high risk avalanche area in northern Norway. In this article we map out how local knowledge held by these local area experts plays out in relation to other forms and sources of knowledge. From this we develop two lines of argument. Firstly that assemblages of climate adaptation are produced as collaborative guesswork related to coupling and negotiation of different types of knowledge in a decision context. Secondly, we discuss what local expert knowledge might mean for the understanding of the relationship between climate science and climate policy.

Keywords: Climate adaptation, local knowledge, expertise, climate adaptation policy

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Knowledge for climate change adaptation

Human societies are facing serious threats as a result of global warming. Coping with the effects of climate change is doubly challenging, since it includes both preparing for the effects of climate change (adaptation) and acting upon its causes (mitigation). Despite the difficulty in connecting specific extreme weather related incidents to climate change in a clear cut way, the importance of adapting to global climate changes has been highlighted in recent years due to increased experiences of extreme weather events and their impact on societies, for instance related to local flood disasters. In relation to the recent super-storm Sandy, New York Mayor Bloomberg said: "Our climate is changing. And while the increase in extreme weather we have experienced in New York City and around the world may or may not be the result of it, the risk that it might be – given this week's devastation – should compel all elected leaders to take immediate action."

Norwegian climate research has shown that climatic changes such as increasing temperatures, precipitation, wind and storm activity and more extreme weather in all parts of the country are likely. Other resulting changes such as a higher probability of landslide and rock falls (RegClim 2005, Haugen & Iversen 2008, Hanssen-Bauer et al 2009) obviously pose serious challenges to maintaining the physical connectivity needed to support critical functions and structures in Norwegian society. In particular, the road system is seen as vulnerable towards climate change because the shift toward greater weather intensity is anticipated to influence the probability of landslide and rock falls.

Climate change has largely been framed as large-scale problems demanding large-scale solutions (Hulme 2009). This perspective has also dominated science and knowledge production related to climate change adaptation where the focus typically has been on downscaling global climate models to more fine-grained models. The way that scientific climate change knowledge to a large degree is filtered through climate models may be seen as a simplification that has aided the process of establishing climate adaptation as an issue. This has led both decision makers and scholars in the rapidly growing literature on climate adaptation to discuss the relevance of climate predictions, but also their limitations (Dessai et al 2009, Adger et. al. 2009). As claimed by these authors, solving the challenge of presenting relevant knowledge is not only about providing more scientific knowledge (McNie 2007, Tribbia and Moser 2008) or more reliable predictions about future climate conditions (Adger et. al. 2009, Dessai et al 2009). On the contrary, we know from previous studies on related topics that there is no simple connection between access to more scientific knowledge and better policy decisions (Jasanoff and Martello 2004, Miller and Edwards 2001, Sarewitz and Pielke 2007, Vogel et al 2007).

There may be many reasons for more scientific knowledge not leading to better policies: The fact that the science provided is not relevant to the user needs, that the knowledge is not appropriate for the decision context and that the information is not sufficiently reliable or is poorly communicated (Sarewitz and Pielke 2007). Climate science, relying heavily on global climate models, has proven quite difficult to translate for many practical purposes (see for instance Adger et. al. 2009; McNie 2007; Næss, Solli & Sørensen 2011, Næss & Solli 2013; Ryghaug & Sørensen 2008; Ryghaug & Skjølsvold 2010; Ryghaug and Solli 2012; Tøsse 2012). Consequently, it is central to ask what type of knowledge other than scientific information (based on downscaling of global climate models) might contribute to decision-making in a way that makes climate adaptation robust.

Adaptation to climate change is a relatively new research domain, where definitions, objectives and methods for adaptation are to a little degree settled in the research literature (Leith 2011). However, one principle that is widely agreed upon is the understanding that adaptation will always be context-dependent (Nelson et al. 2007). In this paper we argue that climate change has to be understood locally and that it is important to explore how climate change knowledge can be generated and made use of in local settings. When observers claim that the threat of climate change produces a new set of problems for policy making, they usually also point to the need to develop new kinds of expertise and knowledge related to dealing with consequences of climate change (Giddens 2009). This may for instance involve local practices of managing risks in relation to weather related events, such as avalanches. Thus, in this paper we shift away from the large-scale oriented perspective that has been dominating knowledge production in relation to climate change science by rather focusing on local adaptation practises and the relationship between different types of knowledge activated in the practice of dealing with the effects of climate changes. To be more specific, we are studying a group of professionals that in their day-to-day business as snow clearers (they actually called themselves snowmen) are responsible for assessing and managing risks related to avalanches. How is their knowledge activated in relation to other types of local adaptation practices?

Assemblages of climate knowledge

In this article we ask how professionals or practitioners involved in climate change adaptation activities handle rather unclear situations when dealing with how to cope with the risks of avalanches. Looking at how situations of impending avalanches are handled involves study of practical knowledge. However, quite often professionals characterize practical knowledge as 'tacit' and therefore difficult to make explicit and into something that can be shared, abstracted and moved (Schön 1983). Also, practical knowledge is often constructed from problematic situations that are confusing, disturbing and uncertain (Schön 1983). The coming together of these traits - silent knowledge and an uncertain situation - may of course challenge the task of providing knowledge that enables societies to adapt to a changed climate. Our point of departure is developed from two questions: if practical knowledge is something that is assembled from different sources, will not such a construction process involve making tacit knowledge explicit? And inspired by Bruno Latour's account of deploying controversies (Latour 2005) as a means to understand how knowledge is produced, we may ask if the uncertainty of how to manage consequences of a changed climate may serve as an occasion where routine and practical knowledge becomes salient and relevant?

In addressing the first question we emphasize that knowledge and different meanings connected to knowledge are negotiated through participation and reification. Lave and Wenger (1991) have defined this as the process of giving shape to the experience of participating through producing objects that freezes these experiences. This includes all abstractions, tools, symbols, stories and concepts that freeze practices in a "rigid" form, which is the subject of new negotiations. This means we are interested in how local practitioners make their knowledge explicit and into something that can be abstracted, shared and moved, as well as how their local knowledge systems overlap and possibly also conflict with other assemblages of climate adaptation knowledge.

To investigate assemblages means to describe the hybrid associations of heterogeneous actors, humans and non-human (Latour 2005; Law 2004). This understanding of assemblage refers not to a depiction of the relation between different elements in a network. Rather we want to stress the point that the process of assembling shapes actors and actors' relations as well as their practices and understandings. In line with this thinking, John Law defines assemblages as a process of bundling 'in which the elements put together are not fixed in shape, do not belong to a larger pre-given list but are constructed at least in part as they are entangled together' (p. 42) hereby underlining the process of making assemblages, as well as the often ad hoc quality of assemblages. Exploring assemblages also includes considering how knowledge objects and tools (be they nature objects, rules of thumb or bureaucratic forms or schemes) contribute to stabilizing an assemblage. Leaning on this kind of understanding also implies that we will be interested in processes of destabilization when analyzing assemblages of climate adaptation knowledge. Thus, by describing climate adaptation efforts as assemblages, we believe this will give us some means to better understand the character and connectivity of practical knowledge in handling practical problems related to climate change adaptation and risks.

Investigating local and practical expertise

In this paper a particular focus will be on ways of dealing with avalanches. In some parts of Norway dealing with the dangers of avalanches and landslides constitutes a normal part of the everyday work of people contracted to clear roadways. In order to make use of local knowledge in risk assessments, the road authorities have linked knowledgeable people together in a network of local area expertise. These are snow clearers and, often, elderly people with a long life in the service of Norwegian Public Road Administration. The main part of our analysis stems from data collected in October 2008, when we conducted fieldwork and interviewed persons that were part of this local professional network in the Tromsø region of Northern Norway. In addition to observing and conducting interviews with three snow clearers working in high-risk avalanche areas, we interviewed two employees of the main contractor responsible for road maintenance in Tromsø and an emergency manager in the municipality of Tromsø.

Our purpose of interviewing representatives of these three groups of actors was to trace and map out their experiences with what constituted relevant knowledge for climate adaptation work, as well as understanding their different roles in practices relevant for climate adaptation work. The snow clearers interviewed had quite extensive experiences from a period of about 10 years working in high-risk areas, and had since 2006 become a part of the local expert network, which contractors with NPRA were obliged to maintain and use (figure 1).

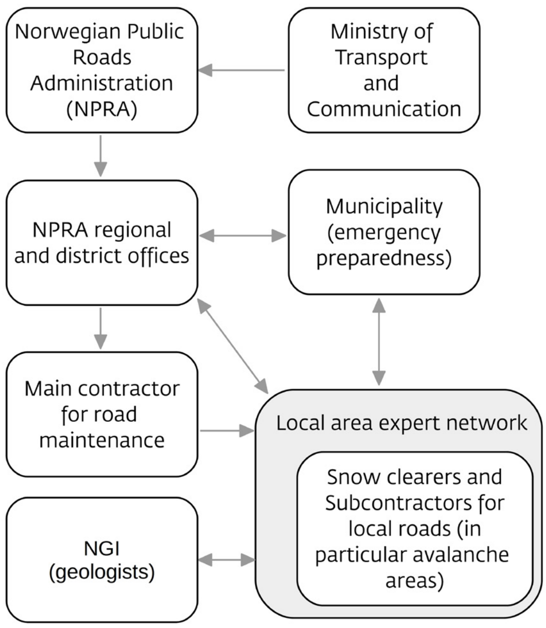

Figure 1. Central actors in the management of avalanche risk and public roads.

We interviewed three snow clearers working in two distinct high-risk avalanche locations. The first interview lasted 90 minutes and the second about 40 minutes. We used a semi-structured list of questions organized around the following main questions: If you have experienced consequences of climate change, what have you experienced? Why did you become enlisted in the network of local area experts? What do you do to reach a decision to close off roads, what kind of knowledge do you use to do this? The interviews were transcribed by a student and we completed one of the transcriptions ourselves as dialect and sound quality made some passages in the recorded interview difficult to comprehend. The analysis of the data has been inspired by grounded theory methodology based on open coding (Strauss & Corbin 1990). Since there were quite few interviews we chose not to support the analysis by the use of a software programme.

The snow clearers also guided us into two high-risk avalanche areas. During our field trip, they pointed out evidential traces in the landscape of past avalanches and places where the most frequent events had happened. They singled out the placements, functions and malfunctions of braking mounds in the hillsides. They also referred to special objects, often large rocks, that they used as snow benchmarks, and explained how knowledge objects informed risk assessments and their decision to close a road or not. These observations gave us valuable insights into how this group of actors developed their expertise and made use of their local expert knowledge in order to make sense of different weather phenomena. We were also made aware of how they interacted with different policy measures and other bodies of expertise.

Each of the guided tours lasted one hour. As we were guided around by the snow clearers, we engaged in a conversation that in practice became a continuation of the interview that had taken place. Our questions in the conversation emerged in a more improvised way and were mostly short questions like “what is this?” and “what happened here?” to encourage the informants to describe and to tell. We took notes from the tours that became useful in analyses. We also recorded fragments of the conversations as we moved along the tour, but these were not transcribed, partly due to poor sound quality.

Collaborative guesswork

Meeting up with two snow clearers at their home place in Breivikseidet in the district of Tromsø in northern part of Norway (almost 70 degrees North and above the Polar Circle), one of them presented himself as a third generation snow clearer. When asked about their understanding of climate changes and whether they had experienced any effects of climate change, they answered affirmatively: They had experienced changes in the weather conditions that affected their work practices. Indeed, they had observed changes in weather that they interpreted as signs that the climate was already changing. For instance, they claimed to have observed greater instability and rapid shifts in the weather conditions due to warmer winter periods. As one of them explained; “It can be four seasons in one day and it wasn’t like that before”. They also observed that the forest belt had moved higher up in the mountain hills. As a result the new vegetation helped bind the snow, a development they partly saw as an effect of increased average temperatures during winter. They believed that as a consequence of climate changes avalanches behaved somewhat differently than before. These days, avalanches took other routes and directions and happened in new areas. The snow clearers evidently acknowledged the effects of climate change based on observed changes in weather and nature, and used their experience to make sense of the consequences of a changed climate in relation their everyday practice.

The everyday practice of the snow clearers involved assessing risks and assembling different information and knowledge. This information and knowledge was mainly mediated through weather and temperature, from interpreting weather prognoses and their local knowledge: experiences from the consequences of shifts in wind direction, doing measurements of snow depth, surveying self-invented benchmarks in the hillside disappearing etc. This typically unfolded as a complex process of assembling different types of knowledge[1], for example as described by one of the snow clearers, here referring to the knowledge of another local person:

> Daily, during winter he pays attention to the lower parts of the mountains, looks at the conditions and contacts us when those marks disappear, which are well-known to him. He uses some rocks as marks when assessing the amounts of snow. When the rocks disappear, when it is smooth up there, then danger is impending, then it is ’overhanging danger’ as he puts it (laughs). When he says this, he is often right. The most recent example [...] he called us in the evening and told us to close the road because the last of his marks had gone. The road was closed, and the avalanche went the morning after. He is certain about this. He is reliable, but these are marks and signs we have learned to look for ourselves in addition to the weather and the wind direction.

The knowledge practice involved a process of making sense of experience-based and often inherited knowledge in relation to interpretations of historic, present and predicted weather data and events. Snow clearers seemed to posit this kind of knowledge themselves, but did also contact or were contacted by other local people with a particular strong knowledge about and interest in the hour by hour development of amounts of snow and wind direction in the

[1] For a more encompassing discussion on different types of knowledge and knowledge systems see Watson-Verran and Turnbull (1995)

mountain landscape. When asked about why he was on the list of local area experts, one of the snow clearers responded: "Well, I'm a third generation snow clearer, so it is old experience, that's why. But, we do also consult others, elderly people, with knowledge about the area, when we assess the danger for avalanche."

When asked to elaborate on the interaction with other actors in the process of assessing risks of avalanches, another snow clearer said:

> The cooperation was intended to go like this: the evaluations of the main contractors were made in cooperation with area experts and NGI, and the Meteorological Institute were supposed to give the weather prognoses. I don't think it works quite like that. In practise, we look at the weather forecast ourselves and make a complete evaluation before we contact the main contractor, or the main contractor calls and asks about the situation. During snowfall they may call us many times a day and want to know if there is danger of avalanches now or if there isn't.

Thus, the process of assembling knowledge was not so much a dialogue with the main contractor as intended by NPRA. In practice, it was more an ongoing dialogue between local area experts and geological expertise, both in the district office of the NPRA and in the Norwegian Geotechnical Institute. As one snow clearer reported, "During snowfall, the NGI call us, and then we will make judgements together based on the conditions of the past days." Local knowledge of weather and events seemed to be the central point in deciding how to deal with the avalanche threat. The overall process unfolds as a complex assembly of knowledge stemming from interpretations of signs in the landscape with a dynamic temporality and collaborative dimension to the knowledge production. The knowledge assemblage could be illustrated as such (Table 1):

	Weather knowledge	Event knowledge
Historic	Snow clearers and others with local, practical knowledge	Snow clearers and others with local, practical knowledge and geologists (NGI)
Present	Snow clearers and others with local, practical knowledge	
Predictions (Future)	Meteorological forecasts	Snow clearers and others with local, practical knowledge and geologists (NGI)

Table 1: Representations of relevant knowledge involved in assessing risks for avalanche

The process of assembling knowledge may be described as guesswork very much defined by being collaborative. Through this collaborative guesswork the snow clearers decided whether they should close the road or not. If we see road closing as a practise, then the collaborative guesswork is what defines its epistemic dimension, and as described above the snow clearers took the lead and managed this collaborative guesswork process. The snow clearers consulted with other local people and geologists or other representatives from NGI through use of weather reports and local, practical knowledge about the shifts in the relations between wind direction, amount of snow and local topography. Further, the snow clearers engaged in discussion about how to read or interpret these shifts. Finally, the snow clearers seemed to manage knowledge of how to time translations into actions. The translation of practical knowledge into actions can be seen as a result and example of tacit or silent knowledge "made to speak" through collaboration where actors with local, practical and indigenous-like knowledge had the leading role.[2] Do we see similar examples in processes of assembling knowledge for translation into local adaptation measures?

Assembling knowledge for the shaping of climate adaptation measures

Climate change has, as presented in the introduction, largely been framed as large-scale problems demanding large-scale solutions. This perspective has also dominated science and knowledge production related to climate change adaptation, where the focus typically has been on downscaling global climate models to more fine-grained models. This way of framing climate change leads to an expectation that climate policy should be shaped top-down. What characterizes efforts of shaping local climate adaptation measures?

Colour warning scheme

Downstream efforts of managing effects of climate change are represented through elements that quantify levels of danger. The road authorities had instructed both the snow clearers and the contractors to use a coordinated "colour warning scheme" in preparedness processes (i.e. green, yellow and red indicating varying levels of danger). When describing how it was to deal with the scheme, a snow clearer referred back to the dilemmas involved in the practice of closing the road:

> The contractor often tells us that one should not close the road unnecessary. They say that you cannot sit and think about your responsibility for people, that you cannot handle these thoughts after you make a wrong decision and human life are lost. But even if you don't have juridical responsibility you still feel a pressure. The guy that worked as a snow clearer before us, he couldn't do it anymore, he got scared and was relieved when he decided to quit the job. It happens occasionally with

[2] For more on indigenous knowledge see Purcell (1988) for definitions and directions within anthropology

> heavy snowfall at night, that we avoid driving through the worst stretches.

Dealing with the expectations of not closing the road unnecessary became problematic when the experiences and knowledge of the snow clearers clearly signalled that caution should be taken. The snow clearers seemed to distance themselves from the warning scheme. For them, the crucial distinction was between closing the road or not. Compared to this choice, then, maybe the warning scheme with its three colours indicating different degrees of danger represented a misplaced abstraction for the snow clearers.

The municipality administrator responsible for emergency planning gave another version of this practise. He pointed to how the NPRA closing the road overflowed the municipality with consequences:

> When it came to all the roads that the NPRA are responsible for, then the NPRA is a very autonomous authority, in the sense that they close and open when they feel for it. We have gradually had a better cooperation [...] Their decisions have consequences for emergency preparedness and have sudden consequences for civil life for which the municipality is responsible: it can be things like the kids don't get to school, or that they don't get home from school, work, travel, post, delivery of necessary medicine, home nursing, so we have some improvisations and extraordinary measures to ward off the worst consequences of it.

The snow clearer and the person responsible for the municipality administration both emphasized how they were responsible for bringing order to the consequences for civic life and compensating for those acting less responsibly. The snow clearer questioned civil society's expectations that failed to take into account the unruly and uncertain character of weather and avalanche behaviour, and the municipality official hinted at NPRA acting irresponsibly and a bit unruly, since "they open and close when they felt for it." In their words the NPRA were not only the sole decision maker, but also closing the road appeared somewhat arbitrary. The person representing the municipality administration shared with the local area expert the task of dealing with both the consequences of the avalanche and the practice of dealing with it. The introduction of the colour-warning scheme did not seem to have much of an impact on the practice of assessing the risks for avalanche and closing the roads. Are there other examples of downstream measures focused on quantifying levels of danger that perhaps are more anchored in local knowledge?

The 30 cm rule

Another proactive measure, which is also a NPRA-introduced 'quantification scheme', is what the snow clearers described as the "30 cm rule". The 30 cm represented a threshold value of what was considered as dangerous amounts of snow that could lead to dangerous avalanche events. The background for the rule was an avalanche accident in 1997 where two people died. This avalanche happened after an extreme snowfall that added large amounts of snow to a high-risk area that already had heavy snow accumulation (see illustration 1).

Illustration 1: Snow clearer pointing to the house hit by avalanche. Photo: Marianne Ryghaug

After this accident, avalanche experts at NGI did mapping work in cooperation with the local area experts, like the snow clearers. Although the rule was introduced by NPRA, it is only partially down-stream in the sense that the rule was constructed regionally by NPRA on the basis of the knowledge from local mapping work.

However, if NPRA in practice applied the rule without consulting with local knowledge, it could delegitimize it. The rule recommended that if there is a snowfall of more than 30 cm, then the road owner had to close the road. The snow clearers saw this as a quite sensible quantification, although they emphasized that in practice, one could not however rely on a scheme that should be obeyed regardless of the circumstances:

> When the 30 cm [rule] came it was to be followed in any case. And when the first snowfall came 4-5 years ago it snowed 40 cm. Then the message came: The road is to be closed! (laughs) And this was the first snow in the mountain. This has been ridiculed. We were not involved in the assessment on this then, were just told to close the road. It seemed a bit silly.

According to the snow clearers we interviewed the whole weather situation, including the weather conditions days prior to a snowfall, also had to be taken into consideration when making these kinds of judgements. In situations like the one described above where the snowfall was the first snowfall of the season hitting bare ground, represented a typical instance where the rule should not apply. Although they pointed to this example of rule-following behaviour as not very knowledgeable, the snow clearers had appropriated this rule as a sensible tool for making judgements that supported their local area expertise. Local measurements of snow amounts and mapping were local knowledge that was translated into a rule of action. Together with the colour warning scheme this example indicated that it was quantifications of danger levels that supported the translation of knowledge into action. But, dealing with avalanches and the maintaining of roads are relatively practical tasks. Where was the materiality of local adaptation measures?

The mocking mound

The construction of a braking mound to shed the roads from avalanches was the physical and highly visible example of a locally placed assemblage of climate adaptation knowledge. The area in which the mould was placed was a naturally high-risk avalanche area. However, what made this area particularly vulnerable was that the road to the ferry landing went through the area. An avalanche at the ferry landing where vehicles frequently lines up for the ferry, could have relatively severe consequences even though the area itself was relatively sparsely populated. In order to diminish the dangers of avalanche hitting this exact part of the road, the NPRA had built what the snow clearers described as a "fancy" avalanche braking mound of rocks, in other words, a large rock wall constructed to protect the nearby road leading to the ferry landing from avalanches (Illustration 2).

Illustration 2: The mocking mound. Photo: Marianne Ryghaug

The snow clearers ridiculed the shape and function of the rock wall construction, pointing out that the wall in fact had no depot behind it, something they saw as necessarily to catch the enormous amounts of snow coming down. They had envisioned the worst case outcome resulting from this malconstruction being that the snow would tear the braking mound apart and bring the big rocks down on the line of cars waiting for the ferry. According to the snow clearers the braking mound was "only a symbol of safety." The construction of this symbol of safety placed right in the middle of their area of local expertise was perceived as a provocation evidenced by the nickname they had given to it – the "mocking mound." So the braking mound, not only served as a symbol of safety, but also was seen as a materialization of mockery. This materialization of mockery acted both ways – as a thing that the snow clearers as local area experts ridiculed, but at the same time it functioned also as a physical reminder that their local indigenous knowledge was not appreciated and taken into consideration to the extent they expected. As it turned out, their local knowledge had not been solicited when the mound was planned and built. Consequently, their confidence that climate adaptation measures would be designed in interaction with local expertise was relatively low.

Knowledge and learning in preparing society for emergency

The observations above of what actors are ascribed to what actions are important to our tracing of the process of making climate adaptation knowledge assemblages in practise. Further, tracing which figures qualify as actors is also important for this task. Even if the fatal avalanche incident described above led to the construction of the 30 cm rule, the snow clearers experienced that the accident did not really lead to any practical changes, for instance in emergency planning or to any new measures indicating there was a willingness to learn from earlier experiences. The snow clearers expressed frustration that there was no following up and little was done to register avalanches they previously had reported. This became evident when reporting on an avalanche in the winter of 2007. In this case they were told that this was not an avalanche area. However, according to the snow clearer;

> 'Yes, it is,' I said, 'many avalanches have happened there.' But, then they asked us; 'Why haven't you told us before, why hasn't it been registered?' It has in fact been reported on many times before, but I have a suspicion that they take it more seriously when you cut off an entire community.

Thus, according to the snow clearers, what they reported was not systematically kept record of by the authorities. Their reports of danger passed by relatively unnoticed except from the situations when the whole community was isolated. The accounts from the snow clearers indicated that their experiences of using relevant knowledge to protect people and traffic on community roads from avalanches were not linked to a sound policy to protect the whole community in a state of emergency. We see how the snow clearers perceived the problem, which is inextricably tied to their work practice and the already existing knowledge about the weather and climate. Their accounts also showed the external constraints of their room for action in terms of materiality, regulation, and the economic resources that could enable it. Their experiences and observations were rather retooled to fit strategies shaped by decision makers located elsewhere, like the colour scheme based on quantifications of threshold values.

A focus on increased preparedness represents a central part of the road authorities' way to respond to climate adaptation. However, according to the snow clearers interviewed here, there had been no answers from the manager in the municipality regarding how one could be able to reach the local community in case of an emergency, or how to bring people out of an isolated community and into safety if a large avalanche were to hit the road. One of the snow clearers said that he had asked for an emergency plan and had even made an offer to the municipality that they themselves could cut down the trees in the area so that they could have an emergency route that could work for caterpillars if they were isolated by avalanches, if they got paid to do it. As they claimed, "We have offered simple solutions, but have not succeeded in getting response from the municipality. We don't feel that our work is valued." The last remark effectively sums up their view of their role in the work of dealing with the consequences of climate change. Further, the lack of an emergency plan lead them to question the will of the wider society, in particular the municipality administration, to actively implement a policy for dealing with risks related to avalanches.

Shaping adaptation policy sideways?

Climate science has been criticised for only to a small extent being able to offer useful knowledge for decision makers (McNie 2007; Næss, Solli & Sørensen 2011, Næss & Solli 2013; Ryghaug and Solli 2012; Tribbia and Moser 2008; Tøsse 2013). Good contact between existing local expertise and professional knowledge is therefore an important condition for making good adaptation and preparedness measures. Here, we have seen that professional users of climate knowledge are actively assembling a network of locally available items in the process of creating meaning around climate change and climate adaptation strategies. We have placed particular emphasis on highlighting the connections between natural objects and snow included in practical, experiential knowledge. Many of the actors also obviously used mediated scientific knowledge such as weather forecasts in the assemblages. Thus, key findings are that the weather forecasts and local area expertise help to develop the understanding of the problem and the problem setting that form the basis for developing climate change adaptation strategies for more resilient societies. Furthermore, we have seen that knowledge about and propositions of new ways of organizing emergency activities represent local practical knowledge arising from direct experience of dealing with the effects of climate change. Such knowledge can be formulated in general, as for example in the form of desire for more collaboration across sectors. When there is not an either/or relationship between scientific climate knowledge and other relevant knowledge in order to do climate change adaptation, then this will both have implications for how we understand the suitability of adaptation measures, and how we understand climate knowledge.

Our general argument in this article is that tracing assemblages of knowledge envisioned a rather broad range of ways of knowing. However, describing this knowledge is not straightforward. For example, the term "indigenous-like" knowledge has long been associated with the terms 'local knowledge' or 'ethnoscience,' indicating knowledge systems that are specific to cultures or groups in particular historical or social contexts (Richards et al. 1989). Adding 'indigenous' to the terms 'knowledge' and 'science', then, signalled the embeddedness of indigenous truths, in contrast to the context-free 'truth' of science. As noted by Philip (2001), the distinct meanings and uses of the terms 'indigenous knowledge' and 'science' both depended on "a dichotomy separating universal, value-free, static truth from situated, value-laden, changing cultural beliefs (Philip 2001: 7292). This dichotomy has been radically challenged by anthropology and STS, which suggests that all knowledge, including scientific knowledge, is specific to its particular cultural context. All knowledge, then, might be considered "local". The distinction between indigenous and scientific knowledge continues, however, to play a role in analysis of knowledge practices. For example, Wynne (2007) has in the field of biosafety pointed to how examination of relations between indigenous and scientific knowledge practices provides perspectives on how to construct more rigorous and publicly legitimate risk assessments. Our analysis describes a process where indigenous and scientific knowledge are assembled locally. But, to what extent is the coupling of forms of knowledge involved in the shaping of climate adaptation measures?

Other studies looking at climate adaption in Norway have demonstrated that regulations and/or coordination support from above in the domain of climate adaptation is in demand (Næss, Solli & Sørensen 2011; Ryghaug and Solli 2012; Næss & Solli 2013). The point in this paper is not to argue that such a need is of little importance in order to create socially robust climate adaptation measures. Rather, we want to cast light on how local knowledge is produced through collaborative guesswork related to judging, communicating and acting on risks and dangers, and that this work has (and should have) possible consequences for the shaping of local adaptation policies. In our study, we saw that the practice of collaborative guesswork involved coupling and negotiation of different types of knowledge (weather data and event data – historic, future and present) in a decision context. Actually, an institutionalization of such a mix of existing local expert knowledge and meteorological prognoses may contrast and possibly provide lessons for governing institutions in translating and moving local knowledge into quantified information as a part of monitoring systems on a greater scale in the road sector.

This single case history provides an example from one sector in Norway, a country that is not especially vulnerable to climate changes compared to societies struggling to cope with threat of sea level rise and its possible devastating consequences. However, Norway seems to share with many countries the trust that model based climate science will be the main provider of useful knowledge to be appropriated by different users in tackling the effects of climate changes. Our study points to the importance of other types of knowledge in the process of developing practices of collaborative guesswork, and hereby suggests an alternative way of understanding a process of policy shaping in relation to climate adaptation without using a standard conception of politics where a policy development process is seen as either moving top-down or bottom-up. Following assemblages of climate knowledge reveals a process that to a greater extent might be seen as moving sideways. This horizontal approach is compatible to thinking about the shaping of climate knowledge and policies in terms of what gets included or excluded and what is considered internal or external to a decision making context.

Despite the vital role of snow clearers and other people with local practical knowledge in the collaborative guesswork their knowledge was largely externalized in both the design of physical avalanche prevention and in the implementation of a local emergency plan. This externalization demonstrates one major constraint related to the room for local action (in terms of materiality, regulations, policy and economy) as these factors are crucial in defining whether knowledge is relevant or not (Sørensen et al 2000). What is thoroughly documented in our analysis is exactly the fact that it is the local experts that are performing the day-to-day climate politics of avalanche protection in this locality. Further, our analysis lends support to the suspicion that constraints of this sort are active through widespread expectations that more accurate and relevant scientific knowledge is to be moved in one direction from climate science through the traditional knowledge and policy institutions and their traditional intermediaries. Although we at this point see few examples of local collaborative knowledge activities and practices integrated into formal policy processes, we do see that there is a potential of integrating this kind of knowledge in decision-making processes. Drawing upon the lessons learned from this case study may provide insights applicable to other decision-making contexts where environmental knowledge should be appropriated. Thus, a call for better translations from the supply side of scientific knowledge to the demand side must acknowledge that the grey areas represented by local, sometimes indigenous-like, knowledge brokers also should be included as being part of the supply side, and that they in practice contribute to shaping policies sideways and hopefully creating more socially robust climate adaptation policies.

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