Resilience, vulnerability and adaptation in reindeer herding communities in the Finnish-Swedish border area

Hannu I. Heikkinen[1], Mervi Kasanen[1] and Élise Lépy[2]
[1] Cultural Anthropology, University of Oulu, Finland
[2] Cultural Anthropology and Thule Institute, University of Oulu, Finland

Abstract: In socio-ecological research, the focus and the conceptual grounding as well as the scales of analysis have shifted several times in recent decades between global and local dynamics and the general rules of evolution and specific local adaptations. Nowadays, the main paradigm emphasises the embeddedness of socio-ecological systems and conceptual tools for studying complex and dynamic systems have been emerging around the concepts of resilience, vulnerability and adaptive capacity. These concepts emphasise the adaptive nature of human societies in general via cultural means such as available new technologies, but they also refer to a political fact that specific societies, livelihoods and individuals are not equal in their possibilities for adaptation and not all means for adaptation are politically allowed or economically available for all people. In this article we provide a brief overview to the key problematic of adaptation from a local reindeer herding perspective in the border area of Finland and Sweden. We investigate how climate change adaptation issues are intertwined with a multitude of other forms of land use and challenges, but which nonetheless influence the resilience, vulnerability and adaptive capacity of local communities.

Introduction

In climate change research the focus has shifted since the turn of the millennium from global assessments of climate change and its impacts towards evaluating the local and regional dynamics of changing environments and understanding the consequences for social-ecological systems. An example of this shift is the Arctic Council's Arctic Climate Impact Assessment (ACIA), which was published in 2005. In these kinds of assessments and adaptation studies, both ecological and social systems are understood to be undergoing processes of constant change compared to how previous paradigms emphasised equilibrium dynamics (e.g. Holling 1973; Bennett 2005 [1976]; Berkes & Folke 1998). Another important turn has been the increasing understanding of the complexities and interconnections of such change. Further evidence of this shift can be found in the development of the concept of ecosystem services (Constanza *et al.* 1997; MA 2005) which seeks to conceptualise the real world complexities of embedded human-environmental systems.

Key concepts in studying dynamic environmental systems and linkages between societal and ecological systems have emerged from discussions on resilience, vulnerability, adaptive capacity and adaptation (Adger 2006; Folke 2006). Today these concepts

underline the adaptive nature of human societies in general via cultural means such as applying new technologies and behaviour, but they also refer to a fact that specific societies, livelihoods and individuals are not equal in their possibilities for adaptation (Alwang *et al.* 2001; Smit & Wandel 2006). The concept of resilience means in short that a system, including a social system, can absorb a certain amount of external stresses and still restore its functions (Folke 2006). On the other hand, vulnerability refers to a condition – a threshold or tipping point, where systems lose their integrity (Adger 2006, cf. Nuttall 2012). From this perspective, adaptation processes might be emerging. Adaptation can be both passive, i.e. an ecological reaction to new pressures in a form of, for example, natural selection which excludes nonviable systems (Holling 1973), or active, which is an intentional, ideal kind of planned or decision-making based adjustment of a previous system to meet better emerging new circumstances (Bennett 2005 [1976]; IPCC 2007; White Paper 2009). When the focus is on human adaptation, the availability of adaptive means, or level of adaptive capacity is important (Smit & Wandel 2006).

The need for understanding the complex interrelations of the modern world system has become evident in the pasture use dilemmas of many animal husbandry-related societies (Stammler & Beach 2006). Hence pasture use studies try to grasp many other relationships than just an animal number-fodder renewal relationship which utilises Maximum Sustainable Yield metrics (Heikkinen *et al.* 2007; Helle & Kojola 2008; Anttonen *et al.* 2011). However, this expansion of approaches has led to an increasing complexity of environmental research, but also to recognizing the increasing needs for interdisciplinary dialogue. An important point in this effort is to clarify how relevant concepts are used, and can be used, in certain contexts.

In this article we reveal these questions through our research on reindeer herding undertaken through work package 8 *"Traditional livelihoods"* of the CLICHE (Impacts of Climate Change on Arctic Environment, Ecosystem Services and Society 2011-2015) project funded by the Academy of Finland under the auspices of its Finnish Climate Change Adaptation (FICCA) programme. The research is focused on the border area of Sweden and Finland, in the Muonio and Könkämä river valleys. Our particular interest is on adaptation of reindeer herding communities of Muonio and Könkämä sameby in Sweden and reindeer herding cooperatives (*paliskunta*) of Muonio and Käsivarsi in Finland (Figure 1). We assess the overall local social-cultural resilience and vulnerability of Finnish and Sámi communities for evaluating the specific challenges arising from predicted and anticipated climatic change. Our work includes a vulnerability assessment from which we will develop scenarios for adaptation with local communities. For the purposes of this article, we discuss our initial findings and outline our approach for future work.

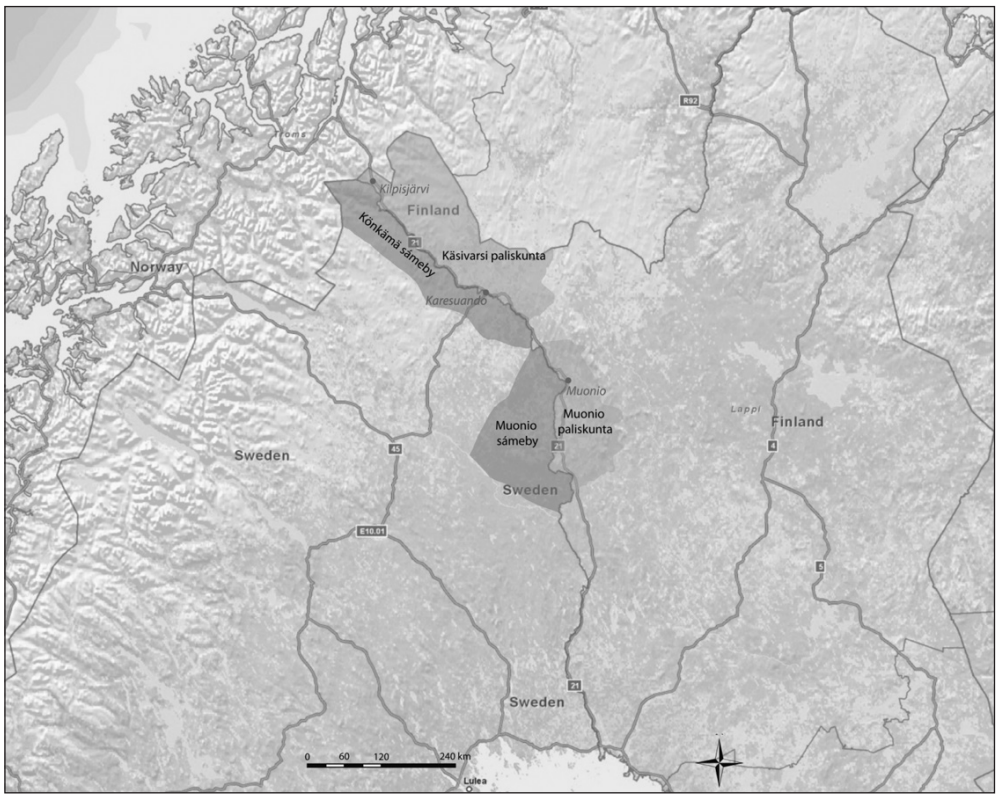

Figure 1. Research area.

Methods, material and study setting

Climate change scenarios for Finland indicate an increase in precipitation of 5-40 % and in air temperature of 2–7°C by the 2080's, depending on the climate model and scenario used (Jylhä *et al.* 2010). On the other hand it has been debated that climatic variations and unpredictability form the two major challenges, at least in the short-term, for local adaptation strategies in nature-based economies, not the average long-term warming or changing of precipitation per se. In addition, there are considerable societal barriers and economic factors which make certain local contexts more vulnerable to climate change than others. An important thing for example in the vulnerability of winter tourism is the timing of autumn and spring vacations – because of this, these tourism seasons are in an immediate danger due to the shortening of winters (Heikkinen *et al.* 2011). Previous research had already considered the multiple stressors and adaptation barriers affecting Sámi and Finnish reindeer herding, so we have focused our research on specific climate-related stressors in relation to the overall situation of herding communities (Heikkinen *et al.* 2007; Hukkinen 2008).

For assessing general resilience and vulnerability, a set of eleven reindeer herder interviews were arranged in 2012. These interviews touched on the role of climate-related issues in comparison to other challenges faced by local herding communities. All people interviewed were in a leading position in their respective herder community, or at least were actively participating in everyday herding tasks on a year-round basis. Interview questions focused on the following themes:

- The role of reindeer in family economics and way-of-life,
- The annual cycle (from calving to rutting, culling and winter tending), with emphasis on perceived climate-related changes in vegetation, insects, snow cover and frost and thaw cycles etc.,
- Other topical reindeer-related issues
- The future of herding in general and in one's own family
- The estimation of the vulnerability of herding at the moment with the most critical factor

Interviewees were also asked to map seasonal migration areas, areas where environmental changes have been perceived such as river and lake ice conditions, vegetation or treeline, and the risky areas where accidents already occurred. They also mapped major land use conflicts. The other data set were local climatic records acquired from The Finnish Meteorological Institute (Table 1).

The rest of this article will first provide some context for current understanding of community resilience. We then proceed to some of our preliminary findings concerning the intertwined nature of climate-related challenges and other local simultaneous

Table 1. Statistical treatments related to weather and climate data.

Weather stations	**Climatic variables**	**Time period**
Muonio Alamuonio	temperatures, precipitations, snow	1.1.1959 – 2.4.2012
	relative humidity	1.1.1961 – 2.4.2012
	Wind	1.5.1961 – 2.4.2012
Enontekiö Näkkälä	precipitations, snow	1.1.1961 – 30.11.1972
	temperatures, wind, relative humidity	11.10.2000 – 2.4.2012
Enontekiö Palojärvi	temperatures, precipitations, snow	1.10.1972 – 30.9.2000
Enontekiö Kilpisjärvi	temperatures, precipitations, snow, relative humidity	1.5.1959 – 2.4.2012
	Wind	1.1.1979 – 2.4.2012
Enontekiö Saana	temperatures, wind	2.10.1991 – 2.4.2012
	relative humidity	2.10.1991 – 19.11.2011

drivers of change, which together form the local puzzle of resilience, vulnerability and adaptation. Our point of view is on each herder's own (emic) estimations of change and definitions of vulnerability because they are respected as the key agents of adaptation in practice. We end the article by discussing our forthcoming scenario work and the need for organising participatory co-research with herding communities.

Environmental history, local resilience and adaptive capacity

In the Könkämä River valley, the herder communities are Sámi, but on the Finnish side of the Muonio River, the herders are mainly Finns. There is considerable diversity in the way of life of reindeer herders in these areas, as there is in the environments in which they move, from the high mountains of the Norwegian border to the more flat and densely forested Muonio River valley. However, in the 19th century these river valleys formed a summer-winter pasture circulation for Sámi reindeer herders, with their summer pastures situated near the coast of the Arctic Ocean and the winter pastures around the pine and spruce forests of the northern Muonio River valley. During the first half of the 20th century, this great cycle of transhumance nomadism ended due to the closing of national borders. Today, a more enclosed model of smaller-scale pasture circulation has been established. Reindeer fences have been erected between nation-states, but herders have erected their own fence systems which separate herder communities' pasture areas from each other. Smaller pasture circulation fences are also used which separate summer pastures from winter pastures (Heikkinen 2002).

This change to smaller-scale pasture circulation, settled housing conditions and to a more enclosed kind of herding is a starting point to assess the overall resilience of today's herder communities (Heikkinen 2002). When this smaller scale pasture circulation, which has to utilise traditional winter areas over and over again, is combined with the steady amount of reindeer, the herders' constant worry is the condition of their winter pastures. In particular, the amount and availability of terrestial lichens (e.g. Cladina spp.) and arboreal lichens (e.g. Alectoria spp.), which form the critical resource for the survival of reindeer over the winter is of great concern (Kumpula 2001; Helle & Kojola 2004, 2005, 2008). On the other hand, reducing reindeer numbers is not an easy task for herder communities, because their income is related to their reindeer property and their way of life is as much money and bank loan-based as are the lives of any other people in the western world today. In short, the amount of alternative pastures is minimal and, for example in Finland, often the only choice to adapt to climatic variations and secure the survival of reindeer is supplementary feeding (Heikkinen 2002; Heikkinen *et al.* 2007).

With these changes constituting an everyday reality, the constant political struggles between reindeer communities and other forms of land use become understandable. The resilience of reindeer pastures is under constant threat even from reindeer grazing and trampling effects, and

many insist that the vulnerability threshold has already been exceeded during the past few decades. In our interviews, older reindeer herders remembered with great longing the thick lichen pastures of their youth, but the disappearing lichen was considered as the sum of grazing and diminishing pasture areas. It was pointed out that herding is constantly losing old pastures to other interest groups, which causes fragmentation of pastures and the remaining areas become difficult to utilise in sustainable way. The major competing land use in forested areas is industrial forestry with its tilling methods, while in other places it is tourism, depending on the activity and tourist density. Nature conservation areas as well as roads and other infrastructure can also decrease and fragment remaining pastures (see Kyllönen *et al.* 2006; Heikkinen *et al.* 2010; Anttonen *et al.* 2011; Kivinen *et al.* 2012; Sarkki *et al.* 2013). The changes in herding – lost and fragmented pastures, the costs of mechanisation and fuel, supplementary feeding, living costs, reindeer losses to predators and varying reindeer meat prices – constitute in general the vulnerable economic setting of reindeer herding today (Heikkinen *et al.* 2007).

The enmeshing of climate, predators, mines and community resilience and adaptation

The interviews first focused on the reindeer herding calendar and with mapping particular climate-related changes, but the questions were open to all kind of challenges that herder's had defined in relation with certain herding seasons (see Figure 2). However, it is important to point out that the circumstances differ between the case communities. For instance, in Sweden reindeer are seldom fed by artificial fodder and mainly in case of emergency, but in Finland this is practised on a more regular basis, particularly among Finnish herders. Nonetheless, both Swedish and Finnish herders experience many of the same threats and changes.

In the calving period from 1st of May to mid-June, the most critical factor was defined to be uncertain weather conditions. Wet weather conditions are especially harmful for calves. Hard or abundant snow cover was also mentioned by the interviewees, although in general, the spring was observed to arrive earlier. This sometimes helps grazing conditions, but melting and freezing of the snow cover also may make the snow surface icy, which makes finding food more difficult for reindeer. The warmer springs also affect bears which wake up a month earlier (in March) from their winter hibernation, and because of this bears cause increasing harm by hunting and disturbing reindeer and calves.

> *"[G]ood conditions for calving are... dry, it doesn't matter if there is some snow. Rain and sleet are the worst in the spring for calving. -- The new calf doesn't get dry. They freeze."*

In the calves' earmarking season from mid-summer to mid-July, the most critical factors concern the temperature and the varying amount of mosquitoes. Too much mosquitoes do disturb reindeer, but the

reasonable amount gathers them into summer herds, but if too few, reindeer tends to move on a wider area. Consequently, if the reindeer are spread all over the land, it is much harder and more expensive to gather them for earmarking. If the temperature is too warm, i.e. above 20°C (Figure 3), it strains the calves and earmarking must be postponed or conducted during nights. The weather conditions of the beginning of the summer may affect the condition of calves and thus have an impact on earmarking.

"...I remember in the 1980's… the snow melted quickly and at the end of June the earmarking began and the reindeer were in corrals. Today for us the earmarking has been delayed for two weeks, and it depends totally on the climate…we had to do the earmarking in the 1990's in September. The calves were in such bad condition…"

During the culling and round-up season from late October to December, the most critical factor is longer and warmer autumn and in general moist ground in late autumn. Moist ground at the beginning of autumn is good, because it affects the growth of mushrooms which reindeer need for storing energy (fat) for the winter. Later in the autumn, excess moist conditions may cause the growth of mold in the ground, which spoils the pastures. Another thing pointed out was uncertain icing conditions, as they may affect how and when the reindeer can be gathered (e.g. if there is sufficient snow cover for using snowmobiles). The sooner the reindeer are slaughtered, the better, because the weight of the reindeer decreases as the winter proceeds.

"[I]n the 21st century autumns have been capricious. It has started with frost and then it has changed to rain and that has been the problem. That has been the biggest change"

"[N]ow there is not much ice. There is bad ice in lakes and in forest rivers there is no ice at all, there is only snow in the surface […]. And ice is bad. It has changed, during the time when I was young and this moment. There is no ice nowadays."

During the winter season the emphasis was on worries concerning more frequent frost and thaw cycles which together with moist ground – and the formation of poisonous mold – force herders to feed their reindeer more frequently. Feeding is needed, for instance, to prevent potential hazards if grazing conditions change quickly in mid-winter.

"...in December, in November, begins the winter, and it rains and freezes the ground [Figure 4]. The possibilities to dig are bad. This 21st century has been exceptional, that supplementary feeding has gradually become more common..."

The spring and winter were often mentioned to be the most critical times of the year for reindeer herding. In spring, finding food and the survival of calves are the most important factors and the beginning of the winter affects the digging possibilities for the whole winter. As for the perceived changes in climate, the clearest changes had happened in these most important seasons: winters were mentioned to be warmer, springs earlier

and autumns longer. On the other hand, as already pointed out, climatic challenges are only one part of the stressors of herding today. Other forms of land use and constant competition on pasture lands influence and affect local resilience and vulnerability. In Figure 5 an example of the land use situation of Palojärvi village with both climatic, vegetation and other changes is presented. According to a description from a reindeer herder living in the area, there have been changes for example in tree line, erosion of the pastures and icing of rivers and lakes. The amount of predators has increased. The surveying of minerals and planning for the development of mines means a further threat to reindeer herding, as does an increasing number of car accidents with reindeer.

In general, it emerged from the interviews that the biggest threats and causes of vulnerability towards local herding were predators, changes in pastures and in nature, including climatic changes, the costs of supplementary feeding and the effects of other forms of land use, especially planned mines. Often the threats were intertwined. There was also variation in some regions in terms of which of the threats were considered most harmful. However, the number of predator animals was said to have increased in all of the areas of the study, and losses of reindeer because of predators were an acute problem for many herders. Increased predator populations increase the need for active herding and decrease the profitability of reindeer herding.

In the area of the Muonio reindeer herding cooperative in Finland, other activities and forms of land use have already caused changes in pastures and many interviewees felt they would be a greater threat in the future: tourism is a competing form of land use, a car test area has divided some reindeer pastures in two, the planned iron ore mine of Hannukainen threatens to diminish the acreages of pastures and will affect a reindeer round-up area. Moreover, forestry has already affected pasture quality and the availability of lichen. Because of the changes in pastures, supplementary feeding is needed and the increasing costs of the feeding affect the vulnerability of reindeer herding. The health of reindeer and the quality of the meat of the reindeer fed in corrals was also said to have been affected. In Muonio sameby in Sweden, forestry has also affected reindeer herding and pastures. Tourism is not yet such a big factor in Swedish Lapland as it is in Finland, but its effect is growing. Unlike in Finland, supplementary feeding of reindeer has not been common in Sweden, but now the iron ore mine of Kaunisvaara has been developed in the middle of summer pastures in Muonio sameby, and it was feared that environmental changes will result in the adoption of costly supplementary feeding to maintain the health and size of the reindeer stock.

In the northernmost research area, the Käsivarsi reindeer herding cooperative, the pasture areas have diminished by the erection of fences that divide the pastures, both between Sweden, Finland and Norway as well as between reindeer communities. Herders were also concerned that planned mines and a possible new railway would constitute future threats to pasture areas. Tourism was considered to have an effect to some extent. Supplementary feeding is

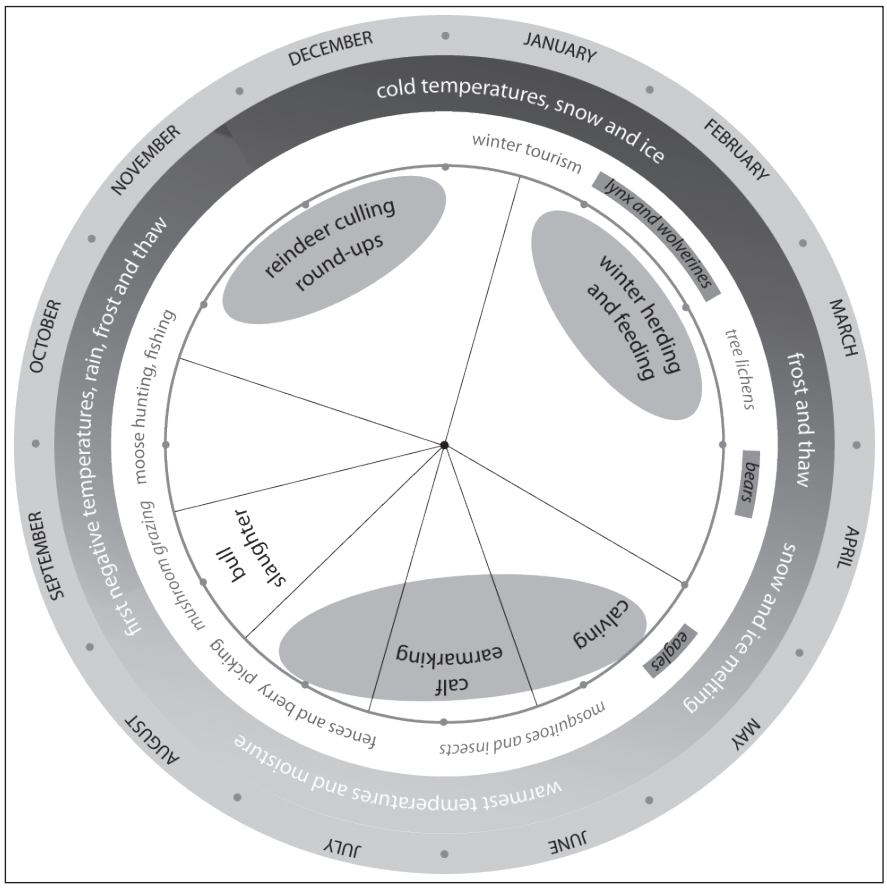

Figure 2. Critical times in a reindeer herder's calendar.

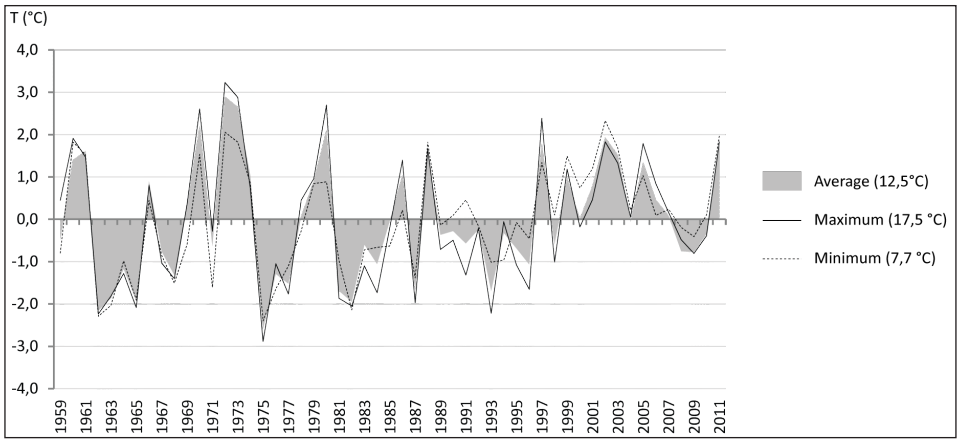

Figure 3. Temperature anomalies from 1959-2011 mean during June and July in Muonio Alamuonio weather station.

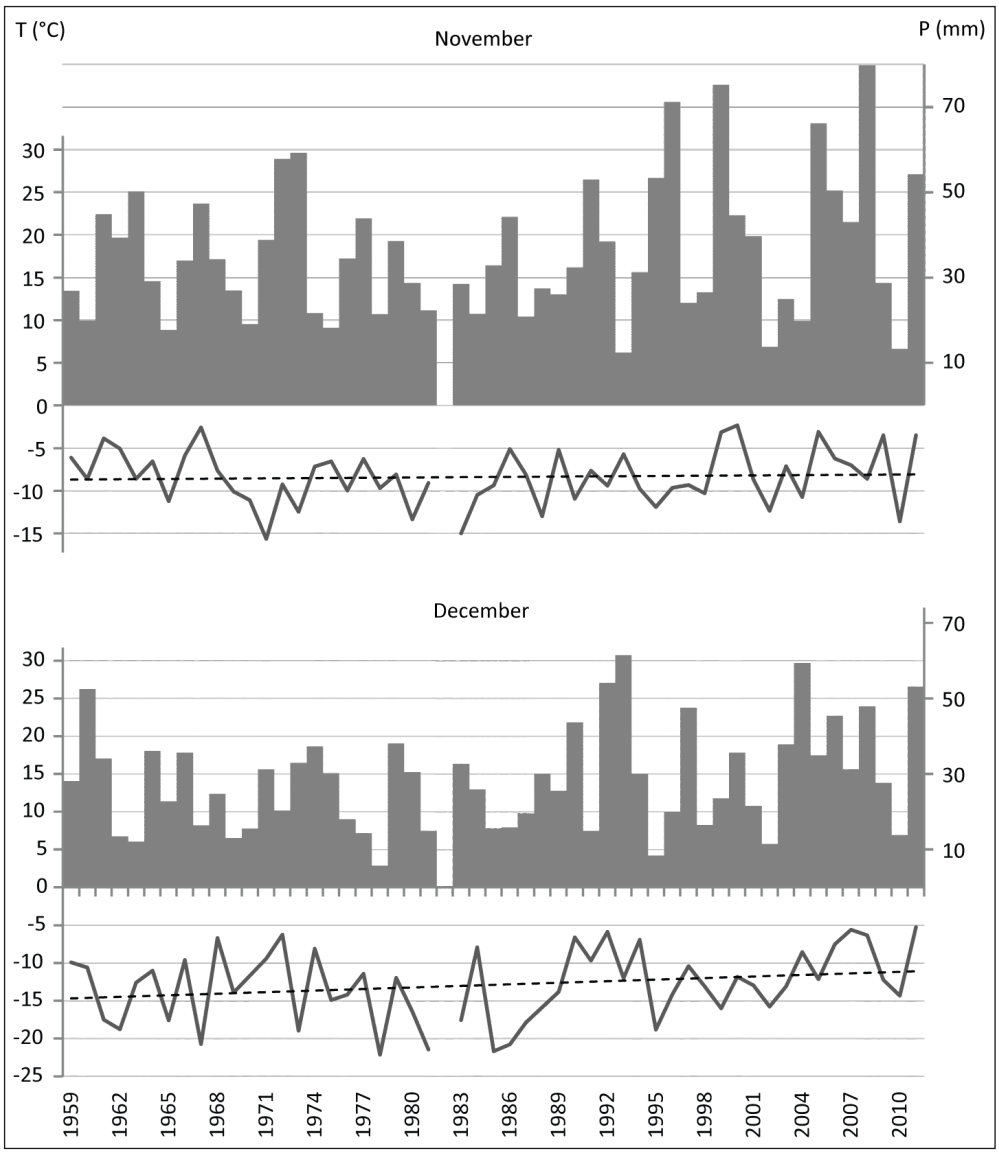

Figure 4. Temperature and precipitation variations in November and December in Muonio Alamuonio weather station.

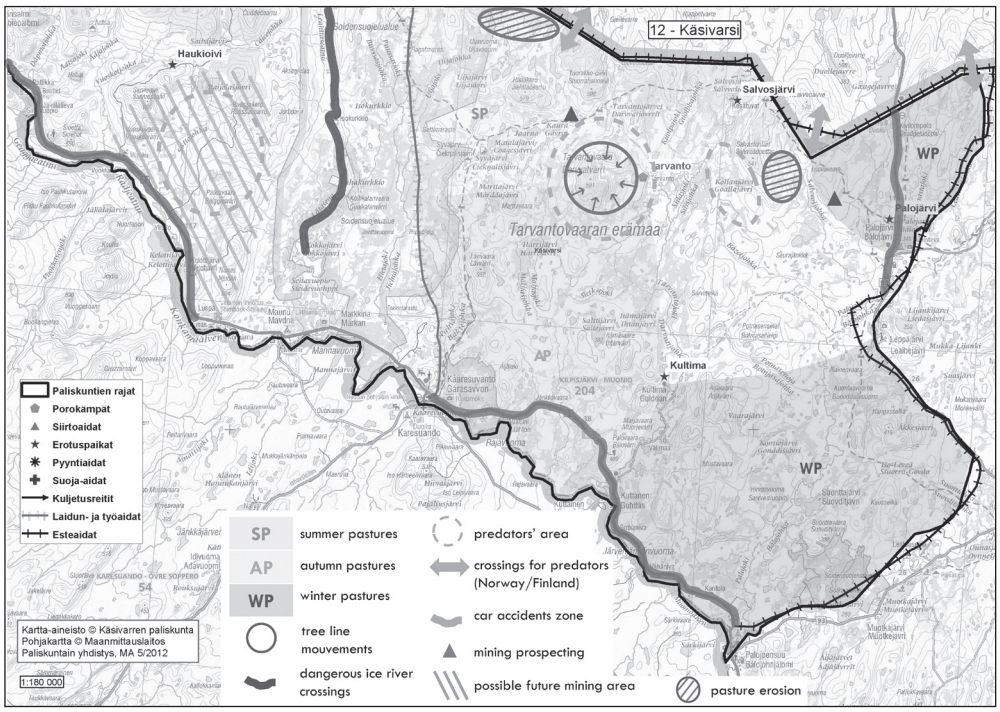

Figure 5. Land use challenges of the Sámi village Palojärvi in the reindeer herding cooperative of Käsivarsi. Permission given by the reindeer herding cooperative of Käsivarsi to use the basemap.

used also in Käsivarsi at times, especially if the snow is hard to dig through in the spring. In the area of Könkämä sameby in northernmost Sweden, tourism was seen to be a growing threat as well as an increased mining activity in Northern Sweden in general. Forestry was considered to be a relatively small-scale land user. In Könkämä the obvious emphasis on threats was made with reference to increasing predation. Supplementary food had not been given to reindeer in Könkämä for at least the last 10 years.

Climatic changes, including unpredictable variations, affect all the phases of reindeer herding during the year and have a connection to the previous threats. For example, if pasture ground becomes icy or moldy or if the snow surface melts and then freezes, making the digging of food hard, the need for supplementary feeding increases. Only in Könkämä sameby were the changes in weather not seen as a threat. In Könkämä, the previous winters have been good for reindeer: the ground has been dry and the amount of snow small. A warming climate was suspected to have some connections to the number of predators, e.g. with the increase of eagles in Käsivarsi. As for other threats, in all of the areas except Könkämä sameby, car accidents were also a growing problem. In general, mechanisation of

reindeer herding has also increased costs, a situation which was considered would worsen in the future.

The prerequisites for further adaptation were not seen to be very good when it comes to other forms of land use and predators. Reindeer herders have negotiations with other stakeholders in their areas, which were seen as a way to adapt, but despite this socially available capacity for adaptation several of the interviewees were not optimistic about possibilities for reindeer herding to survive if pastures were to diminish further. As for the situation regarding predators, hunting is regulated both in Finland and in Sweden, so in this case the adaptive capacity was seen to be limited by political and administrative institutions and regulations. Reindeer herding in general was emphasised to be dependent on money because of increased costs, e.g. due to mechanisation and supplementary feeding. In order to cover the costs, adaptive capacity in the economic sense means that the herds must be bigger than they have been historically.

When it comes to climatic variations, there are ways to compensate their effects, but it often means increasing costs, e.g. because of increasing need of supplementary feeding. Traditionally, the reindeer were also said to have fairly good possibilities to meet weather-dependent challenges: if they cannot dig food from under the snow, the hard snow cover helped to forage tree lichen instead, which was of sufficient availability when competing forms of land use were not yet a problem. Nowadays, this natural way of adaptation by reindeer does not work because of the lack of old growth forests with arboreal lichen. Thus, in general it can be said that a traditional form of reindeer herding – one with no supplementary feeding, no significant dependence on money, and with significant pasture – has reached the limits of vulnerability, yet has already adapted to a new kind of livelihood system. There are different kinds of adaptive capacities that have been utilised, and due to these possibilities, reindeer herding has had a certain kind of resilience, but problems and future threats are still emergent.

Towards adaptation scenarios

In general, our research to date has followed the approach formulated by Smit & Wandel (2006) and Keskitalo (2008). In the future, our assessment will proceed from a consideration of current total vulnerability, and an assessment of climate-related sensitivity and adaptations, to formulating forthcoming climatic vulnerability and potential adaptation strategies. Climate change research is based largely on assessing future impacts and developing scenarios, and entails a great deal of uncertainty (IPCC 2007; Hukkinen 2008). In the real world societal setting when assessing current and forthcoming vulnerability, resilience and adaptation potentials, there are even more challenges. These arise from the great variety of target audiences and relevant communities with their diverse educational and professional backgrounds, but which must nonetheless be included in adaptation deliberations because they possess a critical role in adaptive decision-making in practice. Because of the differences in adaptive capacities and evident uncertainties included in all kinds of future-oriented studies we

defined our approach with the aim of understanding cognitive and social adaptive capacities of the herding communities that form the basis of our research, instead of working to predict forthcoming changes. Furthermore, we intend to engage in discussion with herders about the future from a "what if" basis (Hukkinen 2008:102; Nuttall 2012).

During the next stages of our research we will consider a range of potential scientific scenarios, but we will also work with reindeer herders and engage in dialogue about their understanding of possible, potential or wished for futures. Reindeer herding is always a local adaptation to certain local environmental and societal settings and herders are the only ones who can grasp the full extent of their situation. The participation of herders in the evaluation of climatic records, potential scenarios and societal barriers to adaptation is essential (Heikkinen *et al.* 2007; Heikkinen *et al.* 2012). For the purposes of this current article, it is perhaps apt to end with a comment from one of the herders we interviewed. Reflecting on whether warmer autumns and springs would mean more mushrooms which could compensate for the loss of lichen pastures, he felt that reindeer herding could survive if only society allowed it to do so:

> *"…if climate warming leads to thick snow covers, it means winters of hunger. But if winters get shorter, let's say by a month, so winter comes in December and ends in April, then the enormous mushroom crop could be the resource which reindeer rely on in future, if reindeer are allowed to be here in future…"*

References

ACIA (2005). *Arctic climate impact assessment −scientific report*. Cambridge University Press, Cambridge, UK.

Adger W. N. (2006). Vulnerability. *Global Environmental Change* 16, 268–281.

Alwang J., P. B. Siegel, S. L. Jørgensen (2001). *Vulnerability: A view from different disciplines*. The World Bank. Social Protection Discussion Papers No. 0115: 1–42.

Anttonen M., J. Kumpula & A. Colpaert (2011). Range selection by semi-domesticated reindeer (Rangifer tarandus tarandus) in relation to infrastructure and human activity in boreal forest environment, northern Finland. *Arctic* 64(1), 1–14.

Bennett, J.W. (2005) [1976]. *The ecological transition: cultural anthropology and human adaptation.* Second Edition. Aldine. Transaction publishers, New Brunswick.

Berkes F. & C. Folke (eds) (1998). *Linking social and scological systems: management practices and social mechanisms for building resilience.* Cambridge University Press, Cambridge, UK.

Constanza R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, K. Limburg, J. Paruelo, R. V. O'Neill, R. G. Raskin, P. Sutton & M. van den Belt (1997). The value of the world's ecosystem services and natural capital. *Nature* 387, 253–260.

Folke, C. (2006). Resilience: the emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* 16(3), 253–267.

Heikkinen H. (2002). *Sopeutumisen mallit - Poronhoidon adaptaatio jälkiteolliseen toimintaympäristöön Suomen läntisellä poronhoitoalueella 1980–2000*. PhD. Diss. University of Oulu. Finnish Literature Society, Oulu.

Heikkinen H. I., P. Kauppila, É. Lépy, J. Ponnikas & A. Rautio (2011). Tourism. *In* Bergström I., T. Mattsson, E. Niemelä, J. Vuorenmaa & M. Forsius (eds): *Ecosystem services and livelihoods – vulnerability and adaptation to a changing climate. VACCIA Synthesis Report*, 55–58. The Finnish Environment 26en/2011. Finnish Environment Institute, Helsinki.

Heikkinen H. I., S. Lakomäki & J. Baldridge (2007). The dimensions of sustainability and the neo-entrepreneurial adaptation strategies in reindeer herding in Finland. *The Journal of Ecological Anthropology* 11, 25–42.

Heikkinen H. I., S. Sarkki, M. Jokinen & D. E. Fornander (2010). Global area conservation ideals versus the local realities of reindeer herding in northernmost Finland. *Int. J. Business and Globalisation* 4(2), 110–130.

Heikkinen H. I , S. Sarkki & M. Nuttall (2012). Users or producers of ecosystem services? A scenario exercise for integrating conservation and reindeer herding in northeast Finland. *Pastoralism: Research, Policy and Practice* 2:11 (doi:10.1186/2041-7136-2-11).

Helle T. & I. Kojola (2004). Porokantojen vaihtelut Fennoskandiassa – selitykset ja niiden arviointi. *Suomen Riista* 50, 18–32.

Helle T. & I. Kojola (2005). Ylä-Lapin porojen talvilaitumet: kolme näkökulmaa ylilaidunnukseen. *Metsätieteen aikakauskirja* 3/2007, 253–266.

Helle T. & I. Kojola (2008). Demographics in an alpine reindeer herd: effects of density and winter weather. *Ecography* 31, 221–230.

Holling, C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4, 1–23.

Hukkinen, J. (2008). *Sustainability networks: cognitive tools for expert collaboration in social-ecological systems*. Routledge, London.

IPCC (2007). 4. Adaptation and mitigation options. In: Summary for policymakers. *In* Pachauri, R. K. & A. Reisinger (eds): *Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change, Geneva.

Jylhä K., H. Tuomenvirta, K. Ruosteenoja, H. Niemi-Hugaerts, K. Keisu & J. A. Karhu (2010). Observed and projected future shifts of climatic zones in Europe, and their use to visualize climate change information. *Weather, Climate and Society* 2, 148–167.

Keskitalo E. C. H. (2008). *Climate change and globalization in the Arctic: An integrated approach to vulnerability assessment.* Earthscan Publications, kaupunki?

Kivinen S., A. Berg, J. Moen, L. Ostlund & J. Olofsson (2012). Forest fragmentation and landscape transformation in a reindeer husbandry area in Sweden. *Environmental Management* 49(2), 295–304.

Kumpula, J. (2001). *Productivity of the semi-domesticated reindeer (Rangifer t. tarandus L.) stock and carrying capacity of pastures in Finland during 1960-1990's*. Ph.D. diss. University of Oulu, Oulu.

Kyllönen S., A. Colpaert, H. Heikkinen, M. Jokinen, J. Kumpula, M. Marttunen, K. Muje & K. Raitio (2006). Conflict management as a means to the sustainable use of natural resources. *Silva Fennica* 40(4), 687–728.

MA (2005). *Millennium Ecosystem Assessment. Ecosystems and human well-being: synthesis*. Island Press, Washington.

Nuttall, M. (2012). Tipping points and the human world: living with change and thinking about the future. Ambio 41(1), 96–105.

Sarkki S., H. I. Heikkinen & R. Puhakka (2013). Boundary organisations between conservation and development: Insights from Oulanka National Park, Finland. *World Review of Entrepreneurship, Management and Sust. Development* 9(1), 37–63.

Smit B. & J. Wandel (2006). Adaptation, adaptive capacity and vulnerability. Global *Environmental Change* 16(3), 282–292.

Stammler F. & H. Beach (eds) (2006). *Special issue; humans and reindeer on the move.* Berghahn Journals (NS) Volume 10 No.2 2006.

White Paper (2009). *Adapting to climate change: Towards an European framework for action*. Brussels 1.4.2009. COM (2009) 147.