Climate change in the Arctic: adaptation and its limits- a case study of the Sámi

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Abstract — The traditional knowledge of the Sámi thrives from observations, experiences and the use of natural resources. Traditional lifestyles of the Sámi include reindeer herding and fishing, and a great share of their knowledge is based on these culturally central activities. Climate change proposes a risk for these vulnerable Arctic communities, but the ability for the Sámi to adapt is also greatly being hampered by limitations that exist within our society. The Sámi lack appropriate rights for their land and resources, and required economical and social flexibility is being controlled by many governmental restrictions. Ways in which the Sámi value, apply and depend on the nature often differ from the rest of the world, but as a minority group, Sámi often finds these ways being driven by the values defined by the greater societal norms. This can greatly reduce the ability for the Sámi to adapt and to respond to the changes in the future. To improve the adaptive capacity of the Sámi, the traditional knowledge needs to be appropriately preserved, in the form of language, knowledge and other culturally essential norms and activities. Integration of scientific observations and traditional knowledge, for instance on snow, is considered useful for knowledge sharing and improved understanding between scientists and indigenous people. Local level research and community level adaptation are important in increasing the understanding of the Arctic, not only on the physical changes occurring in the climate, but also on the adaptive measures that are considered sustainable, successful and necessary by the local people.

Keywords — Climate change, Sámi, reindeer herder, traditional knowledge, adaptive capacity.
Table of contents

1 INTRODUCTION ................................................................................................................. 4

2 BACKGROUND ...................................................................................................................... 5
   2.1 Climate change in the Arctic ......................................................................................... 5
       2.1.1 Rain-on-snow ........................................................................................................ 7
   2.2 Sámi- the people and their land .................................................................................... 7
       2.2.1 Reindeer herding and other activities .................................................................. 8
   2.3 Traditional knowledge ................................................................................................... 9
       2.3.1 The importance of snow ..................................................................................... 10
   2.4 Research on the Sámi .................................................................................................... 11
       2.4.1 Snowchange Cooperative ..................................................................................... 11
       2.4.2 EALÁT ............................................................................................................... 12

3 THEORY .............................................................................................................................. 12

4 FRAMEWORK ................................................................................................................... 14

5 MATERIAL AND METHODS .............................................................................................. 15

6 ANALYSIS .......................................................................................................................... 16
   6.1 Observed impacts and current adaptive capacity ....................................................... 16
   6.2 Limits to adaptation .................................................................................................... 17
   6.3 Future adaptive capacity ............................................................................................ 18

7 DISCUSSION ....................................................................................................................... 19
   7.1 Overcoming barriers and challenges to adaptation .................................................... 19
   7.2 The role of traditional knowledge ............................................................................... 20
   7.3 Future adaptation ........................................................................................................ 21

8 CONCLUSION ..................................................................................................................... 23

9 REFERENCES ...................................................................................................................... 24


1 INTRODUCTION

Sámi, an Arctic indigenous group who live across the northern parts of Scandinavia and Kola Peninsula in Russia, are in the frontier of facing the challenges proposed by future climate change. Sámi have a long history of adapting to changes in the past, however, future climate change is expected to introduce a new set of issues, and therefore challenging the adaptive capacity of the Sámi. Sámi people consist of marginalized and vulnerable communities, who practice traditional lifestyles, most common being reindeer herding. Sámi possess extensive traditional knowledge of the history of adapting and living off the nature, but climate change is threatening the existence of these communities and their culture. Climate change proposes a great risk for adaptation, but the vulnerability of the Sámi communities is being accelerated by limitations within our society. Sámi are greatly dependent on their land and resources, but have been neglected from a flexible use of these due to a lack of appropriate rights. The adaptive capacity of the Sámi is therefore being further restrained by other endogenous factors, such as societal and cultural norms within our society.

The research purpose of this paper is to investigate the adaptive capacity of the Sámi, as well as to look at the existing and projected limitations that can decrease the level of adaptation. Emphasis has been given on the endogenous limits within our society, main of which have been identified by Adger et al (2009) as ethics, knowledge, culture and risk. Traditional knowledge is in the center of the culture and livelihoods of the Sámi, and preserving it is of high importance. Integration of traditional knowledge and science is also a way to increase the understanding of these vulnerable Arctic communities and of the challenges they face in adapting to future climate change.

Research question: What role does traditional knowledge of the Sámi play in climate change adaptation, and what limitations are likely to hamper the future adaptive capacity?

The research question is addressed firstly by introducing climate change impacts and projections in the Arctic, by providing background of the Sámi and their traditional knowledge, and research conducted by the Snowchange Cooperative and EÅLAT collaboration. Secondly, analysis is conducted in order to investigate the vulnerability of
the Sámi, the role of the traditional knowledge, and existing limitations in adaptation. Lastly, the possibilities and requirements in overcoming these limitations and challenges to adapt are being discussed.

## 2 Background

This section introduces climate change impacts, projections and Sámi observations in the Arctic, background of the Sámi, and introduction of the indigenous traditional knowledge as well as the research conducted by Snowchange Cooperative and EÅLAT collaboration.

### 2.1 Climate change in the Arctic

The mean global temperature has been increasing since the industrial revolution in the 19th century. Since then, warming has been occurring at an accelerating rate and the last three decades have each been warmer that the previous one (IPCC, 2013). In addition, the year 2014 was the warmest one on record since the observations begun in 1880 (NASA, 2015). Since 1880 the mean global surface temperature has increased 0.85°C, but warming in the Arctic has been recorded at almost twice the rate of the global average (IPCC, 2013). The impacts of climate change are strong and already detectable in the Arctic, and these are expected to continue over the century (IPCC, CH4, 2013). Reduction of sea ice, retreat of glaciers, and increased snow and surface melt have all been observed and linked to anthropogenic climate change (IPCC, CH4, 2013). Table 1 represents the key impacts of climate change relevant to the Sámi, summarized from the ACIA (2004) and IPCC (2013) reports, and combined with local observations recorded by the Sámi living in the Finnish part of Sápmi.

<table>
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<tr>
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<tbody>
<tr>
<td>Rising temperatures</td>
<td>Temperatures have increased sharply, especially over winter months. Even greater increase is expected over the next century.</td>
<td>Since 1980s Arctic has shown warming twice the global average, with greatest warming during winter and spring (≈1°C increase per decade).</td>
<td>Veikko Magga: Fall is extending and getting milder, instead of snow there is rain and sleet. Rune Stokke: More variable weather over the last 30 years. Cold</td>
</tr>
</tbody>
</table>
Increasing precipitation
Increased by 80% over the past century. More precipitation in the form of rain. Expected to increase in the future.

Increased precipitation and more often occurring rain-on-snow events are preventing reindeer access on lichen.

*Sakari Keskitalo: Increasing wet rain before frost days freezes the ground and prevents the reindeer’s access to lichen.*

Declining snow cover
Decline of approx. 10% recorded over the past 30 yrs. Additional 10-20% decline expected to occur by 2070, especially during spring.

Decline in the snow cover observed over 1967-2012. Greatest monthly decline has been measured over June (-53%).

*Niila Nikodemus: Ice has become thinner and permanent snow cover arrives later.*

Heikki Hirvasvuopio: Changes occurred in the snow quality and quantity and the thickness of the snow has been declined.

*Taisto Länsman: During winter 2000-1 snowmobiles could not be used until February.*

Diminishing lake and river ice
1-3 week reduction in the length of ice season in several water bodies in the Arctic region.

Temperatures of the larger water bodies have been increased.

In January 2012 some of Näätämö was still ice-free. In May the Neiden River was freed from ice 2 weeks earlier than the average.

*Gun Aira: Increasing instability of river ice makes reindeer migration more difficult.*

Loss of hunting culture and impacts on reindeer herding
Reduced sea ice is disrupting and destroying parts of the hunting and food sharing culture in the Arctic.

Some ice-dependent species can adapt to ice-free conditions, others have to move to a region with existing sufficient ice. Vulnerability of Arctic mammals and hunting is related to special feeding conditions, ice and snow dependence, prey access and predator avoidance.

*Veikko Magga: Icy rain provides greatest threat for reindeer when ground freezes and reindeer cannot access the lichen.*

Reindeer herding is becoming increasingly difficult due to economic constraints and snow instability.

Change in fisheries
Decrease observed and expected in arctic-specific fish species during the coming century. Some species expected to increase in productivity, e.g. cod and herring, and some to disappear. Migration routes and ranges expected to change.

Shifts of some sub-arctic fish and shellfish species are likely due to their thermal tolerance of water temperatures. Climate variability is likely to change the abundance, quality, and reproduction conditions of fish and shellfish in the Arctic waters.

Smallersalmon sizes have been observed. Wild salmon is threatened by salmon farming, seen by the declining salmon prices the Sámi fishermen receive (half of what it used to be).

There are three key explanations for the Polar amplification and why Arctic regions are warming more than the global average temperature. Firstly, as snow and sea ice melts, darker surfaces are exposed to more sunlight. This results in a reduced albedo effect as more heat is being absorbed, causing further warming, again causing further melt. This is
an example of a positive feedback in further enhancing global warming (ACIA, 2004). Secondly, in the Arctic more of the energy goes into warming of the atmosphere, unlike in warmer regions where more energy is distributed into evaporation. Thirdly, troposphere, which has to warm in order to cause the surface of the earth to warm, is shallower over the poles, and therefore requiring less energy to heat up (ACIA, 2004).

2.1.1 Rain-on-snow

Rain-on-snow or icy rain challenges reindeer herding by threatening reindeer's access for lichen— their main source of food. With increasing precipitation and milder fall and winter seasons, the frost days that normally preserve the lichen on the ground are becoming increasingly rare (Eira et al. 2013). Without an appropriate frost layer, when the ground becomes wet, either from precipitation or snow melt, and the temperature falls below zero Celsius degrees, the ground will freeze and form a layer of ice. If the layer is thin and does not prevent reindeers’ access to food, Sámi call it geardini (Table 2). However, if geardini layer is further covered by fresh snow, lichen underneath the ice and snow usually becomes inaccessible for reindeer. This is what is called rain-on-snow event and the Sámi identify the snow as gaska-geardini (table 2). If neither migration to a new pasture area nor finding a new source of food is possible, the rain-on-snow event can be fatal for reindeer (Eira et al. 2013).

2.2 Sámi- the people and their land

There are over 4 million people living in the Arctic, a region consisting of unique type of natural environments, cultures and natural resources (ACIA, 2004). Sápmi, the land of Sámi, spreads along the northern Scandinavia, including northern parts of Norway, Sweden and Finland, as well as Kola Peninsula in Western Russia (Figure 1). There are approximately 100,000 Sámi living in Sápmi, which is approximately 10% of the local population (Furgberg et al. 2011).

Sámi are known for their ability and knowledge to adapt, and for generations they have coped with changes (ACIA, 2004). Adaptation strategies in the past have included shifting of settlement areas, changing resource bases, implementing new technologies, improving education and communication, and changing location and timing of hunting,
fishing and other activities (IPCC, CH28, 2014). Reindeer herder's essential strategies include ensuring accessibility and good condition of the grazing pastures, as well as preserving the quality and quantity of food sources for the reindeer (IPCC, CH28, 2014). Modern development and infrastructure, tourism, lack of political and economic power, and especially the lack of appropriate land rights and permits for the resource use represent key challenges for the Sámi in terms of adaptive capacity and the level of vulnerability in the future (Mustonen and Mustonen, 2011).

Figure 1. Map of Scandinavia. Blue indicates the Sápmi region. This spreads from northern parts of Scandinavia to Kola Peninsula in Russia. Taken from: https://en.wikipedia.org/wiki/Sami_people#/media/File:LocationSapmi.png

2.1.1 Reindeer herding and other activities

Reindeer herding is culturally, economically, socially and ecologically positioned in the center of the Sámi culture. The domestication of reindeer herding in the 1960s helped to stabilize the livelihood for the Sámi. Technological improvements such as changes from skis to snowmobiles improved the access and efficiency, but these improvements have also been costly and at times unreliable due to the changing climate or availability. Many herders have observed increasing fluctuations and variability within the length of the snow season, as well as decrease in the quality and quantity of snow (Eira et al. 2013). Many of the herding activities, such as calving and migration, are dependent on snow, and difficulties have occurred in practicing some of the activities, especially due to the
rain-on-snow events (Eira et al. 2013) (Snowscapes, Dreamscapes, 2004). Some of the current adaptation strategies the reindeer herders apply include changing pastureland, supplemental feeding, managing herd sizes and retaining castrated reindeer males to break through the heavy ice and access the lichen (IPCC, CH 28, 2014).

Besides reindeer herding there are other culturally and economically important activities for the Sámi, such as fishing. Warmer waters have increased the number of some fish species, such as cod and herring, but many species unique for Arctic waters are also disappearing (Snowscapes, Dreamscapes, 2004). Introduction of farmed salmon has also reduced the price of wild salmon and that additional income for the Sámi (Table 1). The arrival of tourism fishery after 1950s has also declined the fishing quota and permits for the Sámi. Arctic berry is another addition to Sámi’s diet, as well as a part of the cultural importance and source of income for many households. Similar to declining arctic fish species, there are concerns in disappearing of the arctic berry, and many Sámi are reporting of repeatedly occurring bad berry years (Snowscapes, Dreamscapes, 2004).

2.3 Traditional knowledge

Traditional knowledge of the Sámi is often expressed through the Sámi language and not by numbers like typically in the western science. The Sámi often express their knowledge and changes in the environment through culturally essential activities such as reindeer herding and fishing (Eira et al. 2013). Their connection to nature is also reflected through songs and stories and much of this knowledge is being passed on through generations.

Sámi have extensive weather reading skills, some of which include the noise of the birds warning of approaching rain, spreading movement of Aurora Borealis of deep depression, and rings around the moon of approaching dense snowfall (Snowscapes, Dreamscapes, 2004). Traditional knowledge can also provide crucial information for the reindeer herders, such as appropriate timing to gather the reindeer for separation and calf making (Snowscapes, Dreamscapes, 2004). However, as Arctic is undergoing some drastic environmental and climatic changes, the ability for the Sámi to use some of these methods and knowledge is becoming increasingly difficult (IPCC CH28, 2014).
2.3.1 The importance of snow

Snow is essential part of the traditional knowledge and of a cultural significance for the Sámi. Sámi have a unique way of describing the snow, and how their livelihood, environment and every day activities interact with and depend on it. Changes in the snow quality and quantity, and especially depth and density of the snow, are fundamental in planning and maintaining many of the activities that Sámi practice (Eira et al. 2013). Due to the extensive knowledge and the rich language that Sámi have on snow and ice cover, challenges arise to translate the traditional knowledge into a scientific ‘language’, whilst keeping the same level of content and detail.

A study by Eira et al. (2013), combining reindeer herders’ knowledge and modern scientific data, such as ground measurements and satellite observations, was conducted in winter 2007-08 in Guovdageaidnu/ Kautokeino in Northern Norway. The study emphasized the contribution of the language in recording, structuring and transforming the knowledge, and how many herding activities, such as tracking, visibility, mobility and availability of pastureland are dependable on snow. Five key Sámi terms on snow are identified in table 2, and by using a SNOWPACK model, climate variables, such as air and ground temperature, air humidity, wind, snow depth and cloudiness, were measured and correlated with the terminology and knowledge of Sámi (Eira et al. 2013).

Table 2. Five snow terms in Sámi language have been introduced. This represents a way to combine traditional Sámi knowledge with scientific measurements. The terms and characteristics are applied from a study by Eira et al. (2013).

<table>
<thead>
<tr>
<th>Terms in Sámi</th>
<th>Sámi characteristics</th>
<th>Scientific characteristics</th>
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<tbody>
<tr>
<td>Vahca</td>
<td>• Fresh and new snow on the surface of snowpack</td>
<td>• Consists of precipitation particles and is affected by temperature and wind speed</td>
</tr>
<tr>
<td></td>
<td>• Difficult for herders to walk and travel, but good to track for reindeer</td>
<td></td>
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<tr>
<td></td>
<td>• Present during the entire snow season</td>
<td></td>
</tr>
<tr>
<td>Seaŋás</td>
<td>• Most important and beneficial snow type for herders</td>
<td>• Depth hoar crystals, classified by the international snow classification (ISC)</td>
</tr>
<tr>
<td></td>
<td>• Coarse grained snow formed in the bottom of snowpack during cold winter</td>
<td>• Requires thin snow cover and cold air temperatures</td>
</tr>
<tr>
<td></td>
<td>• Good snow conditions and easy access for food for the reindeer</td>
<td>• Requires a large temperature gradient of -10°C/100 cm.</td>
</tr>
<tr>
<td></td>
<td>• Can melt rapidly and provide water source for the Sámi</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Normally present from January to April</td>
<td></td>
</tr>
<tr>
<td>Čearga</td>
<td>Snow transported by strong winds, breaking the snow particles</td>
<td></td>
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<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Broken particles form a strong and dense snowpack, depth of 5cm to 1m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can prevent both herders and reindeer access through the snow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy travelling conditions, bad tracking</td>
<td></td>
</tr>
<tr>
<td><strong>Geardini</strong></td>
<td>Rain on a cold snow layer forms a thin breakable layer of ice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Similar to rain crust conditions (ISC)</td>
<td></td>
</tr>
<tr>
<td><strong>Gaska-geardini</strong></td>
<td>An ice layer buried under the snow. Similar to geardini, but if porous and not polished the ice layer can be classified as melt-freeze crust (ISC).</td>
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</tr>
</tbody>
</table>

2.4 Research on the Sámi

2.4.1 Snowchange Cooperative
Snowchange Cooperative is an independent scientific group with a research focus on climate change in the Arctic and indigenous groups, especially the Sámi. The group consists of Finnish researchers and they have conducted research on this for over 15 years (snowchnage.org, 2015). They hold extensive and exclusive records kept by the Sámi, of histories, interviews and weather diaries, including recorded weather changes, traditional knowledge, and changes recorded in either cultural, social or environmental aspect (Mustonen and Mustonen, 2011). Snowchange cooperates with several international scientific communities and organizations, such as the Arctic Council, Intergovernmental Panel on Climate Change (IPCC) and Indigenous Peoples Climate Change Assessment. The records referenced in this study include many histories and recordings kept by the Sámi, and applied due to the high relevance on assessing the adaptive capacity of the Sámi.

2.4.2 EALÁT
EALÁT, international scientific research collaboration, have conducted a consortium project on the Sámi called ‘EALAT Reindeer pastoralism in a Changing Climate’. The study is led by the reindeer herders, and thus provides a unique research focus
The initiative is a combination of traditional scientific methodology, including remote sensing and Geographic Information Systems (GIS), and traditional knowledge held by the Sámi (Maynard et al. 2011). The research focus of the collaboration is to investigate the adaptive capacity and the traditional knowledge of the Sámi and the impacts that climate change can have on these. This approach is aimed to learn, improve and provide adaptation strategies for the Sámi. Important is to understand the reindeer herders’ requirements for additional and updated scientific data, information and education, in order to improve their adaptive capacity (Maynard et al. 2011).

3 THEORY

This section is to set a theoretical background for the study and a base to assess the limitations to adaptation. Exogenous barriers have been identified outside the theory, such as ecological, technological, economical and institutional, but emphasis here will be given on the endogenous limitations, the limits within our society. Theory by Adger et al. (2009) is applied here in identifying four main endogenous limits as ethics, knowledge, culture and attitude to risk (Figure 2). The theory is applied to address how endogenous limitations can hamper the level of adaptation amongst the indigenous people. All of the key four limits have been identified in this study, but the latter two have found with the most relevance.

Adaptation amongst the Sámi communities is a complex combination of knowledge, methods and traditions, and these are driven by many social norms, perceptions and attitudes within our societies. Sámi face many challenges due to the physical and ecological changes that climate change proposes in the future, as well as the economical and political constrains that can hamper adaptation. However, often these barriers are further emphasized within our society in terms of how and what we value, know, perceive and live (Adger et al. 2009) (Figure 2). Differences exist within a society, in the power and social structures, as well as in the values, customs and perceptions between communities. For a minority group like the Sámi these verdicts are often made on their
behalf, driven for example by inappropriate rights and permits (Mustonen and Mustonen, 2011) (EALAT, 2009). Figure 2 indicates the four main endogenous limits to adaptation based on a theory by Adger et al. (2009). These indicators are applied in a reference to the adaptive capacity of the Sámi, with added information on the societal limits that Sámi experience.

**Figure 2.** Endogenous limits to adaptation are represented in relation to the adaptive capacity of the Sámi. The four indicators are applied from a theory by Adger et al. (2009) and used as a background for the figure.
4 FRAMEWORK

This section represents a Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) framework, introduced by Smit et al. (2010), and is applied here due to its relevance for the study. The framework aims to characterize and identify opportunities that enhance and improve communities’ adaptive capacities. CAVIAR was designed to document vulnerabilities in sensitive communities, assess the ways they could deal with presented changes, identify any constrains that limit adaptation, and integrate scientific and traditional knowledge for improved adaptation (Smit et al. 2010). The framework further looks at changes by which communities are being affected by and how these can affect the current and future adaptive capacity of Arctic communities.

Figure 3. CAVIAR framework applied from a study by Smit et al (2010). The framework is used to assess the level of vulnerability of a community, as well as the current and future adaptive capacity. Additional information relevant to the adaptation of the Sámi has been added and they are indicated in blue.

The framework is applied in this study to improve the understanding of the adaptive capacity of the Sámi. This is done by looking at the current exposure and adaptation strategies of the Sámi, an indication of their current level of vulnerability (Figure 3).
However, to assess the projected level of vulnerability in the future, the expected level of exposure and sensitivity to changes are to be assessed (Figure 3). Eventually this type of framework should form a basis in identifying the future policy needs and options in improving the adaptive capacity of the Sámi, but this is beyond the scope of this project. Figure 3 introduces the applied framework with additional context-specific information relevant to the Sámi. Snowchange and EALÁT Cooperatives have provided workshops that work together with stakeholders and partners in sharing knowledge and information on the adaptation needs and options of the Sámi (Figure 3).

5 MATERIAL AND METHODS

Data used in this study have been drawn from several sources, including scientific articles and reports. The main research on the Sámi has been assessed through the extensive studies conducted by Snowchange Cooperative and EALAT collaborations. Due to the length and time limitations of this paper the focus has been given on the Sámi living on the Scandinavian side of Sápmi, with an emphasis on the reindeer herders.

A theory of endogenous limits to adaptation has been applied from a study by Adger et al. (2009), and used as a point of departure in defining adaptation limitations for the Sámi. Adaptive capacity is based on a CAVIAR framework introduced in a study by Smit et al. (2010), and applied to assess the current and future level of vulnerability and adaptive capacity of the Sámi. The importance of traditional knowledge is evaluated by using the Sámi knowledge on snow as an indicator of the indigenous knowledge (Eira et al. 2013). The role of traditional knowledge is then applied, in addition to the limitations to adapt, in order to assess the level of impact that future climate change is likely to propose on the Sámi. For clarification, gaska-geardini type of snow named by the Sámi is also identified as ‘icy rain’ by many, and is identical to the rain-on-snow events as discussed in a scientific context.
6 ANALYSIS

This section introduces and analyses the level of vulnerability amongst the Sámi communities, in assessing the current as well as the future level of the adaptive capacity. There are various limitations that can hinder the adaptive capacity of the Sámi, some of which are introduced here, with an emphasis on the endogenous limits.

6.1 Observed impacts and current adaptive capacity

Majority of the scientific observations represented by IPCC (2013) and ACIA (2004) correlate closely with the changes observed by the Sámi (Table 1). Especially extending of the mild and warm weather, shortening of winter seasons, increase of precipitation, and rain-on-snow events, have been observed by many, and to affect their everyday lives and cultural activities (Mustonen and Mustonen, 2011). The extensive data have been provided through studies by the Snowchange Cooperative and EÅLAT collaboration. Local scale observations can help in explaining how communities have adapted in the past, and therefore identifying how the adaptive capacity could be improved in the future. Sámi spend a great amount of time outdoors, which is why their observations are often precise, and even slight changes in weather, climate or environment are noticed (Table 1) (Snowscapes, Dreamscapes, 2004).

Sámi, along with other indigenous groups, are known for their success to adapt to changes, and often climate variations are considered natural, if not even inevitable, in the sensitive and unique Arctic environment. Many Sámi, however, observe that recent climatic variations over the past few decades have been more drastic and the changes more evident than before (Snowscapes, Dreamscapes, 2004). Many of the current adaptation strategies applied are essential in maintaining many of the culturally and socially essential activities and concepts of the Sámi, but many of these strategies are being constrained by many societal limitations.

Snow cover is in many ways central to the Sámi culture, but the recent recorded decline in snow and ice cover has generated challenges for reindeer herding as well as other culturally important activities (IPCC, CH28, 2014). Table 2 provides an example in integrating traditional knowledge with scientific measurements, and the importance of
snow in the Sámi culture. Sámi language and knowledge supports an extensive detail of snow and ice cover, but many herders have noticed an increasing unreliability in their traditional calendar (Snowscapes, Dreamcapes, 2004). Different conditions of snow are indicated by diverse Sámi terms and characteristics, and by the implications they have on their livelihoods and cultural activities (Table 2). Rain-on-snow event in Sámi is identified as Gaska-geardini, and these conditions are the most challenging for the reindeer herders to adapt to. This type of snow is identified as poor grazing conditions and in preventing access to food sources through the layer of ice and snow. Scientifically this is identified as melt-freeze crust (Table 2). Integration of these two classifications allow for a greater understanding of these snow events and the implications they have on the Sámi culture. Traditional knowledge, and knowledge on the snow, creates a core for the adaptive capacity, as well as for the cultural identity of the Sámi (Eira et al. 2013).

6.2 Limits to adaptation

Physical changes in climate, as well as political, economical and technological barriers are likely to create challenges for the Sámi to adapt. But it is argued here that the limits within society are, at least to some extent, more defining in terms of adaptive capacity. Not necessary within the smaller Sámi communities themselves, but due to the general social norms. For instance, unsuitable grazing land and unstable ice and snow cover are impacts of the climate, but if the Sámi have appropriate resources available, and if less societal limitations exist, climatic factors might not be as defining in limiting ability to adapt. Appropriate resources could include migration possibilities to a new pasture area, or improving reindeer’s access to additional food sources. Therefore, despite acknowledging that exogenous limitations can hamper the adaptive capacity of the Sámi, the focus of the study will be on the endogenous limits as they are likely to further amplify the need for adaptation.

Sámi are to a great extent dependent on the actions of greater societal norms, in terms of what people value, and how people value (Figure 2). The applied theory by Adger et al. (2009) introduces several limits to adaptation existing within our societies. In a more self-sustainable and less vulnerable community, one who holds the rights in how, when or whether to adapt, presence of endogenous limits are less likely. Climate change
proposes a real and already existing risk for the Sámi, but action to curb the risk of climate change is being hampered by political arguments, disagreements and slow mitigation procedures. Not only do the Sámi suffer from a greater degree of climate change impacts, but they also hold much smaller level of capacity, resources, and rights to adapt to these changes (Keskitalo and Kulyasova, 2009). Therefore, the required level of adaptation for the Sámi is greatly dependent on the values others preserve, the knowledge they possess and the risk they perceive as unacceptable.

Cultural valuation provides limitations to adapt when the same values and beliefs are not shared with others. How the Sámi value and preserve their environment, nature and its resources, culture and language greatly differs from the rest of the world, and often these values can feel distant and strange to others. Without a close connection to the culture, the emergency and importance of preserving and nourishing such a culture is likely to be disregarded. Also what people perceive as a risk varies from one another, which is why finding an all-defining threshold, in preserving cultural identity, and thereby the ability and right to adapt, is found difficult (Adger et al. 2009) (Figure 2).

6.3 Future adaptive capacity

Future climate change projections by IPCC (2013) and ACIA (2004) expect the temperature increase, climate variability as well as acceleration of the weather extremes to continue in the future. Research on the current adaptation strategies and capacity of the Sámi can help in assessing the required level of adaptation for the future. By identifying successful adaptation strategies and current implementation methods, it is possible to determine sufficient actions for maintaining and improving the level of adaptation in the future. Flexible use of natural resources, preserving of traditional knowledge, and improving the level and access for education and awareness, are of great importance in improving the future adaptive capacity.

The richness and detail of the Sámi vocabulary and terminology represents the knowledge that can be shared through an indigenous language (Eira et al. 2013). Preserving traditional knowledge is a key to adaptation and therefore essential addition to improve awareness and education in building the resilience of the Sámi communities. Extending the understanding of applied traditional knowledge, such as on snow
conditions, can help to improve the adaptive capacity of the Sámi in the future. Modern science can provide additional knowledge and information as science progresses and advances, but it should be built and based on the traditional knowledge of the Sámi. By combining these two ways of knowing is considered beneficial in finding a balance for improving the adaptive capacity of the Sámi in the future.

7DISCUSSION

Spreading knowledge on the vulnerable communities in the Arctic and building bridges between the indigenous groups and politicians is essential in making the indigenous people’s voices appropriately heard. To improve the adaptive capacity of the Sámi, it is important to address climate change as a phenomenon seen by the Sámi; how it affects their activities, livelihood as well as social and economic decisions. With communities as remote, unique and vulnerable as the Sámi, they, along with other indigenous groups, are likely to be on the frontier in facing the challenges proposed by future climate change.

7.1 Overcoming barriers and challenges to adaptation

For decades the rights of the Sámi have been violated, greatly hindering their ability to adapt. Modernization, power production, tourism and urbanization are amongst the things compromising the sustainability in the North. Many of these bring development
and growth to the Global South, but despite being extracted in the Global North, due to the lack of legitimate rights for the Arctic people, the benefits rarely stay in the region (Mustonen and Mustonen, 2011). Efforts have been made by the UN and other international collaborations to bring equity and justice for the people in the Arctic. For example the Sámi Council focuses on the human rights of the Sámi, in terms of language, culture and environment. United Nations have also launched an ‘Indigenous Peoples Climate Change Assessment’ (IPCCA) to address the issues that indigenous people face in the Arctic (Mustonen and Mustonen, 2011). Only recently has the Sámi begun to receive more international assistance. Global Citizens Platform Project, an initiative led by the United Nations and cooperated with Snowchange, has been beneficial in gaining assistance for the Arctic issues. Through this initiative, and many others, Sámi communities are hoped to be more recognized and their issues more directly addressed (Mustonen and Mustonen, 2011).

Rain-on-snow events have been identified as especially problematic for reindeer herding, and if no alternative food source for the reindeer is provided, the number of reindeer can drastically decline (Maynard et al. 2011). This is likely to have, not only cultural implications for the Sámi, but also issues of food insecurity. As the unpredictable winter seasons are expected to continue over the future decades, reindeer herding is also likely to become more vulnerable. By preserving reindeer herding, the cultural status of the Sámi is also being preserved. However, if existing limitations to adaptation are not surpassed, or global mitigation efforts do not reach the required level, shifts in livelihood activities might be inevitable. Therefore, flexibility in finding additional sources and activities in supporting the daily livelihoods of the Sámi might be inevitable in the future. In fact, some transitions are already visible as some reindeer herders are shifting away from the herding and relying more for instance on in-land fishing (King et al. 2015).

### 7.2 The role of traditional knowledge

Traditional knowledge of the Sami thrives from observations, experiences and utilization of the natural resources, and as already mentioned, this is most appropriately expressed through the Sámi language (Snowscapes, Dreamscapes, 2004). The experience and traditional knowledge on how to adapt can be considered as a precondition of the Sámi survival. The Sámi face challenges in preserving this knowledge however, for instance
weather unpredictability is making the traditional Sámi calendar more unreliable, or endogenous limitations are causing obstacles to adapt. Finding a new balance between science and traditional knowledge is considered beneficial and to increase understanding and knowledge sharing between these two ways. Although this said, to minimize the impact of endogenous limitations, future adaptation strategies and approaches need to be based on the knowledge of the Sámi (Maynard et al. 2011).

Also essential is that the decision-making system is emphasized with a local level approach, involving reaching out and learning from the indigenous communities, as well as improving the level of education and awareness both inside and outside the local communities. Adaptation should be based on a more bottom-up approach and be based on the knowledge of reindeer herders, fishermen and other indigenous people, and only then be followed by input from the municipality, province and government (Keskitalo and Kulyasova, 2009). Governmental participation is crucial in ensuring leadership and economic support, but intrusive actions should be minimized and actions based on what, where and when considered appropriate by the Sámi.

### 7.3 Future adaptation

Due to the non-linearity of the future climate impacts and uncertainty of the level of endogenous limitations, the old-fashioned way of thinking that indigenous people will continue to ‘just adapt’ to changes in the future, is unlikely to be realistic. To receive a more all-inclusive view of the level and requirements for adaptation in the future, more locally focused research is required, as the level of vulnerability differs between communities in the Arctic. There is a need for a new mind set towards future climate change and the importance in preserving indigenous groups by giving them the same set of rights as other societies retain (Speca, 2015).

Observing current changes is the first step in understanding the current adaptive capacity of the Sámi, and by using this knowledge it is aspired that the future level of vulnerability can be reduced. Without successful climate change mitigation in place, however, the limitations to adapt to future climate change could grow unbearable. Therefore finding long-term, sustainable and locally successful adaptation strategies is
crucial, but also is ensuring that appropriate synergies exist and are applied between climate adaptation and mitigation (Snowscapes, Dreamscapes, 2004).

Communication, knowledge sharing, and improving of education and awareness of the Sámi have been emphasized by both the Snowchange Cooperative as well as the EÅLAT collaboration projects. Workshops involving different stakeholders have been identified as a successful step towards future adaptation, and more workshops are being planned (Snowscapes, Dreamscapes, 2004) (EALAT, 2009). Also integrating science with traditional knowledge is recognized as a good way to improve the communication between scientists and indigenous people, and improving the general understanding of the changes occurring in our environment (Eira et al. 2013). Appropriate hunting and fishing permits, land rights, and support of additional income sources need to be in place in ensuring successful adaptation and flexibility for the Sámi, and this will emergence with an increasing importance over the coming decades (Mustonen and Mustonen, 2011).

Arctic communities are heavily resource-dependent and want to hold the rights for their own resources, but due to the governmental restrictions many indigenous people feel they are not given enough resources or leverage to adapt (Fleener, 2015). Future climate change is also likely to impact those the most who are already vulnerable and limited with resources (IPCC, 2014). To overcome many of the limitations mentioned earlier, and to improve the adaptive capacity of the Sámi, many institutional and societal changes, as well as reformation of social and public policies, are required. Appropriate platform for equitable rights need to be created for the Sámi in supporting of their livelihoods, providing social services, diversifying economic activities and allowing flexibility and support to adapt to the changes in the future (ACIA, 2004).
**8 CONCLUSION**

Due to the high level of vulnerability of the Sámi communities, climate change is expected to propose a new set of challenges for these marginalized communities in the future. The adaptive capacity of the Sámi depends on the impacts of climate change, as well as other ecological, economical and institutional factors. Emphasis here is given, however, on the endogenous limitations that exist within our society. The ability for the Sámi to adapt is dependent on the resources available, but the flexibility to apply these is often neglected by governmental restrictions and the lack of appropriate rights for land and resources. The Sámi value, apply, and depend on the nature in ways that differ from the rest of the world, which is why the availability and access for the Sámi to adapt is often driven by the general societal norms of how others live, perceive risk and value of things.

To improve the adaptive capacity of the Sámi, appropriate rights needs to be accessible, and flexibility to shift resources should be provided. Also preserving the traditional knowledge of the Sámi is crucial to understand how, and in what ways, the adaptive capacity could be improved. In terms of future climate change and its unpredictability, some changes are most likely inevitable, but not all should be accepted. The amount of research conducted in the Arctic is increasing, and certainly more is required in the future to improve the level of understanding, both in terms of the physical impacts, as well as the social responses of the indigenous communities. Local level studies are a desirable way to improve the knowledge of the Arctic, not just on the individual community level, but also to learn from the general vulnerability of the Arctic.
REFERENCES


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