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SAAMELAISNEUVOSTO
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SAAMI COUNCIL

SÁMEDIGGI
SAMETINGET

Climate Change in Sápmi – an overview and a Path Forward

RAPORTA | REPORT 2023

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Ovdasátni

Dálkkádatrievdan lea min áiggi stuorámus áitta olbmo ja luonddu buresveadjimii.

Danin lea dát raporta sihke issoras, dehálaš ja áigeguovdil. Min ruoktu, Sápmi, ja olles Árktalaš guovlu boahtá rievdat sakka čuovvovaš jahkelogiid áigge. Galbmasii ja dálvái heivehuvvan kultuvra, eaiáhusat ja luonddušlájat šaddet rievdat dađistaga, go jahkodagat, dálkkit, luonddušlájat ja politihkalaš dilli rivdet dálkkádatrievdama geažil.

Diehttelasat buktá rievdan morraša, go olu midjiide oahpis ja ráhkis jávká. Eahpesihkarvuođa sáhttit dustet dainna, ahte geahččat ovddosguvlui, mii doppe orru boahtimin ja mo mii dainna buoremus lági mielde ovttasráđiid birget. Mii leat áiggiid čađa koloniserema geažil hárjánan rievdat ja vuogáiduvvat, heivehit iežamet ođđa diliide. Sámi álbmot gal máhttá rievdat ja dan mii šaddat ohpit dahkat.

Sámiráđi bealis giittán norggabeal sámedikki dán raportta diŋgomis. Dán čállin lea addán midjiide vejolašvuođa čiekŋut dálkkádatdiehtagii, -dihtui, -linjemiidda ja -politihkkii, ja daid oktavuhtii sámekultuvrrain, nugo maiddái hástalusaide ja vejolašvuođaide, maid dat buktet sámi eaiáhusaide, -servodahkii ja buresveadjimii.

Čoahkkaneamit ja ságastallamat Sámi árbediehttiiguin ja siviilaservodagain leamašan guovddážis dán ráportta hábmemis. Máilmme stuorra giitosat buot Sámi árbediehttiide ja servodatberošteaddjiide, geat lehpet juogadan jurdagiiddádet, vásáhusaideattet ja fuomášumiideattet dálkkádatrievdama ja dan váikkuhusaid olis!

Dálkkádátrievdama smiehttan ja guorahallan sáhttá leat oalle lossat ja čuohcat olbmui máŋgga láhkai. Mii atnit árvvus dan, go olbmot leat juogadan minguin dáid losses fáttáid birra. Lea earenomáš dehálaš buktit iešguđet hástalusaid beaivečuvgii – mađi buorebut mii sáhttit ovddalgihtii árvvoštallat vejolaš rievdadusaid, dađi buorebut sáhttit daidda ráhkkanit. Mii fertet dihtomielalaččat guorahallat maiddái árbedieđu dáid rievdadusaid olis – go luonddubiras rievdá, nu ferte árbediehtu maid rievdat ođđa árbin ođđa buolvvaide.

Dát bargu lea nannen min gelbbolašvuođa dálkkádatrievdamis ja dasa gullevaš váikkuhusain. Guhkit áiggis dát bargu boahtá maid váikkuhit min doibmii Ovttastuvvon Našuvnnaid olis, maid bargat ee. Dálkkádatsoahpamuša, Luonddugirjáivuođa soahpamuša, nugo maiddái Árktalaš Ráđi olis. Áigodagas 2022-2025 Sámiráđđi ovddasta Árktalaš guovllu ON Dálkkádatsoahpamuša Eamiálbmogiid ja báikkálaš servošiid bargojoavkku stivrenjoavkkus. Dát raporta lea resursan min oasseváldimii ja váikkuheapmái dan orgánas.

Giitosat buohkaide nana movtta ja searalašvuođa ovddas. Addá fámuid oaidnit man olu čeahpes ja viššalis olbmot mis leat, geat áigot ain joatkit bargat ealás ja nana sámevuođa ovddas buohttevaš buolvvaid várás.

Mii sávvat ahte dát raporta lea ávkin Sámi politihkkáriidda, virgeolbmuide ja siviilaservodahkii, nuoraide ja earáide, geat juogadit min fuolaid ja árvvuid. Sávvat maid ahte guorahallamat dorjot min ovttasbargat boahtteáiggi ovdii, gos lea dearvvas biras ja ealás sámekultuvra.

– Áslat Holmberg,
Sámiráđi presideanta

Foreword

Climate change is the greatest threat of our time to the well-being of humans and nature.

Therefore this report is both frightful, important and timely/ of current interest. Our home, Sápmi, and the whole Arctic region will change a lot over the next decades. A culture, livelihoods and species adapted to cold and to winter will slowly adjust when seasons, weathers, species, and geopolitical situations are changing due to climate change.

Changes will of course bring grief, when what is familiar and dear to use are vanishing. We can face the insecurity, by looking forward to what might be coming and how we to the best of our ability in collaboration will cope. Throughout times due to colonialism become accustomed to change and to adjust, adapt to new circumstances. The Sámi people knows how to adapt and we will need to do it again.

The Saami Council wishes to express its thanks to the Sámi Parliament in Norway for the commission of this report. This opportunity has enabled us to spend a year of deeper focus on climate science, climate knowledge, directions and policy and understanding these in relation to the Sámi culture and the challenges and opportunities for Sámi livelihoods, society, and well-being.

The meetings and conversations with Sámi civil society and Sámi knowledge holders have been essential and very valuable in developing this report. We want to express our strongest gratitude to all Sámi knowledge holders that have taken their time to share their thoughts, experiences and observations from climate change and related impacts, and how this impacts them in their life.

We recognise that reflecting upon climate change and related impacts and burdens can be emotionally exposing, and we appreciate your openness in sharing these with us. We emphasize the importance and need of bringing these challenges to the light as we believe it is crucial for the continued work on mitigating impacts and continue developing adaptive measures for long-term resilience. We must consciously investigate the Indigenous Knowledge related to these changes–as the environment is changing, the indigenous knowledge will have to adjust to new heritage for new generations.

The work has strengthened our internal capacity on climate change and related impacts. In the long run the work will impact our activities related to the United Nations, and what we do in the climate convention, biodiversity convention, as well as in the Arctic Council. For the term 2022–2025, the Saami Council is representing the Arctic UN Indigenous socio-cultural region in the UN climate convention UNFCCC constituted body Local Communities and Indigenous Peoples Platform's (LCIPP) Facilitative Working Group (FWG). The report is a resource and knowledge foundation for our participation and contribution in this body.

Thank you to everyone for your strong enthusiasm and commitment. It is empowering to see how many clever and hard-working people we have, keeping Sámi culture strong and vibrant for coming generations.

We hope this report will be found useful for Sámi politicians, bureaucrats and the civil society, youth and others that share our concerns and values. We sincerely hope that this report will be of inspiration for us to come together as a people and continue working together towards a future that is ensuring a healthy environment and a vibrant Sámi culture.

– Aslak Holmberg,
President of the Saami Council

Acknowladgements

The Saami Council wishes to express its deepest gratitude to all the Sámi knowledge holders that have contributed with their/your time, knowledge, experiences and thoughts in the making of this report. We also gratefully acknowledge Clive Desire-tesar for the language editing of the report. Finally, we would also like to extend our sincere thanks to our colleagues Anna Marja Persson, Áslat Holmberg, Elle Merete Omma, Piera Heaika Muotka, Rune Fjellheim and Åsa Larsson Blind for the input, support and assistance.

1. Introduction

Climate change and its related consequees are a serious concern and the most pressing issue of our time.

Climate change and its related consequees are a serious concern and the most pressing issue of our time. Climate science points to the urgent need to reduce human-caused greenhouse gas emissions into the atmosphere in order to mitigate and slow down further cascading impacts within our ecosystems that from global human demands for resources simultaneously have exceeded ecosystems regenerative capacity.

In 2022, the United Nations General Assembly unanimously passed a resolution (A/76/L.75) that affirmed a clean, healthy, and sustainable environment as a human right – and a right for all. The UNGA further calls upon States, international organizations, businesses, and other stakeholders to "scale up efforts" to ensure the full implementation of multilateral environmental agreements. The right to a clean, healthy, and sustainable environment was also later repeated in the UNFCCC COP27 Cover decision.

For decades, Indigenous Peoples around the world have raised alarming concerns about climatic and environmental changes occuring. These changes are experienced in various socio-cultural, economic, and political conditions, and at various scales. However, Indigenous Peoples globally face significant structural and legal barriers: rights to self-determination are being undermined or ignored and participation in environmental governance is limited which risks to increase climate vulnerability. As a result, climate change increases the urgency of addressing these challenges through transformative change.

> The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Global Assessment defines transformative change as 'a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values.[1]

In the Arctic, climate change impacts are occurring at a magnitude and pace unprecedented in recent history, and much faster than projected for other regions of the world. In the declaration from the 6th Arctic Leaders' Summit in Roavvenjárga (2019), Arctic Indigenous Peoples affirmed that "[...] climate change constitutes a state of emergency for our lands, waters, animals and Peoples […]" and underlined that "[...] we will accordingly utilize our local, national and international forums and partnerships to achieve meaningful progress towards the Paris Agreement targets."[2]

Climate change is resulting in complex cascading impacts and challenges for Sápmi. In 2021, Sámi youth issued a declaration on climate change and its impacts, demanding immediate climate action and equitable involvement of Sámi in this work.[3] The Sámi cultural landscape has undergone significant changes over centuries, many of which have impacted Sámi culture and livelihoods and continue to do so until this day. Impacts from a changing climate poses new challenges which will require new, cross-disciplinary measures and strategies for adaptation. While the Sámi society has unique knowledge and solutions for effective climate action–knowledge that is living and constantly evolving in interaction with the surrounding environment–the ability to use this knowledge and our inherent cultural tools is limited by legislation, management policies, and regulations–limitations which all have direct impacts on adaptive capacity. Any limitation to adaptive capacity risks having severe consequences for Sámi culture and livelihoods–consequences that become societal.

Aim

The request to the Saami Council was to write a report assessing the impacts of climate change on Sámi culture, livelihoods and society. Beyond participating in the seminar at Sámi Parliamentarian Conference in May 2022 with a presentation about our work with this report, the workshops and seminar Saami Council conducted referred to in the

1 IPBES, "Transformative Change, Definition."

2 Arctic Leaders Summit, "VI Arctic Leaders' Summit Declaration. Roavvenjárga November 13 – 15, 2019."

3 Nordic Sámi Youth Conference 2021, "Sámi Youths' Declaration on Climate Change."

report, and reviewing some of the existing science by Sámi institutions and experts, we have not engaged with Sámi institutions and organizations specifically.

This report aims to give a snapshot of climate change research and draw on connections to Sápmi, Sámi culture and Sámi livelihoods. By painting a picture of some observed climatic and environmental changes – globally, in the Arctic and with a few examples from Sápmi–combined with the knowledge and observations from Sámi knowledge holders and climate research, this report hopes to raise knowledge about climate change and related impacts in a Sámi context. We hope it also contributes to the beginning of more comprehensive work on the climate's impact on Sápmi and the Sámi people.

The report does not make any claims of being exhaustive or all-encompassing. Climate change science is broad and evolving, and its related impacts are complex and sometimes uncertain. Climate change interacts with multiple factors–some that are non-climatic–and impacts from climatic and environmental change can be dependent on local conditions and contexts. Climate change refers to long-term shifts in temperatures and weather patterns and these shifts may be natural, such as through variations in the solar cycle. However, since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels (see chapter two). While climate change refers to long-term changes, weather refers to short-term natural events that occur in a specific location and time, such as fog, rain, snow, blizzards, wind and thunderstorms and tropical cyclones. Meteorologists use 30-year cycles to describe what is considered normal weather. These cycles can also exemplify shifting baselines–a factor that might challenge how individuals from different age groups reflect on the past. On one hand, humans rather quickly get used to new realities, and on the other, there are different starting points for what is considered normal. A classic example from Sápmi is young Sámi saying that they have never experienced a 'normal winter', as described by their elders. This could also reveal elements of shifts in 'landscape memory' as described by Näkkäläjärvi et al (see chapter five).

The Saami Council regards the Sámi people as one, regardless of state borders. We therefore refer to Sápmi as one region in this report. Acknowledging that Sápmi expands beyond what is generally defined as Arctic boundaries (which are defined differently in different contexts), it is worth noting that some research covering and referring to 'the Arctic' might not include all of Sápmi and/or examples from our region. However, this research is still relevant for understanding current and future projected changes in our home area, and for the purpose of this report. Näkkäläjärvi et al. (2022) highlight in their research that Sámi observations of climate change are in line with those of other Arctic Indigenous Peoples.[4]

Material

The material of the report is mainly, but not exclusively, based on recent findings by the Intergovernmental Panel on Climate Change (IPCC), the Arctic Monitoring and Assessment Programme (AMAP), and diverse research and reports produced by Sámi institutions and researchers, and others related to this topic. The testimonies, observations and reflections on climate change and related impacts on Sámi culture and livelihoods from Sámi knowledge holders have been equally important for the development of this report. Through written interviews and workshops conducted during 2022, their contributions confirmed and elaborated on the findings of climate research. The contributions from knowledge holders also helped us choose the focus areas for the report, and broadened our own perspective on Sámi society, its experiences and its needs, as well as climate change and its impacts on our everyday life. During the workshops and the seminar, there was an expressed need for arenas and meeting spaces to discuss these topics further.

The Sámi knowledge holders that have contributed to this report cover a wide geographical area in Sápmi–from west to east, and from north to south. Still, there were limitations to the depth of input that could be gathered due to capacity and time restrictions. The report unfortunately does not cover Guoládatnjárga (Kola peninsula) due to the restrictions and challenges caused by the COVID-19 pandemic followed by the current geopolitical situation. Crossing into the Russian Federation to participate in face-to-face meetings and conducting workshops were not possible under the circumstances. Researchers also highlight that relatively little has been published on climate change-related impacts in the Guoládatnjárga in the scientific literature outside of Russia.[5] However, the impacts of climate change and related societal impacts described are expected to be relevant and similar for the Sámi society in Guoládatnjárga, but will not be addressed in this report.

4 Näkkäläjärvi, Juntunen, and Jaakkola, "*Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland.*"

5 Marshall, Vignols, and Rees, "*Climate Change in the Kola Peninsula, Arctic Russia, during the Last 50 Years from Meteorological Observations.*"

It is worth noting that the reindeer husbandry, an essential carrier of Sámi culture, is covering a wide geographical area throughout Sápmi and is quite well-represented in climate change and related research, allowing for a wider focus on this subject. Furthermore, Sámi civil society expressed the need for reindeer husbandry to be given particular attention. The research basis on how climate change affects and inhibits various other Sámi livelihoods, cultural practices, and activities, such as hunting, fishing and *duodji*, and how it possibly impacts the Sámi society as a whole, is however insufficient. Nevertheless, we argue that the direct and indirect impacts of climate change on reindeer husbandry has vast implications for Sámi society as a whole, including cultural identity.

Intergovernmental Panel on Climate Change
The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 under the United Nations to provide policymakers with regular scientific assessments on the current state of knowledge about climate change. Within this mandate, IPCC does not conduct its own research but prepares comprehensive reviews and recommendations with respect to the state of knowledge of the science: what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks. This is done through their respective assessment cycles done every five to six years, whereas the latest one–the Sixth Assessment Report (AR6)–was published during 2021-2022. The IPCC also publishes special reports on more specific issues between assessment reports.

Arctic Monitoring and Assessment Programme
The Arctic Monitoring and Assessment Programme (AMAP) is a working group of the Arctic Council. AMAP's mandate is to monitor and assess the state of the Arctic region in terms of pollution and climate change. It documents levels and trends, pathways and processes, and effects on ecosystems and humans, as well as proposing actions for governments to reduce threats. Since its inception in 1991, AMAP has produced a series of high-quality reports and related communication products detailing the status of the Arctic in terms of climate and pollution issues, as well as policy-relevant science-based advice to the Arctic Council and governments. AMAP has translated a number of its summary reports into north Sámi.

Throughout Sápmi there is a need for a greater attention to climate change impacts on the foundations of the entire Sámi cultural system, and not only on the impacts on material culture, as argued by Juvvá Lemet (2009).[6] We hope that this report will inspire and encourage a continuation of knowledge production and sharing on climate change impacts in Sápmi as there is limited coverage of this related to Sámi culture and society in a broader context. We find this crucial for the transformative change required to respond to the Arctic changes also impacting Sápmi.

[6] Näkkäläjärvi, "Perspective of Saami Reindeer Herders on the Impact of Climate Change and Related Research."

Workshops and interviews

The Saami Council has conducted two gatherings in 2022 with Sámi knowledge holders; one focusing on *meahcástallan* (freshwater fishery, hunting and gathering activities) in Ohcejohka/Utsjoki and one focusing on coastal/fjord fisheries in Deanu Šaldi/Tana Bru in October. A more general seminar was organized during the 22nd Sámi Conference in Váhtjer, where approximately 75 Sámi civil society representatives and Sámi decision-makers participated. Written interviews were also conducted with Sámi reindeer herders.

The seminar in Váhtjer in August 2022 included introductions from the UN Special Rapporteur on the rights of Indigenous Peoples, Mr. Jose Francisco Cali Tzay, the former International Chair of the Inuit Circumpolar Council, Dr. Dalee Sambo Dorough, the Executive Secretary of the Arctic and Monitoring Assessment Programme (AMAP), Rolf Rødven, and the Chair of Laevas Čearru, Niila Inga,. These introductions were followed by an open discussion among the participants. The objective of the seminar was to allow for members of Sámi civil society to share their thoughts, reflections, experiences, and needs related to climate change based on their knowledge and insights.

In August 2022, Sámi knowledge holders around Deatnu (River Deatnu/Tana) were gathered in Ohcajohka–Utsjoki for a morning session focusing on observed and experienced climate changes in watersheds and *meahcci*. In October 2022, Sámi knowledge holders from the eastern part of Finnmark were gathered in Deatnu for a half-day event to discuss observations and reflections on observed changes in nature and ecosystems related to their activities and lives by the fjord. For both gatherings, the oldest people participating were born in the early 1940s and recall stories from their parents and grandparents born in the late 1800s/early 1900s. Younger participants were born in the 1970s, 1980s and 1990s. The oldest ones remember weather-related events like heavy storms that threw outhouses to the ground. They recall stories of very mild winters in the 1930s and many other events that by climate scientists are referred to as 'extreme'.

The Saami Council also conducted written interviews with reindeer herders over a large geographical area. We received input from the Finnish, Swedish and Norwegian parts of Sápmi, spanning from north to southern Sápmi from herders aged from 25–65 years old.

Outline of the report

The report consists of six chapters. After its introductory part, the second chapter aims to give a brief snapshot of climate change on a global level through selected categories. In chapter three, the global recognition of Indigenous Peoples knowledge and stewardship of nature is highlighted and exemplified, along with some of the barriers and challenges Indigenous Peoples face in decision-making processes. Chapter four aims to briefly showcase some of the observed impacts of climate change in the Arctic and in Sápmi–how it affects ecosystems and people–but also presents some of the future projections for Arctic change that have been highlighted in research. In chapter five, the results of the workshops and written interviews are presented together with research to give an overview of how climate change impacts Sámi society, culture and livelihoods. Chapter six, and final chapter, highlights some of the themes and needs that are found especially relevant to address and assess further in relation to climate and other changes in Sápmi.

REFERENCES CHAPTER 1

Arctic Leaders Summit. "VI Arctic Leaders' Summit Declaration. Roavvenjárga November 13 – 15, 2019," 2019.
https://static1.squarespace.com/static/58b6de9e414fb54d6c50134e/t/5dea325f7367373ce5087580/1575629412149/Final+ALS6+and+ALYS+Declaration+%28secured%29.pdf.
Marshall, Gareth J., Rebecca M. Vignols, and W. G. Rees. "Climate Change in the Kola Peninsula, Arctic Russia, during the Last 50 Years from Meteorological Observations." Journal of Climate 29, no. 18 (September 15, 2016): 6823–40. https://doi.org/10.1175/JCLI-D-16-0179.1.
Nordic Sámi Youth Conference 2021. "Sámi Youths' Declaration on Climate Change," August 26, 2021. https://www.samediggi.fi/2021/09/23/sami-youth-demand-actions-to-mitigate-climate-change/?lang=en.
Näkkäläjärvi, K. "Perspective of Saami Reindeer Herders on the Impact of Climate Change and Related Research." In Climate Change and Arctic Sustainable Development: Scientific, Social, Cultural and Educational Challenges. UNESCO: Paris: UNESCO, 2009.
IPBES. "Transformative Change, Definition," n.d. https://ipbes.net/glossary-tag/transformative-change.
Näkkäläjärvi, K., S. Juntunen, and J.J. Jaakkola. "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland." In Climate Cultures in Europe and North America, 103–25. London: Routledge, 2022.

2. The state of the climate: a scientific summary

This chapter aims to give a brief snapshot of climate change on a global level through selected categories.

Human influence on global warming

The latest assessments by the Intergovernmental Panel on Climate Change (IPCC) show that it is *unequivocal* that human influence has warmed the atmosphere, ocean and land, which has resulted in widespread and rapid changes in the atmosphere, ocean, cryosphere[7] and biosphere.[8] [9] Climate change is already affecting every region on the planet, and the link between many weather extremes and human influence has grown stronger since the IPCC's fifth assessment cycle in 2013-2014.[10] Climate change has caused, "[…] substantial damages and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems […]"[11] and there is increasing evidence that degradation and destruction of ecosystems by humans increases the vulnerability of people. The capacity of ecosystems, societies, communities and individuals to adapt to climate change is damaged by unsustainable land-use and land cover change, unsustainable use of natural resources, deforestation, loss of biodiversity, pollution, and the interactions of these factors.[12] The scale of recent changes across the climate system, and the present state of many aspects of the climate system, are unprecedented over many centuries to many thousands of years and many changes will persist for a long time–particularly changes in the ocean, ice sheets and global sea level.[13]

It is estimated that there has been a 1.07 °C human-induced global surface temperature increase from 1850-1900 to 2010-2019, to which a near-linear relationship with cumulative anthropogenic CO_2 emissions can be made. Global surface temperature is estimated to continue increasing at least to mid-century, and it is estimated that global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades.[14]

Human activities have caused increases in greenhouse gas emissions since around 1750, and concentrations of carbon dioxide (CO_2), methane, and nitrous oxide have continued to rise in the atmosphere since 2011.[15] In 2019, atmospheric carbon dioxide concentrations were higher than at any time in at least two million years, and concentrations of methane and nitrous oxide were higher than at any time in at least

[7] *Cryosphere*: The components of the Earth System at and below the land and ocean surface that are frozen, including snow cover, glaciers, ice sheets, ice shelves, icebergs, sea ice, lake ice, river ice, permafrost and seasonally frozen ground.

[8] *Biosphere*: The part of the Earth system that includes all ecosystems and living organisms, whether in the atmosphere, on land (terrestrial biosphere), or in the oceans (marine biosphere), as well as derived dead organic matter such as litter, soil organic matter, and oceanic organic material.

[9] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.1.

[10] Masson-Delmotte et al. A.4.

[11] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.1.1.

[12] Pörtner et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.1.

[13] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.2, B.5.

[14] Masson-Delmotte et al. A.1.3, B.1.

[15] Masson-Delmotte et al. A.1.1.

800,000 years.[16] [17] Even though emissions reductions from fossil fuels and industrial processes have improved, rising global activity levels in major sectors (industry, energy supply, transport, agriculture and building) have contributed to increasing emissions.[18]

Burning of fossil fuels not only contributes to increased concentrations of greenhouse gases which exacerbates climate change, it also contributes to air pollution and contaminants (see more in chapter 4) – an issue for both people and the environment. Globally, air pollution is the top environmental health threat and a major cause of premature deaths.[19] [20] According to the Swedish Meteorological and Hydrological Institute (SMHI), improved air quality and lower levels of aerosol particles have likely contributed to increased solar radiation, which has contributed to the strong warming observed in Europe in recent decades.[21]

Observed impacts from global climate change

Since 1970, global surface temperatures have risen faster than in any other 50-year period in at least the last 2000 years, and the last four decades have each been warmer than the decade before it. In the first two decades of the current century, global surface temperature (both global mean surface temperature and global surface air temperature) was 0.99°C higher than in 1850-1900, and 1.09°C higher in 2011-2020 compared to the 1850-1900 level. The greatest temperature increases are found over land, with an increase of 1.59°C compared to 0.88°C over the ocean. The estimated level of human-caused global surface temperature increase from 1850-1900 levels to today is 1.07°C.[22]

Human influence has likely increased the chance of compound extreme events[23] since the 1950s. This includes global increases in the frequency of concurrent heatwaves and droughts, fire weather in some regions of all inhabited continents, and compound flooding in some areas. Since the 1950s, the frequency and intensity of hot extremes (including heatwaves) has increased, while cold extremes have decreased. There is high scientific confidence that human-induced climate change is the main driver of these changes. According to the IPCC (2022), some recent hot extremes observed over the last decade would have been extremely unlikely to occur in the absence of human influence on the climate system.[24]

Globally averaged precipitation over land has likely increased since 1950, with a faster rate of increase since the 1980s. The frequency and intensity of heavy precipitation events have increased across most of the land area, and human-caused climate change is most likely the primary cause. Increased land *evapotranspiration* (the combined processes by which water is transferred to the atmosphere from open water and ice surfaces, bare soil, and vegetation) has also increased agricultural and ecological droughts in some regions.[25]

Climate change has increased the observed windspeed and extreme sea level events associated with some tropical cyclones, increasing the intensity of multiple extreme events and their associated cascading impacts. Human-driven climate change may have contributed to tropical cyclones occurring further north and south in the western North Pacific over the last few decades, and also to an increase in

16 Shukla et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" See section B: Recent Developments and Current Trends.

17 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.2.1.

18 Pörtner et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.

19 AMAP 2021, "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers."

20 AMAP 2020, "AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change."

21 Schimanke et al., "Observerad Klimatförändring i Sverige 1860–2021."

22 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.2.2., A.1.2 and A.1.3.

23 The combination of multiple drivers and/or hazards that contribute to societal or environmental risk is referred to as a *compound extreme event.* Concurrent heatwaves and droughts are given as examples, as are compound flooding (e.g., a storm surge combined with extreme rainfall and/or river flow), compound fire weather conditions (i.e., a combination of hot, dry, and windy conditions), and concurrent extremes at different locations. (IPCC 2022)

24 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.3.5, A.3.1.

25 Masson-Delmotte et al. A.1.4, A.3.2.

the most powerful tropical cyclones. There are also studies that indicate that human-induced climate change increases heavy precipitation associated with tropical cyclones. [26] [27]

Over the last century, oceans have warmed faster than since the end of the last ice age around 11,000 years ago. As a result, marine heatwaves, increased acidification (changes in PH levels), and decreased oxygen levels have occurred. The global upper ocean (0-700 m) has warmed since the 1970s, and it is highly likely that human influence is responsible for more than 50% of the change. Marine heatwaves have approximately doubled in frequency since the 1980s, and human influence has very likely contributed to most of them since at least 2006.[28] Marine heatwaves can cause mass mortality events among important foundational species. Coral reefs in warm waters are already experiencing severe heat stress which has increased bleaching events.[29] Ocean changes are affecting the distribution and abundance of marine life throughout the world. Range shifts of marine species living in the upper ocean have been observed in all ocean regions and are linked to ocean warming. Since the 1950s, average distribution shifts of up to 50 km per decade have occurred.[30]

Oceans absorb carbon dioxide from the atmosphere.[31] As levels of atmospheric carbon dioxide increase, so do the levels in the ocean. By absorbing more carbon dioxide, the ocean has undergone increasing surface acidification and emissions of carbon dioxide are believed to be the main driver of current global acidification of the surface open ocean. There is also high confidence that oxygen levels have dropped in many upper ocean regions since the mid-20th century. Low-oxygen zones are increasing in size and number around the world, with growing impacts on the diversity of fish species and ecosystem functioning.[32]

Global mean sea level is rising, with recent acceleration due to increased rates of ice loss from the Greenland and Antarctic ice sheets, as well as ongoing glacier mass loss and ocean water expanding as it warms.[33] Global mean sea level has risen faster since 1900 than it has in the previous 3000 years, increasing by approximately 0.20 metres between 1901 and 2018. Since at least 1971, human influence has most likely been the primary driver of these increases.[34] Extreme wave heights, which contribute to extreme sea level events, coastal erosion and flooding, have increased in the Southern and North Atlantic Oceans over the period 1985–2018. Sea ice loss in the Arctic has also increased wave heights over the period 1992–2014. Increases in tropical cyclone winds and rainfall, and increases in extreme waves, combined with relative sea level rise, exacerbate extreme sea level events and impacts on coastlines.[35]

Ocean acidification

Ocean acidification is a process where increased uptake of atmospheric carbon dioxide by the ocean makes it more acidic. Acidification reduces the concentration of carbonate ions required by calcifying organisms such as shell-building plankton, shellfish, and cold-water corals to produce calcium carbonate shells and skeletons. When the water becomes undersaturated it is making it difficult for animals to form proper shells and skeletons (AMAP 2021).

Over the last few decades, global warming has also led to widespread shrinking of the cryosphere, including shrink-

[26] Pörtner et al., “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” A.3.6.

[27] Masson-Delmotte et al., “IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change” A.3.4.

[28] Masson-Delmotte et al. A.2.4, A.1.6, A.3.1.

[29] Pörtner et al., “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” A.6.4.

[30] Bindoff et al., “IPCC, 2019: Changing Ocean, Marine Ecosystems, and Dependent Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” See 5.2.3 Impacts on Pelagic Ecosystems.

[31] Pörtner et al., “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” A.2.5.

[32] Masson-Delmotte et al., “IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change” A.1.6.

[33] Pörtner et al., “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” A.3.

[34] Pörtner et al. A.2.4, A.1.7.

[35] Pörtner et al. A.3, A.3.5.

age of ice sheets and glaciers, decreases in snow cover and Arctic sea ice extent and thickness, and increased permafrost temperature.[36] These changes have affected terrestrial and freshwater species and ecosystems and contributed to changing the seasonal activities, abundance and distribution of ecologically, culturally, and economically important plant and animal species, ecological disturbances, and ecosystem functioning.[37] The retreat of nearly all of the world's glaciers since the 1950s is unprecedented in at least the last 2000 years. Since the 1990s, it is very likely that human influence is the main driver of the global retreat of glaciers, as well as the decrease in Arctic sea ice. Human influence has also very likely contributed to the decrease in Northern Hemisphere spring snow cover since 1950 and the observed surface melting of the Greenland ice sheet over the past two decades.[38]

Changes in the land biosphere since 1970 have shifted climate zones poleward in both hemispheres, and the growing season in the Northern Hemisphere outside the tropics has increased by up to two days per decade since the 1950s, consistent with global warming.[39] Species have shifted their geographic ranges and the timing of seasonal events in all ecosystems. Thousands of species spread across terrestrial, freshwater, and marine systems have shifted their ranges to higher latitudes and altitudes,[40] with half to two-thirds shifting to higher latitudes. In response to warming, approximately two-thirds have shifted to earlier spring life events such as migrations or giving birth. In combination with climate change, changes in land use and water pollution are key drivers of loss and degradation of freshwater and terrestrial ecosystems.[41]

In 2005, the Millennium Ecosystem Assessment stated that observed changes in climate, particularly warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems, including causing changes in species distributions, population sizes, the timing of reproduction or migration events, and an increase in the frequency of pest and disease outbreaks.[42] Almost two decades later, global warming is increasing extinction risks for many species. IPCC (2022) highlights that this extinction risk increases disproportionately from global warming of 1.5°C to 3°C and is especially high for species that live in limited areas. Among the thousands of species at risk, many are species of ecological, cultural and economic importance.[43] IPCC (2022) report that the frequency of sudden food production losses has increased over the past 50 years, both on land and sea, with impacts on food security, nutrition and livelihoods. Agriculture and fisheries are experiencing an increase in climate-related food safety risks due to e.g., harmful algal blooms and the movement of toxins and contaminants.[44] Two global bodies, the IPCC and the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), have concluded that in order to succeed in mitigating climate change and biodiversity loss, these fundamental issues must be addressed quickly and collaboratively, as they pose significant threats to human livelihoods, food security, and public health.[45]

The future of global warming

It is estimated that global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades.[46]

To make projections on future global warming, IPCC (2021-2022) uses five ways of looking into the future, called *shared socio-economic pathways* (SSPs). The pathways describe dif-

[36] Pörtner et al. A.1.

[37] Pörtner et al. A.4.

[38] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.2.3, A.1.5.

[39] Masson-Delmotte et al. A.1.8.

[40] Mamantov et al., "Climate-Driven Range Shifts of Montane Species Vary with Elevation."

[41] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.1.1, TS.B.4.5.

[42] "Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Biodiversity Synthesis."

[43] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.C.1.5.

[44] Pörtner et al. TS.B.3.3, B.3.4.

[45] IPBES 2021, "Scientific Outcome of the IPBES-IPCC Co-Sponsored Workshop on Biodiversity and Climate Change. 2021."

[46] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.1.

ferent socio-economic trends. These trends lead to different amounts of greenhouse gases emitted to the atmosphere in the coming years and decades and different climate futures. Under the *very high* and *high* emissions scenarios (SSP5-8.5 and SSP3-7.0), carbon dioxide emissions roughly double from current levels by 2100 and 2050, respectively. Under SSP2-4.5, or the *intermediate* scenario, carbon dioxide emissions remain around current levels until the middle of the century. Scenarios with *very low* and *low* emissions (SSP1-1.9 and SSP1-2.6) mean that carbon dioxide emissions decline to 'net zero' around or after 2050, followed by varying levels of 'net negative' emissions. According to IPCC (2022), only two of the five scenarios for addressing the climate crisis would deliver the goals of the Paris Agreement–to limit global warming to 1.5°C and stay well below 2°C.[47] Both scenarios rely on transformational emissions reductions taking place urgently in all sectors, plus use of Carbon Dioxide Removal (CDR) measures.[48]

'Net zero' and 'net negative' carbon dioxide emissions
'Net zero' carbon dioxide emissions are achieved when human-caused carbon dioxide emissions are balanced globally by removals of human-caused carbon dioxide over a specified period. 'Net negative', simply put, is achieved when more greenhouse gases are removed from the atmosphere than are emitted into it.[49]

Land and oceans act as carbon sinks, absorbing a nearly constant proportion of carbon dioxide emissions (globally, about 56% per year) from carbon dioxide, methane, and nitrous oxide from human activities over the last six decades, with regional variations. Under rising carbon dioxide emissions scenarios, ocean and land carbon sinks are expected to be less effective at slowing carbon dioxide accumulation in the atmosphere, resulting in a higher proportion of emitted carbon dioxide remaining in the atmosphere.[50] Land areas warm faster than oceans, and the Arctic and Antarctica warm faster than the tropics.[51] Land surface areas will continue to warm faster than the ocean surface, probably 1.4 to 1.7 times faster. With further global warming, every region is expected to experience more changes in things that further drive climate change. These changes would be more widespread at 2°C of global warming compared to 1.5°C of global warming, and even more widespread and/or pronounced at higher warming levels. Every additional 0.5°C causes increases in the frequency and intensity of hot extremes, marine heatwaves, and heavy precipitation, agricultural and ecological droughts in some regions, and proportion of intense tropical cyclones. In the Arctic, additional warming causes reductions of sea ice, land ice, snow cover and permafrost.[52]

Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events.[53] Over the 21st century, extreme El Niño and La Niña events are projected to become more frequent and The Atlantic Meridional Overturning Circulation (AMOC) is projected to weaken. The rates and magnitudes of these changes will be smaller under scenarios with low greenhouse gas emissions. El Niño and La Niña are Pacific Ocean climate pattern phenomena that occur during the exchange of the atmosphere and the sea and have a variety of effects on the Earth's weather conditions. El Niño is characterized by a warming of the surface water in the eastern tropical Pacific, whereas La Niña is characterized by a cooling of the area. The Atlantic Meridional Overturning Circulation (AMOC) is the main current system in the South and North Atlantic Oceans and therefore an important component of global ocean circulation. A slowdown of the AMOC is projected to cause a decrease in marine productivity in the North Atlantic and could also have major consequences on for example precipitation patterns around the world, resulting in weaker summer monsoons in Asia or more frequent winter storms in Europe.[54]

47 Masson-Delmotte et al. B.1.3.

48 Shukla et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change."

49 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Box SPM.1. Scenarios, Climate Models and Projections.

50 Masson-Delmotte et al. A.1.1, A.3.2, B.4.

51 Masson-Delmotte et al. See figure SPM.5.

52 Masson-Delmotte et al. B.2.1, C.2, B.2, B.2.2.

53 Masson-Delmotte et al. B.3.

54 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" B.2, B.2.7.

Mountain and polar glaciers are committed to melting for decades or centuries, and carbon loss from permafrost thaw is irreversible for centuries. The ocean is expected to undergo unprecedented changes during this century. It is estimated that rising temperatures, more frequent marine heatwaves, increased upper ocean stratification, further acidification, and oxygen decline will occur, leading to less productive oceans.[55] [56] Global mean sea level will continue to rise over the 21st century. Under the intermediate greenhouse gas emissions scenario, the likely global mean sea level rise by 2100 is 0.44-0.76 metres relative to 1995-2014, assuming emissions remain at current levels until the middle of the century.[57] In the longer term, sea levels are expected to rise for hundreds to thousands of years as a result of ongoing deep ocean warming and ice sheet melt, and will remain elevated for thousands of years. If global warming is limited to 1.5°C, global mean sea level will rise by two to three metres over the next 2000 years and could rise up 19 to 22 metres under 5°C warming.[58] Warming ocean temperatures, acidification, and sea level rise will increase the risks of regional and global extinction of species, and IPCC warns of irreversible changes in marine ecosystems if 1.5°C of global warming is exceeded. Overall, climate feedbacks, changes that cannot be avoided over decades to millennia, abrupt change thresholds, and irreversibility are among the projected responses of the ocean and cryosphere to global warming.[59]

There are multiple serious consequences that humans and ecosystems are facing due to climate change and all of them cannot be addressed here. Two of the many future concerns highlighted are food security and food safety. Climate change will increasingly add pressure on food production systems, undermining food security. With each degree of warming, exposure to climate hazards increases significantly, and negative effects on all food sectors become more common, further stressing food security. The regional disparity in food security risks will grow as temperatures rise. It is likely that opportunities for adaptation for agriculture and food systems will either be constrained or have reduced effectiveness above 1.5°C, at the same time as many locations on Earth already are significantly limited. Increasing competition for critical resources, such as land, energy, and water, can exacerbate the impacts of climate change on food security.[60]

[55] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.5.2, B.5.

[56] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" B.2.

[57] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.5.3, box SPM 1.1.

[58] Masson-Delmotte et al. B.5.4.

[59] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" See Introduction.

[60] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.C.3, TS.D.5, D.5.2, TS.B.3.5.

References chapter 2

AMAP 2020. “AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change.” Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2020.
AMAP 2021. “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts.” Tromsø, Norway: Arctic Monitoring and Assessment Programme., 2021.
AMAP 2021. “POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers.” Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.
Bindoff, Nathaniel, William Cheung, J.G. Kairo, Javier Aristegui, Valeria Guinder, Robert Hallberg, Nathalie Hilmi, et al. “IPCC, 2019: Changing Ocean, Marine Ecosystems, and Dependent Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate,” 2019.
IPBES 2021. “Scientific Outcome of the IPBES-IPCC Co-Sponsored Workshop on Biodiversity and Climate Change. 2021.” IPBES secretariat, Bonn, Germany: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, n.d. DOI:10.5281/zenodo.4659158.
Mamantov, Margaret A., Daniel K. Gibson-Reinemer, Ethan B. Linck, and Kimberly S. Sheldon. “Climate-Driven Range Shifts of Montane Species Vary with Elevation.” *Global Ecology and Biogeography* 30, no. 4 (April 1, 2021): 784–94. https://doi.org/10.1111/geb.13246.
Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, Y. Caud, et al. “IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2021.
Meredith, M., M. Sommerkorn, S Cassotta, C Derksen, A Ekaykin, A Hollowed, G Kofinas, et al. “IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.” Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2019.
Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Biodiversity Synthesis. Millennium Ecosystem Assessment. Washington, DC: World Resources Institute, 2005.
Pörtner, H.O, D.C Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, et al. “IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.
Pörtner, H.O, D.C Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E.S Poloczanska, K. Mintenbeck, et al. “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.” Intergovernmental Panel on Climate Change, 2019.
Pörtner, H.O, D.C Roberts, E.S Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, et al. “IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.
Schimanke, Semjon, Magnus Joelsson, Sandra Andersson, Thomas Carlund, Lennart Wern, Sverker Hellström, and Erik Kjellström. “Observerad Klimatförändring i Sverige 1860–2021.” Klimatologi. Sveriges meteorologiska och hydrologiska institut (SMHI), 2022. [Online] Available at:
https://www.smhi.se/polopoly_fs/1.189743!/Klimatologi_69%20Observerad%20klimatf%C3%B6r%C3%A4ndring%20i%20Sverige%2018602021.pdf. [Accessed 10 February 2023]
Shukla, P.R., J. Skea, R. Slade, A. Al Khourdaije, R. van Diemen, D. McCollum, M. Pathak, et al. “IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.

3. Indigenous Peoples and effective climate action

This chapter highlights the global recognition of Indigenous Peoples knowledge and stewardship of nature, along with some of the barriers and challenges Indigenous Peoples face in climate governance.

> *"The correlation between secure Indigenous land tenure and effective environmental protection is well-documented. Indigenous Peoples have centuries-long traditions of safeguarding the environment and biodiversity for future generations and our knowledge is vital for the sustainable management of natural resources. In other words, as Indigenous Peoples we are uniquely positioned to provide key advice on climate change action and conservation and the advancement of the relevant Sustainable Development Goals." (...)*
>
> *"At the global level, there is increasing recognition of the importance of Indigenous knowledge and that Indigenous Peoples are key partners in finding solutions through climate action and adaption measures. This is underlined in the report by the Intergovernmental Panel on Climate Change (IPCC) in its most recent report released earlier this year."*
>
> **– Francisco Cali Tzay, Special Rapporteur on the rights of Indigenous Peoples, at the Saami Conference in Váhtjer 2022**

Global recognition of Indigenous Peoples' stewardship

Indigenous Peoples are increasingly recognized within several fora on the international scene as invaluable actors in the context of stewardship[61] of nature and effective climate action. This is highlighted in various scientific reports (see for example the reports of IPCC, IPBES, AMAP and more) and in decisions from the highest political level. The most eminent platform of scientific assessments related to climate change, the IPCC, has quite consistently emphasized the importance of including Indigenous Peoples in decision-making, as it will enhance effectiveness of decision-making and governance in the "[...] selection, evaluation, implementation and monitoring of policy instruments for land-based climate change adaptation and mitigation."[62] One example of effective Indigenous community-led adaptation action in IPCC's most recent assessment highlights the Skolt Sámi restoration of habitats in the Vannikej river in Finland.[63]

Indigenous Peoples safeguard most of the world's remaining biodiversity. The lands, territories, and resources that Indigenous Peoples own, manage, use or occupy, represent at least a quarter of the global land area and also significant marine areas. While biodiversity is declining globally, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has reported that biodiversity is declining less rapidly in lands and areas managed by Indigenous Peoples. Recognizing and using the knowledge and values of Indigenous Peoples enhances conservation, restoration and sustainable management of nature and can contribute to addressing the combined challenges of climate change, food security, biodiver-

[61] UNFCCC, "Decision 16/CP.26. Local Communities and Indigenous Peoples Platform."

[62] Shukla et al., "IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems" C.4.

[63] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.3.2.1.

sity conservation, and combating desertification and land degradation, which is relevant for broader society.[64] [65] On a political level, references to Indigenous Peoples and the knowledge of Indigenous Peoples can be found in over 60 decisions adopted by the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), or in reports adopted by its subsidiary bodies.[66] The United Nations Convention on Biological Diversity (CBD), adopted in 1992, and its article 8 (j), also has specific references to Indigenous Peoples as it calls for the application of the knowledge of Indigenous Peoples to achieve sustainable use and conservation of biodiversity. The UNFCCC COP26 cover decision (2021) emphasized the important role of Indigenous Peoples' culture and knowledge in effective action on climate change and urged active involvement of Indigenous Peoples in designing and implementing climate action. Within the same decision, the role of Indigenous Peoples in averting, minimizing and addressing adverse impacts of climate change was also acknowledged.[67] The CBD COP15 that concluded in December 2022 decided on the Kunming-Montreal Global Biodiversity Framework which can be described as a historic document as it represents a major shift in conservation, towards a way that is more inclusive and respectful of the rights of Indigenous Peoples. The Framework recognizes the important roles and contributions to conservation of Indigenous Peoples, Indigenous Peoples' territories and knowledge. The Framework also recognizes that Indigenous Peoples' customary practices and territorial rights must be safeguarded in conservation, and that Indigenous Peoples must be part of decision-making in a full and equitable manner.[68]

The scientific community has also emphasized the importance and potential of Indigenous Peoples' in developing and implementing countries' national climate action plans, also known as National Determined Contributions (NDCs)[69] and National Adaptation Plans (NAPs) under the Paris Agreement. A recent study by the International Working Group on Indigenous Affairs (IWGIA) however concludes that while Indigenous Peoples are increasingly recognized in NDCs, sufficient and appropriate mechanisms to operationalize this recognition are not yet in place.[70]

Climate change impacts on Indigenous Peoples

Climate change and its resulting impacts, such as the loss of ecosystems and their services, have far-reaching and long-term consequences for people worldwide. For Indigenous Peoples, climate change impacts are multiple, e.g. malnutrition, water scarcity, food insecurity, rising death and illness from climate-sensitive diseases, increased respiratory problems, and mental health effects. Exposure to hazards such as floods, droughts, wildfires and and other extreme weather events leads to rising costs, losses of livelihoods and relocations.[71] The loss of biodiversity and ecosystems is causing irreversible damage to Indigenous Peoples' languages, knowledge systems, and livelihoods, threatening adaptive capacity and risking irrevocable losses of sense of belonging, valued cultural practices, identity and home which can damage many generations.[72] Assessments of non-economic losses and damages–including loss of societal beliefs and values, cultural heritage and identity–are lacking, and aggregate losses and damages would be higher if such values were considered.[73] It is also shown that policymaking approaches lack values that encompass nature, society, and future

[64] Diaz et al., "IPBES 2019: Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services" See B6 and D5.

[65] Shukla et al., "IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems" C.4.3.

[66] International Indigenous Peoples Forum on Climate Change and Center for International Environmental Law, "Indigenous Peoples and Traditional Knowledge in the Context of the UN Framework Convention on Climate Change. Compilation of Decisions and Conclusions Adopted by the Parties to the Convention."

[67] UNFCCC, "Decision 1/CMA.3. Glasgow Climate Pact."

[68] UNCBD, "Decision CBD/COP/15/L.25. Kunming-Montreal Global Biodiversity Framework."

[69] A country's *National Determined Contribution* is a climate action plan set to present voluntary emissions reductions and communicate adaptation measures. The NDC thus represents a global mechanism for identifying a country's priorities.

[70] International Work Group of Indigenous Affairs, "Recognition of Indigenous Peoples in Nationally Determined Contributions. IWGIA Policy Paper 2022."

[71] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.3.4, B.3.5, B.4.1, B.4.3, B.4.4, B.5, B.5.4, B.6.4.

[72] Pörtner et al. B.1.6.

[73] International Work Group of Indigenous Affairs, "Recognising the Contributions of Indigenous Peoples in Global Climate Action? An Analysis of the IPCC Report on Impacts, Adaptation and Vulnerability. IWGIA Briefing Paper, March 2022."

generations. IPBES (2022) emphasizes that most policymaking approaches have prioritized a narrow set of values and also frequently ignored values associated with Indigenous Peoples' worldviews in relation to the environment.[74]

Apart from the impacts from climate change, non-climate factors contributing to environmental destruction also directly affect Indigenous Peoples. Deforestation, excessive exploitation of mineral resources and land-grabbing are having a negative impact on local economies, subsistence lifestyles, food security, access to water and cultural practices.[75] IPCC (2022) has for the first time addressed patterns of historical and ongoing colonialism in relation to climate change–factors that exacerbate Indigenous Peoples' vulnerability to climate change. Climate vulnerability is higher in locations where climate-sensitive livelihoods such as pastoralism, smallholder farming and fishing communities can be found, but is also connected to other factors such as economic, institutional, and political capacities.[76] Vulnerability is created and made worse by several factors operating to produce inequity–like ethnicity, gender, income and class. The Arctic is amongst the regions characterized by high human vulnerability and therefore considerably sensitive to climate change and related hazards, says the IPCC.[77]

State responses to climatic and environmental change in terms of mitigation and/or adaptation have forced Indigenous Peoples away from traditional territories, and Indigenous Peoples continue to be criminalized due to state regulations and management policies and government conservation approaches. IPCC (2022) highlights that measures for adaptation that fail to consider adverse outcomes can have opposite effects and instead become *maladaptive*, which risks diminishing adaptive capacity, reinforcing inequality and exposure to risks, and thus enhancing vulnerability. Particular emphasis of maladaptive practices related to Indigenous Peoples is given to cultural and financial consequences of relocation that distress cultural and spiritual bonds to territories, disrupt livelihoods and sense of place but also the planting of unsustainable tree species within the territories of Indigenous Peoples that affect customary rights. Other examples include 'maladaptive mitigation' and how measures to tackle climate change may pose a risk to people or biodiversity through for example the expansion of renewable energies such as solar and wind. The risk of maladaptation is most significant when approaches fail to be interdisciplinary and do not include the knowledge of Indigenous Peoples. The IPCC says rights-based approaches to adaptation and equitable partnership with Indigenous Peoples are fundamental to advancing climate resilience, risk reduction and successful adaptation, preventing maladaptive outcomes.[78] [79]

Human rights violations in Sápmi–an example from Fovsen Njaarke

In 2021, a landmark decision on cultural rights of Sámi reindeer herders was taken by the Supreme Court of Norway. Referring to Article 27 of the International Covenant on Civil and Political Rights (ICCPR), the Supreme Court determined that the construction of the wind industry park in Fovsen Njaarke was illegal as it violates the reindeer herding Sámi in the area to exercise their culture. The Supreme Court determined, citing statements by the UN Human Rights Committee, that although the interference by itself may have such serious consequences as to constitute a violation of Article 27 of the ICCPR, it must also be considered in the context of other projects, both past and future. According to the ruling, whether a violation occurred is determined by the overall impact of the development. As a result, the Supreme Court determined that wind power development would violate herders' rights if adequate remedy measures were not implemented (Supreme Court of Norway, 2020).

As of today, the wind industry park is still up and running, without consequences for the company that owns it, and without action from the Norwegian government to act on its human rights obligations.

74 Pascual et al., *IPBES 2022: Summary for Policymakers of the Methodological Assessment of the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*.

75 Human Rights Council, "A/HRC/36/46. Report of the Special Rapporteur on the Rights of Indigenous Peoples."

Thomas et al (2019). Explaining differential vulnerability to climate change: A social science review. *Wiley interdisciplinary reviews. Climate change*, *10*(2), e565.

77 Pörtner et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.4.

78 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.D.3, TS.D.3.1, TS.D.3.2, TS.D.3.4 and TS.B.6.4.

79 Pörtner et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" C.4.3.

Resilience:
"The capacity to cope with stress and shocks by responding or reorganizing in ways that maintain essential identity, function and structures, as well as the capacity to navigate and shape change, including transformational change" (Arctic Resilience Report 2016).

Supporting Indigenous self-determination, recognizing the rights of Indigenous Peoples and utilizing the knowledge of Indigenous Peoples is crucial as it will not only accelerate effective robust climate resilient development pathways but also address historical inequity and unjust processes which in turn can increase resilience and contribute to multiple benefits for health, well-being and ecosystems.[80] [81] [82] This is important since climate change and related impacts–in combination with legal and institutional barriers that affect coping mechanisms and adaptive capacity of Indigenous Peoples–makes climate change an issue of human rights and inequality. Including Indigenous Peoples and the knowledge of Indigenous Peoples is therefore a fundamental part of climate justice.[83]

"Recognising Indigenous rights and local knowledge in design and implementation of climate change responses contributes to equitable adaptation outcomes. Indigenous knowledge and local knowledge play an important role in finding solutions and often creates critical linkages between cultures, policy frameworks, economic systems, and natural resource management. Intergenerational approaches to future climate planning and policy will become increasingly important, in relation to the management, use and valuation of social-ecological systems."

– Intergovernmental Panel on Climate Change, IPCC (2022)[84]

"For Indigenous Peoples there is no difference where we are located–whether developed or developing countries–our ways of life are threatened because our rights to our territories and resources are not secured or respected."

– International Indigenous Peoples Forum on Climate Change (2022)

[80] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.E.3.4.

[81] Pörtner et al. TS.D.3.2.

[82] Pörtner et al., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" D.3.

[83] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.E.3.4.

[84] Pörtner et al. TS.D.9.4.

References chapter 3

Constable, A.J., S. Harper, J. Dawson, K. Holsman, T. Mustonen, D. Piepenburg, and B. Rost. "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.

Diaz, S, J. Settele, E.S. Brondízio, H.T. Ngo, M. Guèze, J. Agard, A. Arneth, et al. "IPBES 2019: Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services." IPBES secretariat, Bonn, Germany.: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019.

Human Rights Council. "A/HRC/36/46. Report of the Special Rapporteur on the Rights of Indigenous Peoples." United Nations Human Rights Council, 2017.

International Indigenous Peoples Forum on Climate Change & Center for International Environmental Law. "Indigenous Peoples and Traditional Knowledge in the Context of the UN Framework Convention on Climate Change. Compilation of Decisions and Conclusions Adopted by the Parties to the Convention." International Indigenous Peoples Forum on Climate Change & Center for International Environmental Law. [Online] Available at: https://www.ciel.org/wp-content/uploads/2019/08/Indigenous-Peoples-and-Traditional-Knowledge-in-the-Context-of-the-UNFCCC-2019-Update.pdf. [Accessed 10 February 2023]

International Indigenous Peoples Forum on Climate Change. "Principles and Guidelines for Direct Access Funding for Indigenous Peoples' Climate Action, Biodiversity Conservation and Fighting Desertification for a Sustainable Planet." International Indigenous Peoples Forum on Climate Change (IIPFCC), 2022.

International Work Group of Indigenous Affairs. "Recognising the Contributions of Indigenous Peoples in Global Climate Action? An Analysis of the IPCC Report on Impacts, Adaptation and Vulnerability. IWGIA Briefing Paper, March 2022." International Work Group of Indigenous Affairs (IWGIA), 2022.

International Work Group of Indigenous Affairs. "Recognition of Indigenous Peoples in Nationally Determined Contributions. IWGIA Policy Paper 2022." International Work Group of Indigenous Affairs (IWGIA), 2022.

Pascual, Unai, Patricia Balvanera, Michael Christie, Brigitte Baptiste, David Gonzalez-Jimenez, Christopher Anderson, Simone Athayde, et al. *IPBES 2022: Summary for Policymakers of the Methodological Assessment of the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, 2022. https://doi.org/10.5281/zenodo.6522392.

Pörtner, H.O, D.C Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, et al. "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.

Shukla, P.R., J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.O Pörtner, D.C Roberts, P. Zhai, et al. "IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems." Intergovernmental Panel on Climate Change, 2019.

Supreme Court of Norway. Judgement: Appeal against Frostating Court of Appeal's reappraisal 8 June 2020, No. HR-2021-1975-S (Supreme Court of Norway October 11, 2021).

UNCBD. "Decision CBD/COP/15/L.25. Kunming-Montreal Global Biodiversity Framework." Conference of the Parties to the Convention of Biological Diversity (CBD), December 18, 2022.

UNFCCC. "Decision 1/CMA.3. Glasgow Climate Pact." The Conference of the Parties serving as the meeting of the Parties to the Paris Agreement, 2021.

UNFCCC. "Decision 16/CP.26. Local Communities and Indigenous Peoples Platform." Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), 2021.

4. Climate change in the Arctic

This chapter aims to briefly showcase some of the observed impacts of climate change in the Arctic and in Sápmi – how it affects ecosystems and people – and also presents some of the future projections for non-climatic Arctic change that have been highlighted in research.

Cascading environmental and societal impacts and new opportunities

Climate change in the Arctic is already occurring at a magnitude and pace unprecedented in recent history, three times faster than projected for other world regions. The Arctic is projected to become profoundly different in the near future under all warming scenarios.[85] Accelerated melting of sea-ice, glaciers and ice sheets in polar regions affects ocean salinity, sea levels, and circulation throughout the global ocean. Changes in polar ecosystems can induce climate feedbacks to the global climate system which in turn can amplify global warming. While the future direction and magnitude of feedbacks remain unclear, there is high confidence that feedbacks from the loss of summer sea ice and terrestrial spring snow cover have contributed to amplified warming in the Arctic.[86] [87]

The widespread shrinking of ice is changing the Arctic, with impacts on terrestrial, marine and freshwater ecosystems, people and livelihoods. Arctic ecosystems are experiencing rapid transformational changes with impacts on productivity, seasonality, distribution and interactions of species and thus resulting in major impacts on socio-ecological systems. Terrestrial ecosystems are feeling the effects of changes in precipitation, increased permafrost thaw, changes to the movement of water, changes in vegetation, coastal and riverbank erosion, reduction in snow cover and ice cover extent, winter thaw/refreezing events and increased frequency and severity of wildfires.[88] Arctic species have shifted their geographic ranges towards higher altitudes and altered the timing of seasonal events in response to warming. New species coming into the high Arctic pose new realities for Arctic species with risks from pathogens, diseases, predation and competition, even risks of extinction. In the ocean, sea ice thickness and extent are declining and there are changes in the timing of ice melt, changing the ranges and populations of Arctic species. Warming waters provide more suitable conditions for the development of toxic algal blooms, have pushed cold-adapted species poleward, eroded the barrier between boreal and native Arctic species, and rapidly reorganized polar ecosystems.[89] [90]

A warmer Arctic has also brought new attention and economic opportunities to the region. Oil and gas activities, mining, tourism, shipping and fisheries see possibilities for development, but also bring risks of negatively affecting people and the environment. Arctic change also brings new opportunities to Arctic residents, such as hunting and fishing resources, or employment in the new industries that are establishing. However, climate change increasingly threatens many facets of Arctic livelihoods, culture, identity, health and security, particularly for Indigenous Peoples– some of which are mediated or amplified by these novel conditions and opportunities.

85 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" See executive summary.

86 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts."

87 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.1.4.

88 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" See executive summary and CCP6.2.2.

89 Constable et al. See CCP6.2.1.1.

90 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.8, A.8.1.

With additional global warming, marine heatwaves are projected to continue to increase in the Arctic along with further thawing of permafrost, loss of seasonal snow cover, land ice and Arctic sea ice[91], and increased risk of wildfires. The transition towards more extreme precipitation events and weather patterns is prompting further ecosystem changes in both marine and terrestrial environments with impacts that are expected to, or may already, exceed ecological thresholds.[92]

Observed impacts and future projections of climate change in the Arctic and Sápmi

Temperature

With a warmer climate in the Arctic, extreme climate and weather events are increasing in frequency and/or intensity, and the most notable trend is the extreme warm winter temperatures. IPCC (2019) reports that for each of the five years since the 5th Assessment Report cycle AR5 (2014–2018), Arctic annual surface air temperature exceeded that of any year since 1900. During January-March of 2016 and 2018, surface temperatures in the central Arctic were 6ºC above the 1981–2010 average.[93]

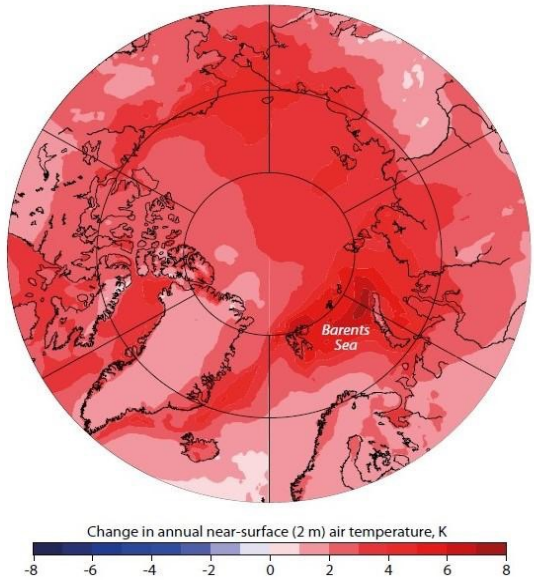

Figure 2.2 Arctic near-surface air temperature trends for the 49-year period 1971–2019. The trend metric is the linear regression temporal slope multiplied by the timespan in years. Data source: ERA5.

AMAP (2021) suggests that Arctic near-surface air temperature (north of 65°N) increased by *three times* the global average over the past 50 years – with annual averages increased by 3.1ºC. The temperature increase is most pronounced in cold seasons, with feedback from loss of sea ice and snow cover contributing to the amplified warming.[94] Warm extremes have increased in the Arctic while cold extremes are decreasing. Cold spells lasting for more than 15 days have almost completely disappeared since 2000.[95] As Arctic warming has accelerated, the largest change in the measurement period (1971-2019) has occurred over the Arctic Ocean during October through May, with warming averaging 4.6°C and peaking at 10.6°C over the northeastern Barents Sea.[96] AMAP also reports that the seven warmest years since 1900 have been the most recent seven years–during the period 2014-2020. The three warmest years were 2016, 2019, and 2020.[97]

Warming has been rapid during all seasons in northern Fennoscandia over the past three decades. Exceptionally warm winter periods have been frequent during the 2000s and increased in frequency.[98] Increases in extremely warm events in spring and autumn have also been reported. The Norwegian Meteorological Institute highlights that the warming trend for northern Norway was quite stable from 1900 until around 1985, with a short warmer period in the 1930, but then has warmed.[99] An example from Guovdageaidnu, Finnmark Norway, showcases that mean spring temperature during March–May during the period 1961–1990 was –4.0°C, whereas the average for the past 30 years was –2.7 °C. Spring temperature has increased by about 3°C between 1922-2018.[100] This affects the timing of snowmelt and duration of the snow season.

[91] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.3, B.2.5.

[92] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 6.

[93] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Executive summary.

[94] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[95] AMAP 2021 Chapter 4.

[96] AMAP 2021 Chapter 2.

[97] AMAP 2021 Chapter 4.

[98] Vikhamar-Schuler et al., "Changes in Winter Warming Events in the Nordic Arctic Region."

[99] Meterologisk Institutt, "Nord-Norge siden 1900."

[100] Eira et al., "Snow Cover and the Loss of Traditional Indigenous Knowledge."

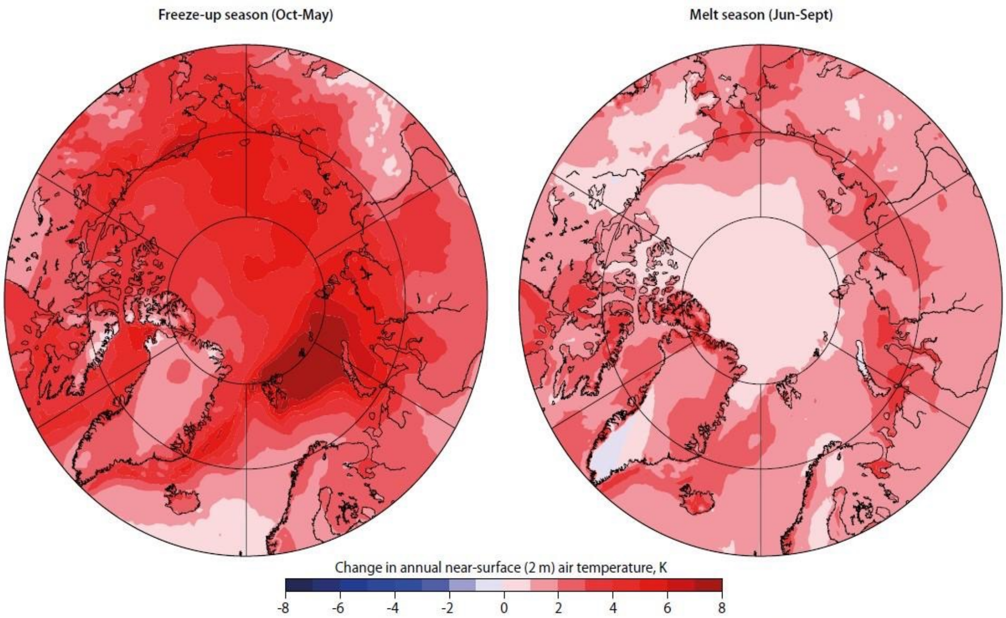

Figure 2.3 Arctic near-surface air temperature trends for the 49-year period 1971–2019 for the freeze-up season (October through May) and 'melt season' (June through September). The trend metric is the linear regression temporal slope multiplied by the timespan in years. Data source: ERA5.

Source: AMAP Arctic Climate Change update 2021

ANNUAL TEMPERATURE INCREASES IN SÁPMI

Norway has experienced a 1°C increase in annual temperature between 1900-2014, with the largest temperature increase found in Trøndelag and Nordland/Troms (Hanssen-Bauer et al. 2017). The 1991–2020 climatology for Finnmark shows that annual temperature was about 0.8 °C higher than 1961–1990 values along the coasts, and up to 1.2 °C higher inland (Hanssen-Bauer et al. 2023). **Sweden** has experienced a 1,9°C increase in annual mean temperature compared to the period of measurements in the late 1800s. The increase is largest during spring. The inner parts of northern Norrland and southern Norrland's mountain areas have seen a slightly smaller change in annual average temperature compared to the rest of the country whereas the biggest change is seen in northern Norrland's mountain areas (Schimanke et al. 2022).**Finland** shows an increase of annual temperature over 2 °C in the years 1847–2013 which equals to 0.14 °C per decade. The increase in temperature has been highest during winter but spring months have also warmed more than the annual average - April in particular (Mikkonen et al. 2014). Annual surface air temperature in the **Russian Kola Peninsula** has increased by approximately 2.3 °C over the past 50 years. Warming has mainly taken place in spring and autumn, although the largest trend has occurred in winter - a seasonal distribution similar to that observed in Finland (Marshall et al. 2016). Even though measurements differ in time periods and scale, these examples show an overall warming trend in Fennoscandia. In a global context, these warming trends are striking.

New records in monthly and seasonal temperatures have been set in the past several years in Sápmi. Finland and Norway recorded their warmest spring months on record in May 2018 – a record heat that continued into the summer of 2018, with many other parts of Fennoscandia setting records for summer heat.

Finland broke its record for the hottest calendar month ever in July 2018.[101] IPCC (2022) states that heat waves have already affected human health in Europe using the 2018 heatwave in northern Europe as an example.[102] The Swedish Public Health Authority found an increase in excess mortality of approximately 700 cases after the summer of 2018. Exten-

[101] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 4.

[102] Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.7 Health, Well-Being and the Changing Structure of Communities.

sive wildfires also occurred in Sweden during 2018 due to the hot weather in combination with unusually dry weather.[103]

Future projections

Warming is expected to continue in the Arctic, and at a faster rate relative to global levels.[104] The highest increase in temperature is estimated for the coldest days, resulting in cold extremes becoming even fewer. Climate model projections estimate that annual mean surface temperature in the Arctic can rise 3.3°C-10°C above the 1985-2014 average by 2100. The amount of change depends strongly on current and future climate policies – i.e., the amount of emissions to the atmosphere.[105]

Future climate conditions within Sápmi show a similar development to the general projections for the Arctic. Mean winter temperatures in Sápmi may increase by as much as 7°C-8°C over the next 100 years, with the most pronounced warming expected in the northeast, north, and over Finnmark in Norway. Finnmark alone is expected to experience an increase of winter temperatures of 6°C and summer temperatures may increase about 3°C.[106] [107] Summers and autumns will be longer and winters shorter. The number of days when the temperature crosses 0 °C, and general temperature fluctuation in Finnmark during the past decades has increased significantly in spring and is expected to continue to increase in frequency throughout this century, both in winter and spring. This increases chances for rain-on-snow events during winter.[108] Annual average temperature in Swedish Sápmi can increase by 3°C to 6°C depending on climate scenarios, also with the most pronounced warming expected during winter. During summer, heatwaves are expected to increase in frequency and towards the end of the century models predict 8-10 days long periods of average temperatures above 20°C.[109] [110] On a European level, increasing temperatures and heat extremes are projected to increase stress and mortality.[111]

Oceans and sea ice

In the period 2011–2020, the annual average Arctic sea ice area reached its lowest level since at least 1850 and late summer Arctic sea ice area was smaller than at any time in at least the past 1000 years.[112] Arctic sea ice extent continues to decline in all months of the year with the strongest reductions in September. Arctic sea ice has also become thinner with a shift to younger ice. Since 1979, the proportion of thick ice of at least five years old has declined by approximately 90%.[113] The Arctic Report Card released in December 2022 highlights that "Arctic sea ice extent was similar to 2021 values, higher than many recent years, but much lower than the long-term average", and that "open water areas developed near the North Pole through much of the summer, making the area easier to access for polar class tourist and research vessels; both the Northern Sea Route and Northwest Passage largely opened." Thirdly, that "multiyear ice extent and sea ice thickness and volume rebounded after near-record low levels in 2021 but were still well-below conditions in the 1980s and 1990s, and the oldest ice continued to be extremely scarce."[114]

Sea ice is critical to how much heat is absorbed by the earth. Snow-covered sea ice can reflect up to 80% of incoming solar energy, whereas the open ocean absorbs 90%. A warming of the Arctic, which leads to melting of the sea ice, absorbs

103 Schimanke et al., "Observerad Klimatförändring i Sverige 1860–2021."

104 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.1.

105 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 3.

106 Benestad, "A New Global Set of Downscaled Temperature Scenarios."

107 Hanssen-Bauer et al., "Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia."

108 Hanssen-Bauer et al.

109 SMHI, "Framtidsklimat i Sveriges Län – Enligt RCP-Scenarier."

110 Sámi Parliament in Sweden, "Klimatanpassning. Handlingsplan För Samiska Näringar Och Samisk Kultur."

111 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Global and regional risks for increasing levels of global warming, (f) Examples of regional key risks. (page 59).

112 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.2.3, A.1.5.

113 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Executive summary.

114 "Arctic Report Card: Sea Ice."

more energy, causing the Arctic to warm even more. Furthermore, sea ice is an important habitat for ecosystems and species that rely entirely on it. Some organisms can only survive in ice-covered waters, and whales, seals, and polar bears all rely on ice for their life cycles.[115]

Sea ice loss is believed to have increased wave heights in the Arctic over the period 1992–2014[116] and sea ice loss in combination with storm surges and melting permafrost has resulted in increased vulnerability to coastal flooding and erosion in many Arctic coastal regions.[117] [118] While land-ice loss is the major regional contributor to global sea-level rise, there are no consistent trends for Arctic sea level rise on a regional level.[119] [120] Rose et al (2019) have estimated Arctic sea level rise at 2.2 mm/yr. from 1996-2018.[121] The question of sea level rise in the Arctic is however not simple. One factor that makes sea levels rise is thermal expansion. Warmer water occupies more volume than cold water, unless it is frozen. All Arctic waters are expected to warm, but some will warm more than others, so those waters will expand more. Prevailing winds, currents and gravitational effects can also raise sea levels higher in some places than in others.[122]

AMAP reported in 2017 that freshwater storage in the Arctic Ocean has increased. Compared with the 1980–2000 average, the volume of freshwater in the upper layer of the Arctic Ocean has increased by 8,000 cubic kilometres, or more than 11%. Arctic rivers are central to the Arctic freshwater circulation and they act as main contributors of freshwater input to the Arctic Ocean. Arctic river discharge to the Arctic Ocean has increased by 8% between 1971-2019. An increase in freshwater flow to the ocean from rivers and melting glaciers can have implications for ocean circulation in the Nordic Seas and the North Atlantic, with implications for ocean circulation and climate that extend far beyond the Arctic. Seas and adjacent land can become warmer or colder if ocean currents change.[123] [124] Freshening water and warming of the Arctic Ocean directly and indirectly affects marine species, leading to changes in seasonality, range shifts of species, and broad changes in ocean ecosystems.

Arctic oceans are acidifying at a rapid pace due to their uptake of carbon dioxide which dissolves more easily in colder water. Ocean acidification in the Arctic is strengthened by low temperatures, increased freshwater supply (from river runoff and ice melt) and low pH Pacific water inflow.[125] Ocean acidification has the potential to drive changes to marine organisms and ecosystems, but strong ecosystem effects have not yet been observed in the Arctic. Studies show that effects vary between species, life stages, locations, and seasons, making it difficult to predict the outcome of ocean acidification for ecosystems and people.[126] The same goes with the consequences of ocean warming; there are still many gaps in knowledge of higher temperatures' impacts on ecosystems in the Arctic ocean. New evidence has found that dominant Arctic phytoplankton species may be able to adapt to higher temperatures.[127] Nevertheless, despite difficulties in isolating its effects, ocean acidification is likely to affect the abundance and distribution of fish stocks and marine animals of commercial and cultural importance to communities in the Arctic and beyond, alongside other ecosystem stressors.[128]

115 Miljøstatus, "Havisutbredelse i Barentshavet."

116 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.3.5.

117 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

118 AMAP 2021 Chapter 4.

119 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.1.

120 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

121 Rose et al., "Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era: 1991–2018."

122 Rose et al.

123 AMAP 2017, "Snow, Water, Ice and Permafrost in the Arctic. Summary for Policy-Makers."

124 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

125 AMAP 2018, "AMAP Assessment 2018: Arctic Ocean Acidification."

126 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

127 AMAP 2019, "Arctic Ocean Acidification Assessment 2018: Summary for Policy-Makers."

128 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts."

Future projections
The Arctic is likely to be practically sea ice free in September at least once before 2050, with more frequent occurrences for higher levels of warming.[129] Climate models project that the Arctic Ocean will become fresher in the Pacific sector, and more saline in the Atlantic sector.[130] The ocean climate of the Norwegian Sea and Barents Sea is largely determined by the inflow of Atlantic water. Norwegian waters are expected to warm during winter: a temperature increase of about 1°C is estimated for the Barents in 50 years on average, and up to 2°C increase in eastern parts, while a somewhat larger increase is estimated for the North Sea. Changes in the upper water masses in these oceans, as well as changes in the ice conditions, can result in large changes in plankton production, and thus for the rest of the ecosystem. Projections also indicate that most coastal areas in Norway will experience rising sea levels.[131]

Land ice and snow cover
With warmer temperatures, all regions of the Arctic are experiencing loss of land ice. Greenland, which accounts for 51% of the Arctic total, is the largest regional source of land-ice loss.[132] Arctic overall snow cover extent and seasonal duration is also declining all months of the year. The most profound change is however taking place during spring, in line with temperature increases. Spring snow cover has decreased in the Northern Hemisphere since 1950.[133] AMAP (2021) suggests that Arctic snow cover extent during May-June has declined by 21%, but with a larger decrease over Eurasia (25%).[134] Reductions in Arctic autumn snow extent and duration is also observed.[135] [136]

Significance of snow
Terrestrial snow cover is a defining characteristic of the Arctic land surface as it covers land areas for most of the year. Snow cover has a central role in climatic, ecological, and hydrological processes, and in ways of life.[137] Snow interacts with and affects vegetation, freshwater and soil temperatures, as well as biogeochemical activity, habitats and species, and reflectivity of surfaces. Snowmelt timing, in particular, has a significant impact on surface moisture and energy budgets in high-latitude land areas. Early snowmelt increases the demand for moisture on the land surface, increasing the likelihood that a period of dry weather will cause moisture stress and drought at some point during the snow-free season. [138] Snow cover also interacts with vegetation. Arctic vegetation is important in energy and carbon exchanges between the land and atmosphere, and changes in snow cover and snowmelt timing can have an impact not only on ecosystem productivity, but also on the total amount of carbon that is taken up by the land each year.[139] [140] [141] A shorter snow season also reduces how much sunlight the snow reflects, and lessens the cooling effect of Arctic snow. Reductions in spring snow cover is already a major contributor to amplified warming across the Arctic.[142]

Emerging concerns connected to snow melt are the darkening of snow by soot and other particles, and pollutants stored in or under the snow cover. There is high confidence that darkening of snow through the deposition of black carbon

[129] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.5.

[130] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 3.

[131] Hanssen-Bauer et al., *Climate in Norway 2100*.

[132] AMAP 2021, "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers."

[133] Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" A.1.5.

[134] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[135] AMAP 2021 Chapter 3.

[136] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Section 3.4.

[137] Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

[138] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[139] Niittynen, Heikkinen, and Luoto, "Decreasing Snow Cover Alters Functional Composition and Diversity of Arctic Tundra."

[140] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 6.

[141] AMAP 2021, "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers."

[142] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

and other light absorbing particles enhances snowmelt.[143] In addition, Arctic snow cover is a storage for contaminants and heavy metal pollution. Reduced snow day cover, snow melt and increased precipitation can expose humans to these pollutants.

In Sápmi, snow covers the ground about eight months a year[144]–with local differences–but Sápmi is no exception to the decrease in length of the snow season. As a part of a melting Arctic, the snow season has become shorter. This is observed throughout Finnmark, Norway and on the local level, Guovdageaidnu has experienced approximately two weeks earlier snowmelt in the past 60 years.[145] There has also been a small increase in the average March snow depth.[146] Further south in Norway, coastal areas in Nord-Trøndelag and Nordland experience an average of 15 days earlier start of spring compared to the 1980's.[147] In the southern parts of the reindeer herding area in Sweden, the snow season in winter grazing areas has also become shorter.[148] The western mountain areas within the Kola Peninsula experience significantly wetter springs but also drier autumns. There has also been an overall trend towards stronger winds.[149]

Future projections

Mountain and polar glaciers are expected to continue melting for decades or centuries.[150] In regions with smaller glaciers and relatively little ice cover, e.g., glaciers in the European Alps and Scandinavia, glaciers are expected to lose more than 80% of their current mass by 2100 under a high emissions scenario and many glaciers are expected to disappear regardless of emission scenario.[151] Warmer winters with more precipitation are expected to contribute to a change in snow cover extent, a possible increase in snow depth in the Arctic tundra but also shortening the part of the year when there is a continuous snow cover–thus a prolonged snow-free season. Autumn and spring snow cover extent is projected to decrease by 5-10% until 2050, relative to the period 1986-2005, with later snow onset and earlier snow melt.[152] [153] Under a high emission scenario, the length of the snow-free season in the Northern Hemisphere increases by about two months.[154]

In the future Finnmark, the overall snow season is expected to be 1–3 months shorter.[155] Along the coasts of Finnmark, models predict a snow season that is three months shorter toward the end of the century while inland areas can expect a one-month shorter duration of snow cover, meaning that inland Finnmark may experience conditions that were earlier found along the fjords. The coastal areas are also projected to experience a 60% reduction in the winter maximum snow amount. Inland sites may have a slight increase in maximum snow amounts as average precipitation is projected to increase. Overall, higher temperatures will probably lead to changes in snow structure.[156] The same result is found in a study from

143 Meredith et al. Section 3.4.1.1.3 Drivers.

144 Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

145 Eira et al., "Snow Cover and the Loss of Traditional Indigenous Knowledge."

146 Hanssen-Bauer et al., "Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia."

147 Riseth and Tømmervik, "Klimautfordringer Og Arealforvaltning for Reindrifta i Norge Kunnskapsstatus Og Forslag Til Tiltak. Eksempler Fra Troms."

148 "SWECO, 2019: Syntesrapport: En Sammanställning Av Fyra Samebyars Pilotprojekt Med Klimat- Och Sårbarhetsanalys Samt Handlingsplan För Klimatanpassning."

149 Marshall, Vignols, and Rees, "Climate Change in the Kola Peninsula, Arctic Russia, during the Last 50 Years from Meteorological Observations."

150 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.5.2.

151 Hock et al., "IPCC, 2019: High Mountain Areas. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Executive summary.

152 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" B.1.3.

153 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

154 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 3.

155 Hanssen-Bauer et al., *Climate in Norway 2100*.

156 Hanssen-Bauer et al., "Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia."

Finland: the snow season on average will be shorter with less snow, but likely with more frequent ice layers in the northern snow towards 2050.[157] Data projecting climate change in Swedish Sápmi estimates that the number of snow cover days in northern Sweden might decrease by between 40 and 60 days in certain mountain areas at the end of the century with the largest change expected in coastal areas and low-lying areas in the counties of Jämtland and Dalarna. [158] [159]

Rivers, lakes and freshwater

Arctic rivers are freezing up later in the autumn and ice is breaking up earlier during spring. Ice thickness is decreasing in most Arctic rivers, reducing the risk of spring ice-jam floods.[160] [161]Seasonal lake ice cover thickness and duration has declined over most Arctic lakes. Lake ice cover has decreased especially in spring.[162] In Scandinavian mountain areas, lake and river ice cover duration show high variability in trends during the last decades.[163]

Future projections

Due to warmer temperatures, many Arctic lakes are expected to lose more than one month of lake ice cover by 2050. Reductions in average seasonal river ice duration on rivers in the Northern Hemisphere of six days per 1°C of warming is also projected.[164] The period of the year with frozen lakes and rivers will therefore be significantly shorter than today and ice thickness will be reduced. Freshwater systems across the Arctic are expected to warm as a result of a warmer climate. While some studies project increased productivity in freshwater systems due to warming, cold water species such as Arctic Grayling (*Thymallus arcticus*), whitefishes (*Coregonus spp*.) and Arctic char among others are at risk since some surface waters may become inhospitable. Warming temperatures can increase the risk of fungi (*Saprolegnia fungus*) growing and spreading among fish, and increase growth of harmful algal blooms.[165] Thawing permafrost can favour formation of groundwater storage instead of surface water such as ponds and lakes.[166] Changes in precipitation and snowmelt are expected to contribute to earlier spring floods in rivers, and higher flows during winter and autumn, changing seasonal flow patterns. This in turn risks threatening Arctic fish dispersal and migration activities and can result in mismatched timing of spawning events.[167]

From studies in Sweden and Finland, researchers have found that as a result of higher temperatures and a shorter snow season in spring, daily river discharge may decrease by approximately -1% per decade, while flows during autumn may instead increase by 3% due to more intense precipitation. Spring floods in Finland and northern Sweden might thus occur earlier and become weaker towards the end of the century. In northern Sweden, this would mean that the boundary zone between snow- and rain-driven floods is projected to move north. Others have found that while spring floods may become weaker, the overall frequency of extreme floods in Fennoscandia may increase.[168] [169] While

157 Rasmus, Räisänen, and Lehning, “Estimating Snow Conditions in Finland in the Late 21st Century Using the SNOWPACK Model with Regional Climate Scenario Data as Input.”

158 Sámi Parliament in Sweden, “Klimatanpassning. Handlingsplan För Samiska Näringar Och Samisk Kultur.”

159 Schimanke et al., “Observerad Klimatförändring i Sverige 1860–2021.”

160 AMAP 2021, “Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers” Chapter 2.

161 AMAP 2021.

162 Constable et al., “IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change” Table CCP6.1.

163 Hock et al., “IPCC, 2019: High Mountain Areas. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.”

164 Constable et al., “IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.”

165 Meredith et al., “IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate”3.4.3.2.3 Freshwater.

166 Brittain et al., “Arctic Rivers.”

167 Meredith et al., “IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate”3.4.3.2.3 Freshwater.

168 AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 4.

169 Arheimer and Lindström, “Climate Impact on Floods: Changes in High Flows in Sweden in the Past and the Future (1911-2100).”

there are no clear trends on widespread inland flooding events in the Arctic due to the lack of uniform trends in heavy rain or snow, AMAP (2021) underlines that the projected increases in heavy rainfall and potential for increased flooding are often forecast by climate model projections for northern land areas.[170]

Precipitation

Arctic overall precipitation has increased by 9% during the period 1971-2019. The largest increase in precipitation north of 65°N is during the cold season, from October to May, especially along the southeastern coasts of Greenland and Iceland, across the northern North Atlantic and Barents Sea, and in the areas near Svalbard.[171] AMAP (2021) underlines that evaluating precipitation levels and trends is complex for a number of reasons and that regional trends in heavy precipitation events are sensitive to time period and to the choice of region and season. However, the number of days with heavy precipitation has shown significant trends in increases in large parts of the terrestrial Arctic and daily precipitation intensity has increased in Eurasia. Increases are also found over Finland and northern Sweden and there are indications of increases in northwestern Russia.[172] Marshall et al. (2016) however report that annual precipitation has not undergone any significant change on the Kola Peninsula.[173]

The Norwegian Centre for Climate Services (NCCS) finds that annual precipitation over Norway has increased approximately 18% since 1900, and particularly from the late 1970s. The increase was largest in spring and smallest in summer.[174] Finnmark shows an increase in annual precipitation of about 12% relative to 1961–1990 levels, mainly caused by increased winter and spring precipitation.[175] AMAP (2021) highlights that while evidence of changes of freezing rain occurrences in northern regions is uneven, studies have found substantial increases of freezing rain over northern Norway.[176] Other research also highlights that increased winter precipitation has been recorded in northern Sweden and Norway during the past 30 years. In Sweden, several reindeer herding districts have experienced a 30% increase in winter precipitation, and that snowpack thickness has varied up to 50% between years. [177] [178]

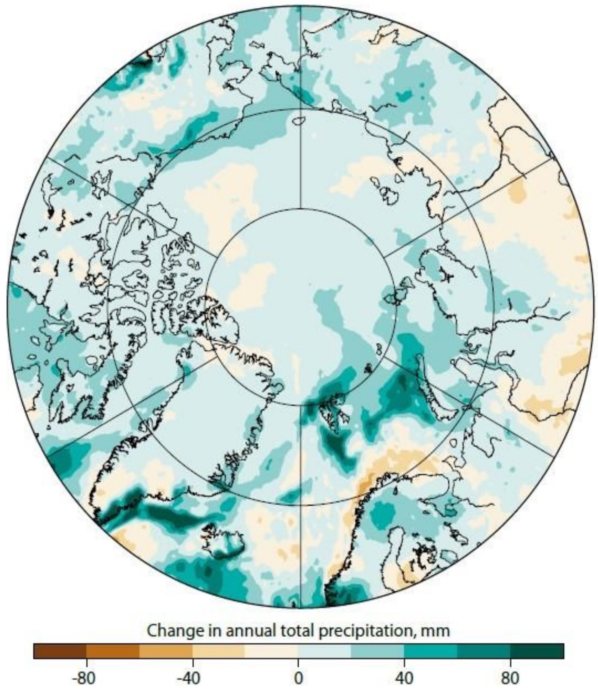

Figure 2.4 Arctic total precipitation trends for the 49-year period 1971–2019. The trend metric is the linear regression temporal slope multiplied by the timespan in years. Data source: ERA5.

Source: AMAP Arctic Climate Change update 2021

As Arctic overall precipitation has increased, AMAP (2021) reports that it has been driven by a 25% increase in rainfall. The greatest increases of rainfall are found across the North Atlantic, especially along the mountainous Norwegian and Icelandic

[170] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 4 and Chapter 7.

[171] AMAP 2021 Chapter 2.

[172] AMAP 2021 Chapter 4.

[173] Marshall, Vignols, and Rees, “Climate Change in the Kola Peninsula, Arctic Russia, during the Last 50 Years from Meteorological Observations.”

[174] Hanssen-Bauer et al., *Climate in Norway 2100*.

[175] Hanssen-Bauer et al., “Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia.”

[176] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 4.

[177] Vikhamar-Schuler et al., “Changes in Winter Warming Events in the Nordic Arctic Region.”

[178] Sirpa et al., “Reindeer Husbandry and Climate Change. Challenges for Adaptation.”

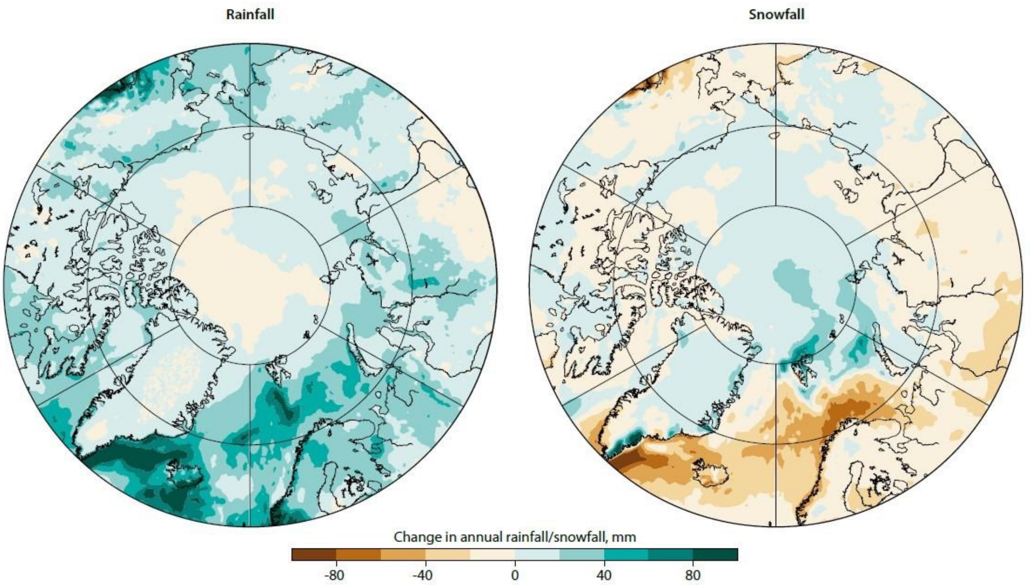

Figure 2.5 Arctic rainfall trends (left) and snowfall trends (right) for the 49-year period 1971–2019. The trend metric is the linear regression temporal slope multiplied by the timespan in years. Data source: ERA5.

Source: AMAP Arctic Climate Change update 2021

coasts.[179] The Norwegian Centre for Climate Services (NCCS) also reports that intensity and frequency of heavy short-duration rainfall has increased in Norway in recent years and is expected to further increase with warming temperatures.[180]

AMAP (2021) reports that there is no net overall Arctic snowfall trend. While there are observed increases in snowfall in the northern Barents Sea, Svalbard and southeastern Greenland, a decrease in snowfall is evident across the Arctic as a whole.[181]

Future projections

The projection is for more water to cycle through the Arctic, including increased precipitation, evapotranspiration, and river discharge to the Arctic Ocean.[182] Increases in cold-season precipitation of 30–50% over the Arctic Ocean is estimated toward the end of this century, with an increasing portion of precipitation falling as rain instead of snow.[183] The same results are likely to be expected over terrestrial parts of the Arctic – heavy precipitation events will increase in northern high latitudes–even though measurements and projections for precipitation are complex and more unsure.[184] There are very few systematic evaluations of future changes in heavy snow or other snow-related extreme events in the Arctic. Future changes in heavy snowfall in the high north are expected to vary between regions and to be sensitive to air temperature.[185]

Precipitation is projected to continue to increase in northern Fennoscandia as a warmer climate contributes to higher evaporation. Mean annual precipitation in Swedish Sápmi is expected to increase by 20% to 45% by the end of the century, depending on emissions scenarios, with the highest increase in northern latitudes and mountain areas, and smallest increase in coastal areas. Maximum daily precipitation is also expected to increase by approximately 15-25%. In the south Sámi area, projections also estimate an increase in precipita-

[179] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[180] Hanssen-Bauer et al., *Climate in Norway 2100*.

[181] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[182] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" B.4.3.

[183] AMAP 2017, "Snow, Water, Ice and Permafrost in the Arctic. Summary for Policy-Makers."

[184] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 3.

[185] AMAP 2021 Chapter 4.

tion, especially during winter. It is likely that this precipitation will fall as rain.[186] Depending on the emissions scenario, regional studies concerning local projections for precipitation in Finnmark indicate an increase of about 10–15% possible, but these projections are regarded as more uncertain than temperature scenarios.[187] With projections of a change in the switch from snow to rain in the winter, there is also a reasonable expectation of a general increase of freezing rain.[188] Freezing rain and an increased frequency of thaw-freeze cycles is also likely to contribute to more frequent events of ice crusts in the snow and on the ground. This represents a significant shift with major impacts on reindeer husbandry in Sápmi.[189] See more about this in chapter five.

Permafrost

Permafrost temperatures since the 1980s have increased across polar and high mountain regions globally.[190] In the Arctic, there is an overall trend of rising permafrost temperatures over the past 3-4 decades as well as increases in the permafrost active layer thickness.[191] AMAP (2021) estimates that Arctic permafrost has warmed 2-3 ºC since the 1970s.[192] In the Scandinavian Arctic, data indicates that permafrost extent is decreasing. Permafrost warming has been shown to accelerate at some sites during recent decades.[193] [194] Rainfall and soil moisture are among the key factors driving permafrost thaw and together with freeze-thaw cycles and warming temperatures it is increasingly contributing to landscape degradation.[195] New research has also found that increased permafrost temperatures can be linked to increasing snow thickness.[196]

Increased permafrost temperatures come with impacts on important ecological and hydrological systems and can increase risks for climate extremes and hazards.[197] In addition, changes in permafrost can pose serious health risks as thawing permafrost also exposes risks from contaminants such as persistent organic pollutants, mercury and disease-causing organisms that have been kept in the frozen ground.

Permafrost degradation and increasing thawing rates of the active layer risks accelerating the rate of global warming through emissions of carbon dioxide and methane that were earlier preserved in the ground.[198] Even though methane is only a small fraction of the total additional carbon release by volume, it is significant because of its higher warming potential. Arctic and boreal permafrost is estimated to contain 1460–1600 gigatonnes of organic carbon–almost twice the carbon in the atmosphere.[199] While there has been no consensus on whether northern permafrost regions are currently releasing additional net methane and carbon dioxide due to thaw, IPCC (2022) reports that thawing of permafrost in combination with other factors has already shifted some Arctic areas from carbon-sinks to carbon sources.[200]

186 "SWECO, 2019: Syntesrapport: En Sammanställning Av Fyra Samebyars Pilotprojekt Med Klimat- Och Sårbarhetsanalys Samt Handlingsplan För Klimatanpassning."

187 Hanssen-Bauer et al., "Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia."

188 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 3.

189 Eira et al., "Snow Cover and the Loss of Traditional Indigenous Knowledge."

190 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.1.3.

191 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.1.

192 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts."

193 Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change."

194 Hock et al., "IPCC, 2019: High Mountain Areas. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"2.2.4 Permafrost.

195 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts."

196 Biskaborn et al., "Permafrost Is Warming at a Global Scale."

197 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts."

198 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.1 Global Climate Feedbacks.

199 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.1.3, B.1.4.

200 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.1.5.

Palsa mires and thermokarsts

> *" The palsas have started to melt."*
>
> **– reindeer herder**

There is vast evidence that climatic warming causes permafrost thaw and degradation in sub-Arctic peatlands throughout northern areas of Sápmi and these impacts are the most profound and visible in palsa mires. Palsa mires are sub-Arctic peatland areas with perennially frozen permafrost in patches, in the form of high plateaus. These plateaus are an essential part of these ecosystems, affecting hydrology, vegetation, microhabitat and species diversity, and they are sensitive to climate variations.[201] [202] In Sápmi, research shows that palsas are melting with few signs of new palsa formation. Wetter, warmer and shorter winters are explained as the main causes of large and rapid changes in palsa extent since the mid-1950s. The largest coherent palsa in northern Sweden, *Vissátvuopmi*, is sinking, and the area is moving towards a total loss of the palsa.[203] In northern Norway, a general degradation of palsas and peat plateaus has, according to researchers, been a consistent process during the second half of the 20th century. Studies have also found that significant emissions of nitrous oxide (another greenhouse gas) have been observed in peat plateaus in northwestern Russia and in palsa mires in Finland.[204] In Finnish Sápmi, fell habitats and palsa mires are the most vulnerable ecosystems.[205]

Palsas are not only melting in Sápmi, but throughout the whole Arctic. Melting palsas can create lakes when thawing permafrost is accompanied by sinking land and unstable marshy hollows, craters and basins. These 'thermokarst' ponds and lakes and wetter conditions create impacts on hydrology, flora, and fauna, challenging traditional activities and livelihoods. Peatlands are important pastures for reindeer husbandry, and for berry picking. Melting palsas can pose serious risks to subsistence activities, travel and herding across the tundra.[206] [207] [208] People have already been forced to change their patterns of movement on palsa mires in Finnmark, Norway.[209]

Climate related extremes and hazards

Combined impacts of long-term warming increase risks for climate extremes and hazards. Climate extremes can severely affect Arctic residents, but according to AMAP (2021) there is little research that focuses on the societal consequences of present and future extreme events. In fact, most climate impact and risk assessments focus on one hazard affecting one sector at a time, and do not account for cascading effects and feedbacks such as human activities and their associated impacts on ecosystems and society. This is problematic since research suggests that warmer winters and shorter duration of the snow season in the Eurasian Arctic has occurred at the same time as extreme snowfall or heavy rainfall, increasing the risks of avalanches, road destruction, spring flooding, and landslides, or increasing the impact of extreme snowfall on production and costs for reindeer herders as seen in winter 2020.[210]

As noted earlier, permafrost degradation interacts with multiple physical processes. Increased water flow into frozen slopes can for example increase the rate of movement of frozen ground, and unstable slopes, avalanches, landslides and glacier instabilities are a direct result of this. The tsunami in the Nuugaatsiaq fjord in Greenland in 2017 was created by a large landslide.[211] Increased debris flow activity (i.e., higher frequency, larger magnitudes) or slope destabilization is documented in

[201] Markkula, Turunen, and Rasmus, "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland."

[202] Olvmo et al., "Sub-Arctic Palsa Degradation and the Role of Climatic Drivers in the Largest Coherent Palsa Mire Complex in Sweden (Vissátvuopmi), 1955-2016."

[203] Olvmo et al.

[204] Borge et al., "Strong Degradation of Palsas and Peat Plateaus in Northern Norway during the Last 60 Years."

[205] Markkula, Turunen, and Rasmus, "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland."

[206] Olvmo et al., "Sub-Arctic Palsa Degradation and the Role of Climatic Drivers in the Largest Coherent Palsa Mire Complex in Sweden (Vissátvuopmi), 1955-2016."

[207] Borge et al., "Strong Degradation of Palsas and Peat Plateaus in Northern Norway during the Last 60 Years."

[208] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[209] "Multeforkomster, Klima Og Vær."

[210] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[211] AMAP 2021 Chapter 7.

sites in Scandinavian mountains.[212] In the Troms region in Norway, snow avalanches have resulted in 28 fatalities over the past ten years. Heavy snowfall and blizzards have increased in some communities, resulting in snow avalanches and lack of road access during winter, making these communities highly vulnerable.[213] A reindeer herder highlighted to the Saami Council her concern about avalanches: "*Over time, there has been a greater danger of avalanches. The fact that you no longer know where the avalanches are going to go creates uncertainty at work. You are always afraid for those you know as family when they are out in the snow season, because you know that avalanches can now occur in areas that have never occurred before.*" Although there is inconclusive evidence on how climate change affects safety, rising rates of search and rescue incidents have been documented in some warming regions in the Arctic.[214]

There is accelerating coastal erosion in many parts of the Arctic. In Alaska, as much as five metres of coastline are disappearing annually in some areas.[215] IPCC (2022) suggests that cities in Sápmi like Tromsø and Murmansk also are at significant risk from climate change through permafrost thaw, shoreline erosion and flooding, as are many other Arctic communities and settlements.[216] Accelerating permafrost thaw, especially in the upper active layer, is already causing damage to buildings, roads, and other infrastructure across the Arctic.[217] IPCC (2022) highlight that the higher number of freezing–thawing cycles of construction materials will increase risks for roads in northern Scandinavia.[218]

Future projections

Arctic permafrost thaw is projected to affect most infrastructure by the middle of this century, with impacts on millions of people and economies, costing billions in damages.[219] Disaster risks are expected to increase due to future changes in hazards such as floods, fires, conditions, and increased exposure of people and infrastructure.[220] Predicting what future greenhouse gases will be emitted from the permafrost is uncertain according to AMAP (2021) as it largely depends on surface wetness. If the Arctic is warming and getting wetter, an increase in methane emissions can be expected. If it is warmer and dryer, thawed carbon will primarily be released to the atmosphere as carbon dioxide.[221]

Permafrost during 1981-2010 covered approximately 6% of the land area in Norway. Projections indicate that within 2050, most permafrost areas at Finnmarksvidda will have thawed, and that by 2100 permafrost will only exist on the highest mountains in Norway.[222] Palsa loss is expected to continue throughout Sápmi, most likely at a higher rate than today, with serious ecological impacts as a consequence.[223] As weather triggers certain types of slides and avalanches, climate change will affect their probability. Increased precipitation and extreme rainfall in steep terrain will increase the likelihood of earth slides – including flood slides in Norway. The probability of wet snow avalanches and slush slides is also expected to increase in Norway, and these can occur in areas where they have not occurred previously, according to the 2100 estimate.[224]

[212] Hock et al., "IPCC, 2019: High Mountain Areas. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"2.3.2.1.1 Unstable slopes, landslides and glacier instabilities.

[213] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[214] AMAP 2021 Chapter 7.

[215] AMAP 2017, "Snow, Water, Ice and Permafrost in the Arctic. Summary for Policy-Makers."

[216] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.5.

[217] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[218] Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.6 Cities, Settlements and Key Infrastructures.

[219] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Executive summary.

[220] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" B.7, B.7.1.

[221] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 6.

[222] Hanssen-Bauer et al., *Climate in Norway 2100*.

[223] Olvmo et al., "Sub-Arctic Palsa Degradation and the Role of Climatic Drivers in the Largest Coherent Palsa Mire Complex in Sweden (Vissátvuopmi), 1955-2016."

[224] Hanssen-Bauer et al., *Climate in Norway 2100*.

Tundra, boreal forests and vegetation

Observations of the Arctic tundra show a widespread greening of tundra over the past few decades, indicative of increased plant productivity in response to longer and warmer summers.[225] [226] There is high confidence that increases in seasonal temperatures lead to tundra greening, as well as increases in the length of the growing season and the expansion of shrubs into tundra. Other factors that stimulate tundra greening include increases in snow water equivalent and soil moisture, increases in permafrost active layer thickness (thawing), change in herbivore activity, and human use of the land.[227] However, despite an increase in summer warmth, remote sensing has shown little change in greenness in the majority of the Arctic. This may be due to differences in local conditions such as nutrient and moisture limitation or grazing and trampling by animals.[228]

Changes in tundra vegetation can have important ecosystem effects on hydrology, carbon and nutrient cycling and surface energy balance which together affect permafrost and climate in general. Aside from physical impacts, changing vegetation also influences the diversity and abundance of plant-eating animals and other species.[229] [230]

Tundra greening with increased plant productivity and growth of shrubs can contribute to shade and thus influence heat transfer. Shrubs also enhance *evapotranspiration* (water vapour going into the atmosphere from plants) which can cause a cooling effect and enhance cloud formation. There are however simultaneous processes related to tundra vegetation and growth that can have opposite effects: expansion of shrubs can also reduce the reflectivity of the landscape which in turn results in increased absorption of warmth from the sun, because vegetation that is higher than the snow cover itself decreases surface albedo. Taller shrubs can capture more snow which insulates the ground in winter and warms the soil–this in turn can trigger permafrost thaw and surface subsidence. As described, climatic feedbacks from changing tundra vegetation depend on the integrated response of the ecosystem to multiple factors.[231] [232]

While tundra areas are greening, there are parts of the Arctic where the opposite is observed; a process called Arctic browning, as observed in parts of the Canadian, Alaskan and Siberian Arctic. Tundra browning can be indicative of vegetation cover and productivity decrease. There is however limited research on tundra browning, but research suggests that drivers that contribute to tundra browning include changes in winter climate–such as reductions in snow cover due to winter warming events that expose tundra to subsequent freezing and drying – combined with insect and pathogen outbreaks, increased herbivore grazing and ground ice melting.[233]

Boreal forest vegetation shows trends of both greening and browning. Vegetation change in boreal forests is a result of direct responses to changes in climate (temperature, precipitation and seasonality) and other driving factors for vegetation such as nutrients and disturbance. Observations also show a poleward shift of boreal forest into tundra across the Arctic. Research also suggests that while boreal forest may expand at the northern edge of the Arctic, it could diminish at the southern edge.[234]

> *"Today the tundra area is our saviour for back up. It is a great risk that if the climate gets warmer, the tundra area will also become harder or more packed (by ice layers or packed snow) and nothing can get through."*

– said by Sámi knowledge holder at the workshop in Ohcejohka

[225] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[226] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 2.

[227] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[228] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 6.

[229] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[230] AMAP 2021, "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers."

[231] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[232] AMAP 2021, "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers."

[233] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[234] Meredith et al.

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

In the Murmansk region, the growing season has lengthened by 18.5 days from 1951-2012. This matches the pattern observed in Fennoscandia, according to researchers.[235] Another example from Sápmi shows that both forest and above-ground vegetation in Finnmark, Norway have developed in ways that reflect more oceanic conditions in recent decades. Satellite imagery from both Guovdageaidnu and Kárášjohka areas show an increase in the abundance of mountain birch.[236] Higher temperature and increased precipitation has shown to be favorable for seed production of birch trees near the tree line. At the same time, lichens have decreased in these areas[237], and similar reports come from areas in Finnish Sápmi as well.[238] Lichens grow slowly, and some vascular plant species like blueberries (*Vaccinium myrtillus*) are better competitors under moist conditions.[239] The documented increase in precipitation in the Finnmark area during the last century is believed to be favorable for these developments.[240] In the past, the tree line has migrated further north and to higher elevations when air temperatures have been high enough, even though the effects of climate change on the mountain birch tree line can be difficult to isolate from other factors that affect it simultaneously.[241] There are however reports that these spatial greening trends in Finnmark are not as visible, or not occurring at all, on reindeer summer grazing areas.[242]

Future projections

A shorter snow season and longer growing seasons will change Arctic environments. For all warming scenarios, declines in snow cover can accelerate vascular plant, moss, and lichen extinction rates, with risks higher in higher elevations. Together with thawing permafrost, snow melt may lead to further soil drying, or soil moisture increase.[243] [244] Feasible growing areas across the Arctic are expected to shift northward and increase within the 55°-69°N region. Thawing permafrost can provide both benefits and obstacles to agriculture.[245] In northern Europe, the advantages of a longer growing season are however outweighed by the increased risk of early spring and summer heatwaves.[246] Arctic warming is projected to result in forests expanding northwards and becoming denser. The treeline is also projected to climb into higher elevations.[247] Almost all of northern Fennoscandia is believed to have temperature conditions that are warm enough for tree growth during the 2070's, according to climate projections[248] and the overall longer growth season in

[235] Blinova and Chmielewski, "Climatic Warming above the Arctic Circle: Are There Trends in Timing and Length of the Thermal Growing Season in Murmansk Region (Russia) between 1951 and 2012?"

[236] Tømmervik et al., "Vegetation Changes in the Nordic Mountain Birch Forest: The Influence OfGrazing and Climate Change."

[237] Forbes et al., "Changes in Mountain Birch Forests and Reindeer Management: Comparing Different Knowledge Systems in Sápmi, Northern Fennoscandia."

[238] Näkkäläjärvi, Juntunen, and Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland."

[239] Tømmervik et al., "Vegetation Changes in the Nordic Mountain Birch Forest: The Influence OfGrazing and Climate Change."

[240] Forbes et al., "Changes in Mountain Birch Forests and Reindeer Management: Comparing Different Knowledge Systems in Sápmi, Northern Fennoscandia."

[241] Forbes et al.

[242] *Ims A. Finnmark 2100: Hva Betyr Kimaendringene for Artene På Land? Meahcásteapmi Nuppástuvvan Meahcis. Nanne Konferensen 2022.*

[243] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.2 .

[244] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

[245] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.3.2.

[246] Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.5 Food, Fibre and Other Ecosystem Products.

[247] Karlsen et al., "Future Forest Distribution on Finnmarksvidda, North Norway."

[248] Käyhkö and Horstkotte, *Reindeer Husbandry under Global Change in the Tundra Region of Northern Fennoscandia*.

northern Europe will support the establishment of invasive species.[249] Few invasive alien species are currently well established in the Arctic, but many are thriving in the sub-Arctic region and may spread due to climate change. CAFF (2013) report that the *Lupinus nootkatensis* has spread throughout Arctic western Eurasia, Greenland, and Iceland, posing serious threats to native fauna and flora. The status of invasive non-native species in Arctic and sub-Arctic aquatic environments is less well understood, but the introduced Pacific red king crab is reportedly causing disturbance in benthic communities in northern Norway and the Kola Peninsula.[250] [251]

As a result of the extension of the treeline (sám. *orda*), forest productivity in northern Europe is expected to rise, and forest growth in Finnish Lapland could double by the end of the century. The extent to which forest damage by pests and diseases is likely to increase under a warming climate is unclear.[252] IPCC reported in 2019 that by 2050, the extent of most tundra types in the Arctic will decrease by at least 50%. Woody shrubs and trees expanding into tundra are projected to cover between 24-52% of the current tundra region. Shrubs replacing grasses and sedges can be problematic as shrubs are more flammable, and trees moving into tundra could further increase risks of tundra wildfires.[253] Depending on emissions scenarios in the future, projections estimate an extension of the vegetation period by approximately 30-60 days in the northern parts of Swedish Sápmi at the end of the century.[254] The expected extension of the treeline to higher altitudes in Sweden over the next hundred years could range from 233-667 metres. This would result in a 75-85% decrease in treeless alpine heaths, affecting all aspects of the tundra ecosystem.[255] Preventing shrubs moving into the tundra, and preserving the more reflective tundra biome would serve as climate mitigation according to researchers.[256] Herbivores, and grazing by reindeer in particular, have the potential to counteract climate-induced shrubification–see more in chapter five. AMAP (2021) suggests that while increasing growth and thus continued greening is the overall response to increasing summer temperatures, it remains unclear whether winter warming (a potential driver of Arctic browning) may weaken the greening trend in the future.[257]

Wildfire

A warmer climate is associated with an increase in wildfires due to higher air temperatures, reduced snow cover and surface dryness, among other things. Further evidence shows that warming and changes to the Arctic water cycle increase the risk of wildfire. IPCC (2022) highlights that Arctic wildfires' frequency and area burned during recent years are unprecedented compared to the last 10,000 years. Fire risk levels are projected to increase across most tundra and boreal regions due to interactions between climate and shifting vegetation.[258] The fire season has lengthened, and the number of fires has increased in the North American part of the Arctic over the last four decades[259] Siberia also expe xrienced an increase in wildfires between 1996 and 2015–which has caused substantial economic damages.[260] Apart from the ecosystem impacts and risks to life, health and property, wildfires are also a large and increasing source of black carbon and particu-

[249] Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.5 Food, Fibre and Other Ecosystem Products.

[250] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Box 3.4.

[251] CAFF 2013, "Arctic Biodiversity Assessment: Report for Policy Makers."

[252] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

[253] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[254] "SWECO, 2019: Syntesrapport: En Sammanställning Av Fyra Samebyars Pilotprojekt Med Klimat- Och Sårbarhetsanalys Samt Handlingsplan För Klimatanpassning."

[255] Moen, "Climate Change: Effects on the Ecological Basis for Reindeer Husbandry in Sweden."

[256] Käyhkö and Horstkotte, *Reindeer Husbandry under Global Change in the Tundra Region of Northern Fennoscandia*.

[257] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 4.

[258] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.2.

[259] Constable et al. Table CCP6.1.

[260] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.9.2.

late emissions to the atmosphere, further driving melting when the black particles land on ice or snow.[261]

Wildfires are much less common in tundra areas than in boreal forests, but there are indications that tundra wildfires may be increasing from recent events in Greenland and Alaska. Warm and dry weather in late spring and early summer increases tundra wildfire occurrence and fire intensity on the circumpolar scale and increasing numbers of electrical storms mean that lightning is starting more fires. [262] [263] In Finland, data suggests that most of the peak burned-area years correspond with extremely high near-surface air temperatures and early snow melt.[264]

The overall trend for wildfires in Sápmi shows that due to the economic importance of forestry and active monitoring and suppression, wildfires have become less frequent in Fennoscandia since 1900. However, there are still wildfire events in Sápmi. In 2018, 81,000 hectares of reindeer pasture were lost to fires on the Swedish side of Sápmi. As climate change increases the likelihood of fires this means a major adaptation challenge ahead for reindeer husbandry.[265] [266]

Future projections

Wildfire is projected to increase for the rest of this century across most Arctic tundra and boreal regions. Interactions between climate and shifting vegetation will influence future fire intensity and frequency.[267] [268] In northern Europe specifically, where wildfires have been uncommon, and where fire management capacity is slowly increasing, new fire-prone regions can emerge, according to the IPCC (2022).[269] AMAP (2021) suggests that while there is a general expectation of increased wildfire severity in the future as summers become longer and warmer, along with the projected increases in lightning activity over northern land areas, climate models predict an increase in precipitation and moisture availability as well. While it is also known that snow and permafrost decline also might lead to further soil drying, AMAP concludes that available information points to low-to-medium confidence in future increases of wildfire activity in northern land areas.[270]

Contaminants, toxins and pathogens

Climate change increases the risk of movement of contaminants, toxins and increases risks of disease. Transport and movement of contaminants happens through multiple pathways. Some substances are carried to the Arctic from elsewhere via atmospheric and oceanic currents while others are present in materials and products that are used and disposed of locally within the Arctic.[271] Long-range transboundary air pollution contributes to acidification of lakes and streams through the spread of contaminants. Acidification of lakes and streams is already one of the most severe and spatially extensive environmental problems in northern Europe, affecting ecosystems and biodiversity negatively.[272]

As a result of warmer temperatures, thawing permafrost can release pathogens and contaminants such as mercury. Mercury accumulates in aquatic ecosystems and affects water quality.[273] Similarly, persistent organic pollutants (POPs) and black carbon that due to historic use may be found in glaciers and sea ice, can pose threats as rapid melting and

[261] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 4.

[262] AMAP 2021 Chapter 4.

[263] Chen et al., “Future Increases in Arctic Lightning and Fire Risk for Permafrost Carbon.”

[264] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 2.

[265] AMAP 2021 Chapter 4.

[266] Sirpa et al., “Reindeer Husbandry and Climate Change. Challenges for Adaptation.”

[267] Constable et al., “IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change” CCP6.2.2.

[268] Pörtner et al., “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate” B.4.3.

[269] Bednar-Friedl et al., “IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change”13.3.1.3 Observed impacts and projected risks of wildfire.

[270] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 4.

[271] AMAP 2021, “POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers.”

[272] Fölster et al., “Acidified or Not? A Comparison of Nordic Systems for Classification of Physicochemical Acidification Status and Suggestions towards a Harmonised System.”

[273] AMAP 2021, “AMAP Arctic Climate Change Update 2021: Key Trends and Impacts” Chapter 7.

heavy rainfall over longer periods can increase transport of these pollutants into freshwater systems. In the Canadian Arctic, thawing permafrost has been linked to increased concentrations of POPs in freshwater and Arctic char.[274] [275] According to the AMAP Human Health in the Arctic Report (2021), most POPs and metal concentrations are declining across many parts of the Arctic, even though these declines are not uniform or consistent across all regions. PFASs (per- and polyfluoroalkyl substances) are an exception, with some concentrations increasing in Sweden.[276]

Overall, climate change contributions to changes in surface conditions–i.e. increased open water areas, loss of glaciers, thawing permafrost, changes in snow deposition patterns–along with changes in air and water circulation patterns and precipitation rates, can have effects on movement of contaminants and thus increase their mobility.[277] Another important factor of climate-related effects on Arctic contaminants is the changes in the abundance, distribution and seasonal movements of species. Poleward shifts in species' geographic distribution alter Arctic ecological communities and food webs, creating new contaminant exposure pathways and levels in wildlife and food chains. Exposure, movement and accumulation of contaminants, but also of pathogens and bacteria poses serious risks to human health, and the sustainability of subsistence and commercial hunting and fishing in the Arctic. Health risks are mostly from eating animals but also come from drinking water from untreated rivers, streams and lakes.[278] [279] [280] With new waterborne pathogens emerging in the Arctic, safe drinking water is reported to have decreased according to IPCC (2022), thus increasing risks for waterborne disease.[281] IPCC also reports that biomagnification of persistent organic pollutants (POPs) and methyl mercury is already affecting fisheries and that Arctic Indigenous Peoples are among the most vulnerable to these risks.[282]

Future projections
Climate change will affect contaminant transport pathways to the Arctic in the future according to model-based studies. A warmer climate risks remobilizing pollutants, both within the Arctic and with effects on pollutants coming in, because of thawing permafrost and change in atmospheric circulation patterns.[283] Increased development activity in the Arctic is also likely to lead to enhanced local release of chemicals, including siloxanes, parabens, flame retardants, and PFASs.[284] The latter is of special concern due to PFAS being tenaciously persistent in the environment. According to Roos et al (2022), studies of PFAS in Arctic terrestrial animals are relatively few.[285]

Impacts on Arctic ecosystems

Terrestrial ecosystems
Terrestrial ecosystems in the Arctic are feeling the effects of changes in temperature, precipitation, increased permafrost thaw, changes to tundra hydrology and changes in vegetation, coastal and riverbank erosion, reduction in snow cover

274 AMAP 2021, "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers."

275 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.3 Freshwater.

276 AMAP 2021, "AMAP Assessment 2021: Human Health in the Arctic" Chapter 3.

277 AMAP 2020, "AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change" Chapter 2.

278 AMAP 2021, "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers."

279 AMAP 2021, "Mercury Assessment. Summary for Policy-Makers."

280 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

281 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.6.

282 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.3.4.

283 AMAP 2021, "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers."

284 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.3 Freshwater.

285 Roos et al., "Perfluoroalkyl Substances in Circum-ArcticRangifer: Caribou and Reindeer."

and ice, winter thaw/refreezing events and the frequency and severity of wildfires.[286] A warmer Arctic poses a major threat to cold-adapted Arctic species and ecosystems due to changes in snow conditions and tundra vegetation, and loss of their habitat from multiple drivers. Increased threats from encroaching sub-Arctic species and biological communities in combination with very limited refugia means Arctic species risk being displaced and outcompeted. IPCC (2019) authors describe the situation as the 'Arctic squeeze'–a result of the fact that the area of the globe shrinks as one moves poleward and that there is nowhere else to go for speices that live on land. The expected overall result of these shifts and limits will be a loss of Arctic biodiversity.[287]

A few examples of changes occurring with range expansions of species heading northward in Fennoscandia are roe deer (*Capreolus capreolus*, sám. ruoigu), wild boar (*Sus scrofa*, sám. vildaspiidni) and raccoon dog (*Nyctereutes procyonoides*, sám. neahtebeana).[288] White-tailed eagles (*Haliaeetus albicilla*) have begun to prey in Finnish Sápmi.[289] Several bird species in Finnmark are also declining, but the reasons for the declines are not well known.[290] Because of their effects on vegetation, lake eutrophication (an increase in lake nutrients that encourages water plants, but diminishes oxygen), and as hunting species, changing bird populations may have significant consequences. Some grouse species, which are important for hunting and seed dispersal, may be more directly affected by changes in insect abundance and the disappearance of snow beds.[291]

Because snow dominates the landscape for most of the year, it is one of the most important determinants of ecosystem functions in Arctic landscapes (see chapter 4). Snow enables the creation of different habitats and species diversity, and many plants and animals are adapted to the protection of snow. As snow beds provide cover and temperature relief in the summer, decreasing snow cover may be critical for overwintering small rodents.[292] A change in snow cover and length of the snow season has impacts on the diversity of Arctic tundra vegetation[293] [294] which also affects wildlife, species abundance, and traditional fishing and hunting. A shorter snow season combined with more productive vegetation has shown to have negative effects on the abundance of willow ptarmigan (*Lagopus lagopus*) due to increased nest predation. The expansion of tall shrubs higher than 1 metre is projected to provide the necessary winter fodder for moose populations to establish on the tundra.[295] Change in vegetation has also contributed to changes in cloudberry (*Rubus chamaemorus*) abundance, which has been reported in Finland and other parts of the Arctic.[296]

There is high confidence that habitat loss or change caused by climate change affects Arctic fishes. According to research, some inland regions have seen a decrease in fish abundance which has been linked to changing river hydrology (lower water levels) and changing spawning behavior. Fresh waters are particularly vulnerable to climate change. Water temperature and availability are highly dependent on climate, and freshwater species have limited ability to disperse as the environment changes.[297] Warming resulting

[286] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.2.

[287] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Box 3.4.

[288] *Ims A. Finnmark 2100: Hva Betyr Kimaendringene for Artene På Land? Meahcásteapmi Nuppástuvvan Meahcis. Nanne Konferensen 2022.*

[289] Näkkäläjärvi, Juntunen, and Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland."

[290] *Ims A. Finnmark 2100: Hva Betyr Kimaendringene for Artene På Land? Meahcásteapmi Nuppástuvvan Meahcis. Nanne Konferensen 2022.*

[291] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

[292] AMAP 2017 Chapter 6.

[293] Niittynen, Heikkinen, and Luoto, "Decreasing Snow Cover Alters Functional Composition and Diversity of Arctic Tundra."

[294] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.1 Vegetation.

[295] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[296] Markkula, Turunen, and Rasmus, "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland."

[297] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

in thin ice on lakes and streams changes the overwintering habitat of aquatic fauna by influencing winter water volumes and oxygen levels. Changes in the timing and magnitude of seasonal flows, as well as surface water loss thus have a direct impact on habitats for spawning, feeding, and rearing.[298] In northern lakes where climate change has extended the ice-free season, primary production and the amount of fish might benefit, while delayed autumn cooling can affect autumn-spawning species as waters may be too warm for the survival of eggs and hatchlings. As a result, freshwater fisheries may gradually shift from cold-water species that spawn in the autumn to spring-spawning species.[299]

Pollinators

According to researchers, the negative effects of global warming on pollinators (such as bees) are likely made worse in Europe by the lack of landscape diversity, and by natural areas being cut up by development. These limit the ability of pollinators to move elsewhere, and reduce the protective effect of local climate conditions. Increasing similarity of pollinator populations may have a negative impact on pollinators' resilience and increase vulnerability to extreme events. Climate change is believed to have the greatest impact on aspects of biodiversity that are rarely measured or given attention, such as genetic diversity and species evenness. Temperature fluctuations in winter, changes in the length of the growing season, and increased frequency of extreme weather events, are also particularly harmful to pollinators. This suggests, according to the researchers, that conservation efforts should focus on increasing connectivity between natural landscape areas, and ensuring that there are enough different landscape types available locally, regionally, and nationally (Vasiliev & Greenwood, 2021). Future impacts on pollinators are expected to be mixed across Europe, but they will be greater as temperatures rise. In northern Europe, species richness may increase for some groups, with bumblebees showing mixed results (Bednar- Friedl, 2022).

The ability of species at higher altitudes to endure higher temperatures is largely unknown as studies are lacking, despite the fact that vegetation, insects, and some terrestrial and marine species have known temperature tolerances. One of the reasons is that the effects of extreme temperatures on species' survival are often intertwined with the effects of wind, snow, and other environmental factors. Research in the Russian Arctic has found that warming has had a positive effect on populations of moose and sable, which are important species for hunting and trapping in the northern taiga of Yakutia, while warming has had the opposite effect on tundra reindeer populations in Taimyr and Yakutia. Warming is altering reindeer migration routes and causing a significant decrease in productivity. However, assessing the impact of climate change on reindeer population numbers was not possible in this case because other impacts and drivers, such as poaching and over-harvesting, interact with climate change. [300] Other climatic effects, such as increased occurrences of rain-on-snow and winter thaw/refreezing events, have affected grazing herbivores like caribou, reindeer, and muskox and their access to food on the ground. Caribou populations are declining across most of the Canadian Arctic, and reindeer and caribou abundance has declined 56% in Alaska and Canada over the last 20 years,[301] despite the fact that caribou body condition has improved in some areas. Extreme snowfall and rain-on-snow events, as well as winter thaw/refreezing events, have resulted in significant herd losses in Sápmi and Russian Siberia, with the latter expected to become more common in the future.[302] [303]

Diseases, pathogens and pests

As climate change contributes to shifts in geographic range of species and altered timing of seasonal events, new diseases have been brought into the high Arctic. The move of diseases and their vectors (mostly animals that can carry disease, such as mosquitoes and ticks) has resulted in numerous ecological disruptions.[304] It has also increased opportunities for diseases spreading from wildlife to human

[298] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.3 Freshwater.

[299] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

[300] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[301] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.3.

[302] AMAP 2021, "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers."

[303] AMAP 2017, "Snow, Water, Ice and Permafrost in the Arctic. Summary for Policy-Makers."

[304] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.1.1, TS.B.5.8.

populations. In 2019, the IPCC reported that pathogens are very likely responsible for increased deaths of Arctic ungulates (muskox, caribou/reindeer), threatening the sustainability of subsistence hunting and fishing, as well as the safety of traditional foods.[305]

Zoonoses (diseases that can be transmitted from animals to people) that have been historically rare or never documented in the Arctic are also emerging as a result of climate induced environmental change, and spreading poleward–e.g., *anthrax* and rabbit fever (*tularemia*).[306] Exposures to pathogens such as anthrax is a special concern. In 2016 over 2000 reindeer along with one child died from anthrax linked to warming environments in the Yamalo Nenets region in the Arctic Russian Siberia.[307] In 2019, Sweden experienced its largest outbreak of tularaemia in over 50 years.[308] Researchers at Stockholm University have found a link between climate change and tularaemia but emphasize that there is a need for more research on how projected climate changes may affect future outbreaks.[309]

> *"The birch forests in our area. When we flew over it recently – it is brown. Insects destroy it."*
> **– said by a Sámi participant at the seminar in Váhtjer**

Climate change and range shifts of species bring concerns about insects and pests that damage vegetation. One example is the area of damaged Arctic birch in northern Fennoscandia which has increased significantly during the last few decades. This can be partly explained by the increasing winter survival and range expansion of the winter moth (*Operopthera brumata*) and the autumn moth (*Epirrita autumnata*).[310] See more about moths and moth outbreaks in Sápmi in chapter five.

Marine and coastal ecosystems

Marine ecosystems are experiencing declines in sea ice thickness and extent, along with changes in the timing of ice melt, changing the ranges and populations of Arctic species. Warming waters have caused polar ecosystems to quickly reorganize, pushing cold-adapted species poleward, dissolving the 'cold barrier' separating native Arctic species from boreal species, and promoting the formation of harmful algal blooms. The impacts on marine ecosystems have negative consequences for human health and well-being, especially for Arctic Indigenous Peoples dependent on fisheries.[311 312]

Over the past 70 years, many marine species across various groups have undergone shifts in geographical range and seasonal activities in response to ocean warming, sea ice change and biogeochemical changes (such as oxygen loss) to their habitats. This has resulted in poleward shifts in species composition, abundance and biomass production of ecosystems.[313] Arctic marine ecosystems are facing cascading impacts and feedbacks from global warming and ocean acidification which are rapidly changing their physical environment. In Arctic seas, climate change has contributed to altered ecosystem structure, functioning and food web dynamics. Warming and other climate impact drivers, especially sea-ice retreat, have effects on phytoplankton blooms and ice algae, and have led to range contractions of Arctic marine and ice-associated species, poleward expansions of boreal species, and also allowed for invasive species, competitors, and patho-

305 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.2 Wildlife.

306 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.5.8.

307 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.6.

308 Dryselius et al., "Large Outbreak of Tularaemia, Central Sweden, July to September 2019."

309 Ma et al., "Potential for Hydroclimatically Driven Shifts in Infectious Disease Outbreaks: The Case of Tularemia in High-Latitude Regions."

310 Jepsen et al., "Climate Change and Outbreaks of the Geometrids Operophtera Brumata and Epirrita Autumnata in Subarctic Birch Forest."

311 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.1.1.

312 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.8, A.8.1.

313 Pörtner et al. A.5.

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

gens.[314] These distribution shifts and changes in food webs, induce declines in many species with impacts on subsistence harvests, local subsistence economies and commercial fisheries. This also threatens the global dependence on polar regions for substantial marine food production.[315]

Species have shifted northward in the Bering, Greenland, and Barents Seas, resulting in changes in species living together in the Arctic. Higher numbers of economically important boreal species like haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*gadus morhua*) have been observed many hundreds of kilometres north of their normal range. The temperate Atlantic mackerel's summer feeding distribution in the Nordic Seas is the most pronounced and recent range expansion into the Arctic.[316] Other species such as snow crabs (*Chionoecetes opilio*) are undergoing range contractions poleward in the Barents Sea and northern Bering Sea with increased numbers in the north and declining numbers in the south.[317] In the northern Barents Sea, increased predation mortality for key species and incursions of boreal fish have induced entire ecosystem reorganization.[318]

Increased competition with, and predation from invading boreal species, among other factors, is expected to result in cold-adapted Arctic fish species such as Polar cod (*Boreogadus saida*) losing spawning habitats and numbers at global warming levels over 1.5 °C.[319] The decline in the polar cod stock may cause structural reorganization of the Arctic food web in the future.[320]

At the same time as these northward expansions or shifts take place, a number of populations of species including Arctic char (*Salvelinus alpinus*), salmon species, snow- and king crab (*Chionoecetes opilio, Paralithodes camtschaticus*) and Pacific cod (*Gadus macrocephalus*) show range contraction or population declines throughout the circumpolar Arctic.[321] [322] Expansion of Atlantic cod (*Gadus morhua*) into the northern Barents Sea has resulted in increased spatial overlap and predation pressure from Atlantic cod on Polar cod and the pink salmon's (*Oncorhynchus gorbuscha*) poleward expansion into Arctic waters presents both new opportunities and threats to key subsistence and commercial species such as Arctic char and Atlantic salmon (*Salmo salar*).[323] See more about salmon and salmon fishing in Sápmi in chapter five. Overall, these changes are causing a structural change in Arctic ecosystems, leading to a 'borealisation' or 'Atlantification' of European Arctic biological communities, as researchers describe it. This means that the Arctic biological community, dominated by small, benthic (bottom-dwelling), slow-growing species, are being replaced by a boreal community dominated by large, fast-growing species such as Atlantic cod. As a result, the food web will shift from a low-consumption benthic-dominated system based on ice algae production to a high-consumption system based on phytoplankton in the water column. The fishing yield in the northern Barents Sea is likely to increase as a result of these changes.[324] [325]

314 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CPP6.2.1.

315 Constable et al. See executive summary.

316 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Box 3.4.

317 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.4.

318 Constable et al. CCP6.2.1.4.

319 Constable et al. Executive summary and CCP6.2.1.1.

320 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

321 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Executive summary.

322 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Box 3.4.

323 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

324 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" Box 3.4.

325 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

Climate change is expected to have both positive and negative impacts on salmonid species'[326] abundance in the subarctic and Arctic region. Some species are expected to have higher future survival and reproduction rates, while others will face temperature stress. Cold-adapted species are threatened with extinction as a result of habitat loss and competition. However, the effects of climate change are more complicated for freshwater-born fish, such as salmon, who spend the majority of their lives in saltwater before returning to freshwater to spawn, because they must cope with a variety of habitats and conditions throughout their lifecycles.[327] [328]

Barents Sea

The Barents Sea can be seen as the most productive Arctic shelf area of the world's ocean. The region supports a rich fishery for Atlantic cod (gadus morhua), haddock (Melanogrammus aeglefinus), capelin (*Mallotus villosus*), and herring (*Clupea harengus*). The Barents Sea is a shallow ocean characterized by a wide range of environmental conditions because of the mixing of cold Arctic and warm Atlantic waters, creating a polar front. Such front systems create rich biological production of planktonic algae feeding the zooplankton, which again feed fish, seabirds and marine mammals.[329] [330]

To use the red king crab (*Paralithodes camtschaticus*) to illustrate the fluctuations in the ecosystem caused by climate change, the relationships between life in the upper part of the sea, and on the seabed may explain a number of the effects of climate change. The time period available for growth of primary producers (phytoplankton–very small plant-like life in the seawater) increases during warm periods when the ice cover in the Arctic seas is reduced. Warm periods increase the amounts of these very small water plants, their predators, and dissolved organic carbon, which may provide additional food sources for animals on the sea-bed, which are then prey for red king crab. These effects have relative long-time lags (3-7 years).[331] It should be kept in mind that the red king crab is an introduced species to these waters, so other factors might affect the population, such as diseases, parasites and predators.

Commercial fisheries and expanding aquaculture industries

Acknowledging that ecosystem interactions are complex and affected by policy and management decisions, research suggests that range expansions of sub-Arctic fish can increase opportunities for commercial fishing in some regions of the Arctic (e.g., the northern Barents Sea and northern Bering Sea). This would likely bring economic benefits for some coastal Arctic communities as well as with potential adverse impacts to Arctic ecosystems when disturbing the seabed and removing Arctic species. The positive effect of warming is most pronounced in opportunities for fish farming, but could possibly also increase the yield of kelp cultivation (seaweed). Salmon farming and other forms of aquaculture have already expanded northward in parts of the North Atlantic Arctic. Norway, which already dominates the salmon industry, is planning for an increase in the production of cultivated salmon based on the assumption that the optimal climate conditions for salmon farming are expected to move north under further warming.[332]

An expanding aquaculture industry in the Arctic creates complex societal and environmental costs and benefits. Apart from the potential of creating additional economic opportunities, an expansion of commercial fisheries and aquaculture industries can also affect vulnerable Arctic ecosystems and challenge traditional livelihoods and culture. Local environmental concerns related to growth in the salmon farming industry in Norway have been raised more frequently in recent years and have become an increasingly important part of the regulatory framework. Concerns regarding the negative impacts of cultivated Atlantic salmon on the wild salmon populations have been documented. There have also been concerns raised around the industry

[326] *Salmonids* include salmon (both Atlantic and Pacific species), trout (both ocean-going and landlocked), chars, freshwater whitefishes, graylings, taimens and lenoks.

[327] Hedger et al., "Predicting Climate Change Effects on Subarctic–Arctic Populations of Atlantic Salmon (Salmo Salar)."

[328] Jansson et al., "Future Changes in the Supply of Goods and Services from Natural Ecosystems: Prospects for the European North."

[329] Dvoretsky and Dvoretsky, "Inter-Annual Dynamics of the Barents Sea Red King Crab (Paralithodes Camtschaticus) Stock Indices in Relation to Environmental Factors."

[330] Miljøstatus, "Barentshavet."

[331] Dvoretsky and Dvoretsky, "Inter-Annual Dynamics of the Barents Sea Red King Crab (Paralithodes Camtschaticus) Stock Indices in Relation to Environmental Factors."

[332] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

being highly technology-intensive, resulting in relatively modest local employment, but also concerns related to the strong concentration of ownership by a few large international companies, reducing local ownership and benefits.[333] Additionally, Young et al. (2019) suggest that conflicts are likely to be made worse due to the lack of relevant legislation concerning the aquaculture industry, and due to differing views on user rights held by Indigenous Peoples.[334]

According to AMAP (2021), the societal impacts of climate change on Arctic fisheries will be determined not only by cascading effects from climate-induced changes in the marine ecosystem, but also by the availability of infrastructure, labor, fishery management, and international agreements. These factors, coupled with societal and environmental costs such as competition with local fisheries and the spread of parasites such as salmon lice to local wild fish populations, must be taken into account in marine spatial planning and regulatory measures.[335]

Future projections for expanding aquaculture suggest it will face increasing challenges from climate change. Numbers of small fish or krill used for feed may be affected. Increasingly frequent storms will threaten sea farms, and extreme temperatures and warmer conditions that favor pathogens, parasites and harmful algal blooms will occur. Increased distances from ports to fishing grounds are expected to affect commercial fisheries. Longer distances increase risks and costs for fishery operations and affect shore-based infrastructure and emergency response services.[336] While large-scale commercial fisheries are projected to continue moving poleward under future warming, global and regional models differ in their projections of the future catch potential.[337] For example, the effects of ocean acidification on Arctic ecosystems could potentially counteract increased commercial fishing opportunities. These effects are uncertain due to variances in effects of acidification depending on species, locations, life stages and seasons.[338] Studies in Arctic waters have found detrimental impacts on Atlantic cod, with reduced hatching success due to ocean acidification, and higher mortality rates of cod larvae. Impacts of acidification have also been studied in Atlantic herring, and results indicate stunted growth and development, decreased condition, and severe tissue damage in several organs.[339] The effects of ocean acidification are expected to limit the farming of vulnerable shell-building species such as clams, mussels and oysters.[340]

The Arctic cod fishery has been a cornerstone for communities in northern Norway for over 1000 years and currently supports a large commercial fishery. A modeled study of the combined impacts of fishing, warming, and ocean acidification on the Arctic cod stock discovered that while near-term climate change is likely to benefit the fishery, warming and acidification risk causing it to collapse by the end of the 21st century, despite the best adaptation effort in terms of reduced fishing pressure.[341] Continued commercial and large-scale fishing in the Arctic is expected to increase the likelihood of conflict within fisheries management as poleward shifts bring them closer to geopolitical and management boundaries.[342]

333 AMAP 2021 Chapter 7.

334 Young et al., "Limitations to Growth: Social-Ecological Challenges to Aquaculture Development in Five Wealthy Nations."

335 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

336 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.3.2 and CCP6.2.4.

337 Constable et al. CCP6.2.3.3.

338 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

339 AMAP 2018, "AMAP Assessment 2018: Arctic Ocean Acidification.

340 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

341 AMAP 2021 Chapter 7.

342 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.3.3.

Impacts on Arctic Indigenous Peoples

Climate change has impacted Indigenous subsistence resources across the Arctic (*very high confidence*), and future food systems and ecological connections are at risk from future climate change hazards interacting with non-climate pressures, some of which are mediated or amplified by novel conditions and opportunities in Arctic regions.[343]–IPCC (2022)

Similar to Indigenous Peoples globally, colonialism has resulted in land dispossession and landscape fragmentation, carbon-intensive economies, discrimination, racism, and social, cultural, and health inequities for Arctic Indigenous Peoples which all shape risks to climatic hazards and increase climate vulnerability, according to the IPCC (2022).[344] Climate change has already negatively affected the mental health and well-being of Arctic Indigenous Peoples, and increased risks of injury, food insecurity and foodborne and waterborne disease. Food safety in particular is a concern for Arctic Indigenous Peoples reliant on the environment for subsistence, livelihoods, and identity.[345] [346] Subsistence-based livelihoods are affected by the spread of food- and water-borne diseases, as well as changes in access to, abundance of, and/or nutritional and cultural value of food. There are reports that these changes already occur due to climate change.[347] [348] AMAP (2021) underlines that while studies on food safety and security have a high level of agreement that climate change has the potential to increase risk and may already be doing so in some regions, the quality and quantity of evidence documenting current impacts is low. Climate change's effects on food security in the Arctic, as well as potential adaptation strategies, must be investigated which will require an examination of, and respect for, community-led initiatives that can provide solutions that support Indigenous knowledge, preferences, practices, traditions, and priorities, AMAP (2021) underlines.[349]

Food self-sufficiency in the Nordic countries

Nilsson (2020) highlights that food self-sufficiency in the Nordic countries is considered insufficient. The Nordic region is generally regarded as food secure, however, this level of food security is achieved through a high level of trade dependency (more than 50%). While this low level of food sovereignty makes the system less vulnerable to Arctic climate fluctuations, it does make it more vulnerable to food prices and socio-economic impacts on trade, as well as from system shocks like global pandemics affecting borders and trade in general. Even though Sápmi is rich in resources, these resources value to food sovereignty is not always recognized. For example, Nilsson highlights that the Swedish National Food Strategy action plan briefly mentions reindeer and game meat, however only in the context of their contributions to growth in the food supply chain, while wild herbs and berries are not mentioned at all. The value of reindeer husbandry to Sámi culture is emphasized, but its potential value to food sovereignty is downplayed.

Arctic Indigenous Peoples' food systems are unique, and imperative for ensuring the vitality of ways of life, cultures, and survival as distinct peoples. These food systems are resilient and have been sustained by steadfast continuation of our traditional livelihoods, occupations, values, and practices.[350] Subsistence livelihoods including reindeer herding, fishing, hunting, gathering, and trapping are the foundation of economic, cultural, and spiritual connections with terrestrial and marine ecosystems and thus fundamental to culture, identity, values, and ways of life.[351] [352] Impacts on food security thus go beyond access to food and physical health. Research indicates that Indigenous

[343] Constable et al. CCP6.2.3.1 Arctic subsistence resources

[344] Constable et al. Box CCP6.2.

[345] Constable et al. Executive summary.

[346] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.7.2.

[347] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.3.3, TS.B.3.4.

[348] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[349] AMAP 2021, "AMAP Assessment 2021: Human Health in the Arctic" Chapter 2.

[350] Arctic region, "Arctic Region Declaration in Preparation for the Global Food Systems Summit."

[351] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.7.

[352] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.3.

Peoples eat more locally-sourced food than non-Indigenous Peoples in Fennoscandia and throughout the Arctic, proving the strength of subsistence culture.[353] While there are no statistics on harvest relating to ethnicity in Sápmi, Petrenya et al. (2018) found in their study that Sámi eat more traditional food such as reindeer, moose and freshwater fish than non-Sámi.[354]

To respond to the changes in seasonality, and safety of land, ice, river, and snow travel conditions, IPCC (2019) reports that Arctic Indigenous Peoples have already adjusted the timing of activities[355] and communities are experiencing disruptions to livelihoods and subsistence harvests due to factors such as changes in precipitation, snow conditions, temperatures and tundra productivity. This affects the availability of traditional foods, as well as their traditional preparation and storage.[356] An example from Sápmi was highlighted by a participant at a Saami Council workshop: *"The snow is different. We usually do ice cellars but it's different now. It's not possible."* Transportation access for subsistence activities on frozen sea, rivers, lakes and land is decreasing with warming conditions due to thinner ice, later freeze-up, earlier ice break-up and unpredictable weather. The safety of boats on open water is also affected by the changing climate, affecting fisheries.[357] For some coastal communities in the Arctic, harmful algal blooms and waterborne diseases threaten food security, economy and livelihoods.[358]

As noted in previous sections, food safety risks have increased. New waterborne diseases emerging in the Arctic[359] in combination with the enhanced movement and accumulation of toxins, contaminants and persistent organic pollutants (POPs) coming into marine food webs increases risks for human health.[360] AMAP (2021) underlines that understanding climate-related changes in contaminant transport and its possible consequences for Arctic Indigenous Peoples in particular is critical for predicting future risks and then addressing them through national, multilateral or global policy actions.[361] Health and well-being connected to climate change are further discussed in chapter five.

A climate driven increase in diseases in ecosystems on the land might threaten the safety of traditional foods.[362] This is in addition to declines in wildlife populations in parts of the Arctic. Observations of change in taste and quality of berries and meat have also been reported. AMAP (2021) highlights that reindeer husbandry in Sápmi and in parts of Russia has been particularly affected by rain-on-snow events and extreme snowfall, resulting in losses of herds during winter and late spring.[363] Climate change impacts in relation to reindeer husbandry are further complicated by limited flexibility and non-climate factors. In the latest assessment by the IPCC,

[353] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[354] Petrenya et al., "Food in Rural Northern Norway in Relation to Sami Ethnicity: The SAMINOR 2 Clinical Survey."

[355] Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.7.3.

[356] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.D.2.2.

[357] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

[358] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.3.4.

[359] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.6 Human Health and Wellness in the Arctic.

[360] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.3.4.

[361] AMAP 2021, "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers."

[362] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.4.3.2.2 Wildlife.

[363] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

Sámi reindeer husbandry is highlighted under the section 'loss and damage to vulnerable livelihoods in Europe' which states that, "…impacts cascade due to a lack of access to key ecosystems, lakes and rivers, thereby threatening traditional livelihoods, food security, cultural heritage (e.g. burial grounds, seasonal dwellings and routes), mental health, and growing costs from supplementary feeding of reindeer."[364]

Climate change will pose future risks to culturally and economically important fundamental activities for Arctic Indigenous Peoples. Impacts from increasing heat waves, extreme precipitation, permafrost loss and rapid seasonal snow and ice thaw events threaten subsistence food resources across the Arctic.[365]

Loss and damage

'Loss and damage' is a frequently used term within global climate politics and negotiations under the UNFCCC and is generally understood to result from both extreme weather events like cyclones, floods, droughts and heatwaves, and slow-onset events. Slow-onset events include changes such as sea level rise, desertification, glacial retreat, land degradation, ocean acidification and ocean salinization. 'Losses' include those that can be of economic and non-economic nature, with the latter referring to loss of human lives, culture, livelihoods, cultural identity etc. Non-economic losses have cascading and long-term effects on the well-being of affected people, despite being more difficult to quantify and monetize.[366] More broadly, loss and damage is climate change affecting ecosystems and people by causing severe damage to critical infrastructure, as well as emergency preparedness systems and monitoring systems, but also to culture and traditional livelihoods – with impacts that can affect societies across generations.[367] Indigenous Peoples are already negatively impacted by the loss of ecosystem functions, replacement of endemic species and regime shifts in the environment which threatens adaptive capacity. IPCC emphasizes that as global warming continues, more human and natural systems will reach their adaptation limits and therefore increase the risks for losses and damages. Deep cuts in emissions will be necessary to minimize irreversible loss and damage.[368]

International debates on loss and damage have not addressed the Arctic, even though Arctic Indigenous Peoples advocate for the need to properly acknowledge and address that loss and damage is occurring in the Arctic, which in turn requires measures for immediate action for mitigation and adaptation. Tundra decline, permafrost thaw, tree line advance, loss of palsa mires, along with albedo changes and diminishing sea ice, soil and coastal erosion, sea-level rise, and changes in snow cover extent are a few examples of slow-onset events currently threatening the Arctic region, together with direct impacts from extreme events such as storms, floods, and landslides. These events come with major impacts on people and ecosystems. [369]

[364] Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.8.1.3 Loss and Damage to Vulnerable Livelihoods in Europe.

[365] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.3.1.

[366] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.1.6.

[367] Landauer and Juhola, "Loss and Damage in the Rapidly Changing Arctic."

[368] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.B.1.6, TS.D.2.3 and TS.E.4.5.

[369] Landauer and Juhola, "Loss and Damage in the Rapidly Changing Arctic."

Changes in coastal ecosystems, intensified by extreme events, affect coastal communities that also are increasingly vulnerable to coastal erosion through wave and storm action, in particular in the North American Arctic.[370] As warming temperatures increase, so does the risk of microbial and chemical contamination of locally harvested foods, food-borne disease risks are expected to increase. It might also further challenge traditional food preparation techniques and utilities of traditional food storage such as ice cellars.[371]

A changing Arctic: growing attention and new opportunities

Climate change is only one of many multiple drivers contributing to change in the Arctic. Hundreds of billions of dollars are expected to be invested in the polar regions in the next several decades while climate change is expected to lead to an increase in human populations, activities and developments of many kinds. Climate change enables development possibilities for fisheries, agriculture, the sharing and subsistence economy, maritime trade, tourism, forestry, transportation and shipping, and natural resource development.[372] [373] While these developments are not risk-free, they are however projected to be a part of the future of the Arctic.

AMAP (2021) reports that there has been a general increase in Arctic tourism. This increase is centered around Iceland, Arctic Fennoscandia, and Alaska among other places, and winter tourism has increased in Tromsø, Norway and in Rovaniemi, Finland.[374] While the 'opening of polar seaways' due to loss of sea-ice is enabling increased shipping, there are weak correlations to increased shipping from those vessels supporting international trade etc. at the moment, but stronger correlations to the traffic coming from yachts and cruise ships.[375] The Arctic cruise ship industry has been expanding to meet demand and the biggest expansion has happened within the 'last chance tourism' that is marketing vulnerable or vanishing destinations or features to be seen 'before they are gone'. Northern Norway and its ports alone have experienced a 33% increase in cruise tourism between 2014 and 2019. Tourism is an integral part of local economies, both inland and along the coasts, and has become an alternative source of income for many. Tourism increases also generate risks to ecosystems, and rising infrastructure costs, local overcrowding, congestion, and cultural impacts.[376] [377]

Polar cruise tourism is expected to increase further with more maritime accessibility[378] and land-based summer and winter tourism is also estimated to increase in the Nordic countries. In Finland, particularly northern Finland, climate change is expected to enhance winter tourism in the near future as skiing conditions in central Europe will be affected by lack of snow.[379] IPCC (2022) suggests that even at 1.5-2°C warming, climatic conditions from May to October are projected to become more favorable for summer tourism in northern Europe.[380] Tourism is sensitive to societal crises such as pandemics, as seen recently with covid-19, but events like a pandemic can also increase in-country tourism. In Sweden a higher demand for recreational activities has grown over time but this demand grew even further during the pandemic. This development put a lot of pressure on the mountain areas. Increased littering and disturbance to reindeer husbandry was reported during this period. Debates began on who has the right to claim mountain areas, pitting

370 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

371 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.6.

372 Constable et al. CCP6.2.4.

373 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

374 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

375 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" FAQ CCP6.2.

376 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

377 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.2.4.2.

378 Constable et al. CCP6.2.4.2.

379 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 6.

380 Bednar-Friedl et al., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change"13.5 Food, Fibre and Other Ecosystem Products.

reindeer husbandry and tourism against each other and spurring racism and prejudice against reindeer-herding Sámi on social media.[381] [382]The increased interest in Arctic tourism reveals a gap in current regulations and policies addressing human safety, environmental risks, and cultural impacts, according to the IPCC (2019). The industry's expected growth also emphasizes the need for multiple actors and stakeholders to identify and evaluate adaptation strategies, such as disaster relief management plans and visitor codes of conduct and respond to residents' perceptions of tourism in local destinations.[383]

Loss of sea ice presents the possibility for more shipping through quicker and cheaper Arctic routes. The Northern Sea Route is one out of three identified trade routes in the Arctic that is expected to become more accessible by mid-century, with both potential benefits and impacts. IPCC (2022) highlights that general risks for increased shipping include increased emissions, underwater noise pollution[384], potential for invasive marine species, and geopolitical issues that might stem from sovereignty tensions. Increased shipping and industrial activity in Arctic waters also means an increased risk for accidents.[385] Reductions in sea-ice combined with improved extraction and transportation technologies have also increased accessibility to natural resources across the Arctic. By 2040, under an intermediate emissions scenario, it is expected that sea ice will have declined enough to make gas production technologically feasible in the European off-shore Arctic. While opening up economic opportunities for Arctic residents and their governments, such development may also bring challenges, according to the IPCC. Improved accessibility to natural resources and/or an increased extraction of these, both on land and in the seas, has consequences for the environment and ecosystems, human safety, and local economic development of other sectors. It could also undermine global mitigation efforts as it would support continued global dependence on fossil fuels, contributing to further warming.[386] [387]

Cumulative impacts of climate change

Climate change impacts on wildlife, ecosystems, and people interact with many other factors including industrial development, pollution, hydroelectric development, tourism, shipping, and resource overexploitation.. The combined threats affect human safety and well-being in Arctic communities especially for Indigenous Peoples who rely on functioning marine and terrestrial ecosystems.[388] [389] This means that in addition to environmental changes, policy, governance, economic, and social factors all play a role in responding to climate change effects on communities, livelihoods, and people.

IPCC (2022) notes that the complexity of decision-making in polar regions can be a barrier to effective climate adaptation. Globalization interacts with governance arrangements ranging from local to global in scope, as well as diverse stakeholder perspectives and needs. Reduced adaptation effectiveness, or even maladaptation, can result from decision-making processes that do not explicitly consider local impacts and responses. This can occur as a result of non-polar states' interest in and management of polar resources. In an Arctic context, the societal burden of climate change impacts will be felt at the local level. This means that local governance bodies must lead and be heard in decision-making for effective adaptation.[390]

381 Sveriges Radio, "Länsstyrelsen: Stor Okunskap Bland Fjällturister – Bryter Mot Förbud."

382 Dagens Nyheter, "Samer: "Nya Trender i Fjällturismen Stressar Renarna"."

383 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate"3.5.2.4 Tourism.

384 'Noise pollution' can be described as the impacts from underwater noise, that in some parts of the Arctic is already at levels that are likely interfering with the abilities of whales, seals, and walrus to communicate and use sound, and could be affecting other marine life.

385 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Box CCP6.1.

386 Constable et al. CCP6.2.4.1.

387 Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate."

388 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Table CCP6.3.

389 Pörtner et al., "IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" A.7.4.

390 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.3.2.3 Maladaptation and limits to adaptation.

Assessing societal impacts, according to AMAP (2021), necessitates an understanding of complex causal chains, such as how physical drivers underpin multiple climate-related hazards and how societal drivers exacerbate the effects. Future assessments must therefore be more cross-disciplinary in order to address compound and cascading effects. Assessments should also include an authentic co-production process with respectful engagement of Indigenous Peoples.

A partnership approach that builds on co-design and co-production of knowledge can contribute to a better and more integrative understanding of the societal impacts of climate change by including those who stand to be most affected. However, a full partnership with Indigenous communities to bridge Indigenous knowledge and Western science approaches is not yet the norm.[391]

Energy transition and resource extraction destructing Sámi land

In Sápmi, impacts of climate change are exacerbated by new industrial developments taking place within Sámi territory (see example in chapter 3), hampering adaptive capacity and putting a large burden on the Sámi society - the burden of climate change but also the burden of mitigation. "It is land grabbing in the name of the climate. It is unjust" Aili Keskitalo, former president at the Sámi Parliament in Norway said at the Arctic Circle assembly in 2018. The term **green colonialism** is frequently used by the Sámi to critique hegemonic climate change policies, as the current climate and ecological crisis is a result of colonization and capitalist expansion on Indigenous lands (Fjellheim, 2022). Developments taking place in Sápmi aimed to secure what governments refer to as a 'green transition' include measures such as increased mining for raw materials, increase in energy production through wind power plants and hydropower and increases in bioenergy from forestry. In the declaration from the sixth Conference of Sámi Parliamentarians in May 2022, it is emphasized that the green transition in terms of designing climate action globally and in the Arctic, cannot violate the Sámi right to self-determination or prevent Indigenous Peoples from exercising their traditional economy and land use (Conference of Sámi Parliamentarians, 2022).

Green colonialism takes many shapes in Sápmi through already existing energy projects, resource extraction, and mitigation policies. With the recent developments in Europe and the need to build energy resilience and strengthen its autonomy due to the geopolitical crisis, even greater pressure from external actors on Sámi land is expected. The EU Commission proposed in May 2022 to increase the EU's 2030 target for renewables from 40% to 45% with the new REPowerEU Plan, even more than what is already envisaged under EU's Fit for 55 package. To get there, short term measures include among other things 'rapid roll out of solar and wind energy projects combined with renewable hydrogen deployment…' to decrease EU's dependency on imported gas (EU Commission, 2022). The European Investment Bank means that the current geopolitical situation which has pushed Europe into an energy crisis requires urgent action, through which Europe must strengthen its energy resilience and accelerate its transition to a low-carbon economy, not only to mitigate climate change but also to ensure security and autonomy (European Investment Bank, 2022). The Arctic has already been identified as a region with 'huge potential for renewables' and development of clean energy in EU's updated Arctic policy. It further stresses that the Arctic states are 'potentially significant suppliers of critical and other raw materials' (European Commission, 2021). The Saami Council issued a statement noting the great concern for EU's support for further resource extraction in the European Arctic (Saami Council, 2021).

"Climate change is leading to a massive change in the way Sámi land is used. Sápmi continues to be a source of resources targeted by governments and outside capital.. The green shift is nothing more than a continued extraction of resources in Sámi areas, as has been the tradition since the earliest encounters between cultures. The difference is that resource utilization has been given a nice color, green; we call it "green colonization." We were first colonized by people from outside our lands, then colonized by climate change itself, driven by people from outside our lands, and are now being colonized a third time by responses to climate change. […] It will lead to Sámi culture balancing on the verge of extinction in many areas. Reindeer husbandry and small-scale fisheries need more flexibility to adapt their activities, not less flexibility, which are the consequences of the green shift. At the same time, the business community still lives by the principle of seeking continuous economic growth, economies that are built on people's ever-increasing consumption patterns."
– Gunn-Britt Retter, 2021

[391] AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

State and EU Climate related Policies

Finland, Norway, Sweden and the European Union's climate commitments at a glance:
Under the UNFCCC, the Paris Agreement (2015) in article 2 establishes three elements as a global response to the threat of climate change: (a) that the global average temperature should not exceed 2C above pre-industrial levels, but calls to limit the temperature increase to 1,5C; (b) a call for adaptation efforts to the adverse impacts of climate change and to enable climate resilience, specifically not to threaten food production; and (c) it calls for finance flows to ensure a development towards low greenhouse gas emissions and climate resilient development.

FINLAND

Finland declared it must become climate neutral by 2035. Thereafter aiming to reduce greenhouse gas emissions by at least 80% by 2040 and by at least 90 % by 2050, but aiming for 95%, compared to the levels in 1990.

As an EU member, Finland is bond by the EU climate and energy legislation. See section on EU. (EU: 55% reduction of greenhouse gas emissions by 2030 compared to 1990 levels. EU's objectives is to become the first climate-neutral continent by 2050.

Finland's climate policy steering instruments under the Climate Act consists of four national policy plans: Long-term Climate Plan, Adaptation Plan, Medium-term Climate Plan and Climate Plan for the Land Use Sector. In addition, there is the separate Energy and Climate Strategy. The Climate Act further calls for actions for climate adaptation through strengthening of climate resilience and the management of climate crises. (4. man genom nationella åtgärder anpassar sig till klimatförändringar genom att främja klimatresiliensen och hanteringen av klimatrisker.)

The monitoring of climate actions is built on an annual Climate Change Report describing the trends of emission reductions in Finland, as well as implementation of emission reduction measures and their adequacy relative to the targets. Finland also reports to the EU.

Part of the Climate change Act is to establish a Sámi Climate Change Council (§21). A Sámi Climate Change Council will be set up as an independent expert body consisting of Sámi Indigenous knowledge holders and representatives from relevant fields of science. It will support the preparation of the climate change policy plans and give opinions on them from the perspective of the Sámi people. The Sámi Climate Change Council can also carry out other tasks related to develop the knowledge foundation related to climate change and the Sámi culture and rights (author's translation of the text in the act). [392]

NORWAY

Norway adopted the Climate Act in 2017 and updated its target in June 2021 now stating its climate goals are by 2030 to reduce the greenhouse gas emissions with at least 50 going towards 55 percent compared with 1990 and by 2050 reduced to 90 -95 percent. When assessed, the calculations should be based on Norway's participation in the European climate quota system. The ambition is by 2050 to be a low emission society.

The act does not intend to hinder that the targets can achieved jointly with the EU. (Loven skal ikke være til hinder for at klimamål fastsatt i eller i medhold av denne lov kan gjennomføres felles med EU.)

Starting from 2020, the act calls, among other things, for an update of the set climate goals every five years. These updated climate goals should be based on the best available scientific foundation; and as far as possible be quantified and measurable. The Government is committed to provide annual updates to the Parliament on among other things the status of development towards low emission society, and how Norway is preparing for adaptation to climate changes.[393] [394]

[392] "FINLEX ® - Säädökset alkuperäisinä."

[393] "Lov Om Klimamål (Klimaloven) - Lovdata."

[394] "Lov Om Endringer i Klimaloven (Klimamål for 2030 Og 2050) - Lovdata."

SWEDEN

In 2017 Sweden passed a climate policy framework entailing national climate goals, a climate act and a climate policy council. The policy framework long-term climate goal establishes that, by 2045 at the latest, Sweden is to have zero net emission of greenhouse gases and followed thereafter with negative emissions. By 2045, greenhouse gas emissions from Swedish territory are to be at least 85 per cent lower than emissions in 1990.

The EU's climate policy has a major impact on how Swedish policy can be conducted. Milestone targets for Swedish emissions covered by the EU's effort sharing regulation (i.e. outside the EU Emissions Trading System) for 2020, 2030 and 2040.

Sweden's Climate Act represents an obligation on current and future governments to pursue a policy based on the national climate goals. The Climate Policy Council is an independent expert body tasked with evaluating whether the overall policy decided by the Government is compatible with the climate goals.[395] [396]

What does it mean to be net zero?

Net zero means achieving a balance between the greenhouse gases put into the atmosphere and those taken out.

Think about it like a bath – turn on the taps and you add more water, pull out the plug and water flows out. The amount of water in the bath depends on both the input from the taps and the output via the plughole. To keep the amount of water in the bath at the same level, you need to make sure that the input and output are balanced.

Reaching net zero applies the same principle, requiring us to balance the amount of greenhouse gases we emit with the amount we remove. When what we add is no more than what we take away, we reach net zero.[397]

[395] Naturvårdsverket, "Sweden's Climate Act and Climate Policy Framework.

[396] Persson, "Sweden's Long-Term Strategy for Reducing Greenhouse Gas Emissions."

[397] Nationalgrid, "What Is Net Zero? | National Grid Group."

EUROPEAN UNION

The European Commission presents the The European Green Deal in December 2019. The EU's ambition is a climate-neutral EU by 2050 with less pollution, better protection of health and the environment, increased quality of life, healthy ecosystems and conservation of biological diversity, as well as clean and safe food and energy. The green transition will give European business and industry a competitive advantage, and new, green jobs will be created. The EU aims to keep the consumption of resources within the planet's tolerance. The transition to a circular economy is an important prerequisite for managing this. Research and innovation are key drivers in the transition to a low-emission society.

The European Climate Law writes into law the goal set out in the European Green Deal Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.

Climate neutrality by 2050 means achieving net zero greenhouse gas emissions for EU countries as a whole, mainly by cutting emissions, investing in green technologies and protecting the natural environment. The law aims to ensure that all EU policies contribute to this goal and that all sectors of the economy and society play their part.

Sweden and Finland as EU members are bound by the EU ambitions. Norway has in its Climate Act expressed that they intend to follow EU's ambitions and commitments.

The European Green Deal will guide EU's commitments also to the global processes in the climate conventions, Sustainable Development Goals and Global Biodiversity Framework (CBD).

Several revisions of existing policies, regulations are adjusted to match the ambitions the Green Deal. Fact sheets, mechanisms and strategies are developed to deliver on the transformative change called for and to fulfil the ambitions of EU becoming the first climate neutral continent.

«The European Green Deal sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind»[398]

There ambition is to increase offshore wind production will be essential. Smart integration of renewables, energy efficiency and other sustainable solutions across sectors will help to achieve decarbonisation at the lowest possible cost.

Green finance is an incentive EU will use to encourage in the desired direction. The Commission will present a Sustainable Europe Investment Plan, which will combine dedicated financing to support sustainable investments and proposals for frameworks leading to green investments. A Just Transition fund is also part of this finance mechanism, intending to leave no one behind.[399] [400]

[398] European Commission, "A European Green Deal."

[399] European Commission, "European Climate Law."

[400] EUR-lex, Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').

References chapter 4

AMAP 2017. "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area." Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2017.
AMAP 2017. "Snow, Water, Ice and Permafrost in the Arctic. Summary for Policy-Makers." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2017.
AMAP 2018. "AMAP Assessment 2018: Arctic Ocean Acidification." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2018.
AMAP 2019. "Arctic Ocean Acidification Assessment 2018: Summary for Policy-Makers." Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2019.
AMAP 2020. "AMAP Assessment 2020: POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2020.
AMAP 2021. "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts." Tromsø, Norway: Arctic Monitoring and Assessment Programme., 2021.
AMAP 2021. "AMAP Assessment 2021: Human Health in the Arctic." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.
AMAP 2021. "Arctic Climate Change Update 2021: Key Trends and Impacts. Summary for Policy-Makers." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.
AMAP 2021. "Mercury Assessment. Summary for Policy-Makers." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.
AMAP 2021. "POPs and Chemicals of Emerging Arctic Concern: Influence of Climate Change. Summary for Policy-Makers." Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.
Arctic Program. "Arctic Report Card: Sea Ice," January 5, 2023. [Online] Available at: https://arctic.noaa.gov/Report-Card/Report-Card-2022/ArtMID/8054/ArticleID/989/Sea-Ice. [Accessed 10 February 2023]
Arctic region. "Arctic Region Declaration in Preparation for the Global Food Systems Summit." Inuit Circumpolar Council & Saami Council, 2021. [Online] Available at: https://summitdialogues.org/wp-content/uploads/2021/07/FINAL-ARCTIC-REGION-Declaration-in-preparation-for-the-FSS_29062021.pdf. [Accessed 10 February 2023]
Arheimer, Berit, and G. Lindström. "Climate Impact on Floods: Changes in High Flows in Sweden in the Past and the Future (1911-2100)." *Hydrology and Earth System Sciences* 19 (February 4, 2015): 771–84. https://doi.org/10.5194/hess-19-771-2015.
Bednar-Friedl, B., R. Biesbroek, D.N Schmidt, P. Alexander, K.Y. Børsheim, J. Carnicer, E. Georgopoulou, et al. "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.
Benestad, Rasmus E. "A New Global Set of Downscaled Temperature Scenarios." *Journal of Climate* 24, no. 8 (2011): 2080–98.
Beniston, Martin, Daniel Farinotti, Liss Marie Andreassen, Erika Coppola, Nicolas Eckert, Adriano Fantini, Florie Giacona, et al. "The European Mountain Cryosphere: A Review of Its Current State, Trends, and Future Challenges." *The Cryosphere* 12 (March 1, 2018): 759–94. https://doi.org/10.5194/tc-12-759-2018.
Biskaborn, Boris, Sharon Smith, Jeannette Noetzli, Heidrun Matthes, Gonçalo Vieira, Dmitry Streletskiy, Philippe Schoeneich, et al. "Permafrost Is Warming at a Global Scale." *Nature Communications* 10 (January 16, 2019). https://doi.org/10.1038/s41467-018-08240-4.
Blinova, Ilona, and Frank-Michael Chmielewski. "Climatic Warming above the Arctic Circle: Are There Trends in Timing and Length of the Thermal Growing Season in Murmansk Region (Russia) between 1951 and 2012?" *International Journal of Biometeorology* 59 (August 27, 2014). https://doi.org/10.1007/s00484-014-0880-y.
Borge, Amund, Sebastian Westermann, Ingvild Solheim, and Bernd Etzelmüller. "Strong Degradation of Palsas and Peat Plateaus in Northern Norway during the Last 60 Years." *The Cryosphere Discussions*, February 5, 2016, 1–31. https://doi.org/10.5194/tc-2016-12.
Brittain, J., Gísli Gíslason, Vasily Ponomarev, Jim Bogen, Sturla Brørs, Arne Jensen, Ludmila Khokhlova, et al. "Arctic Rivers." In *Rivers of Europe*, 337–79, 2009. https://doi.org/10.1016/B978-0-12-369449-2.00009-6.
CAFF 2013. "CAFF 2013: Arctic Biodiversity Assessment: Report for Policy Makers." Akureyri, Iceland: Conservation of Arctic Flora and Fauna (CAFF), 2013.
Chen, Yang, David Romps, Jacob Seeley, Sander Veraverbeke, William Riley, Zelalem Mekonnen, and James Randerson. "Future Increases in Arctic Lightning and Fire Risk for Permafrost Carbon." *Nature Climate Change* 11 (May 1, 2021): 1–7. https://doi.org/10.1038/s41558-021-01011-y.
Conference of Sámi Parliamentarians. "Declaration from the Sixth Conference of Sámi Parliamentarians in Aanaar, 19 May 2022," 2022. [Online] Available at: https://www.sametinget.se/168525. [Accessed 10 February 2023]
Constable, A.J., S. Harper, J. Dawson, K. Holsman, T. Mustonen, D. Piepenburg, and B. Rost. "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.
Dagens Nyheter. "Samer: "Nya Trender i Fjällturismen Stressar Renarna". *Dagens Nyheter*, June 9, 2021. [Online] Available at: https://www.dn.se/insidan/samer-nya-trender-i-fjallturismen-stressar-renarna/. : [Accessed 10 February 2023]
Dryselius, Rikard, Marika Hjertqvist, Signar Mäkitalo, Anders Lindblom, Tobias Lilja, Disa Eklöf, and Anders Lindström. "Large Outbreak of Tularaemia, Central Sweden, July to September 2019." *Eurosurveillance: Bulletin Europeen Sur Les Maladies Transmissibles = European Communicable Disease Bulletin* 24 (October 17, 2019): 7–11. https://doi.org/10.2807/1560-7917.ES.2019.24.42.1900603.
Dvoretsky, Alexander G., and Vladimir G. Dvoretsky. "Inter-Annual Dynamics of the Barents Sea Red King Crab (Paralithodes Camtschaticus) Stock Indices in Relation to Environmental Factors." *Polar Science* 10, no. 4 (December 2016): 541–52. https://doi.org/10.1016/j.polar.2016.08.002.
Eira, Inger Marie, Anders Oskal, Inger Hanssen-Bauer, and Svein Mathiesen. "Snow Cover and the Loss of Traditional Indigenous Knowledge." *Nature Climate Change* 8 (October 29, 2018). https://doi.org/10.1038/s41558-018-0319-2.
European Commission. "Joint Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Stronger EU Engagement for a Peaceful, Sustainable and Prosperous Arctic," October 13, 2021.
European Commission. "REPowerEU: Affordable, Secure and Sustainable Energy for Europe." Official website of the European Commission, n.d. [Online] Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en. [Accessed 10 February 2023]

European Investment Bank. "The Answer Is Green." European Investment Bank, November 16, 2022. [Online] Available at: https://www.eib.org/en/stories/green-transition-energy. [Accessed 10 February 2023]

Fjellheim, Eva Maria. "Green Colonialism, Wind Energy and Climate Justice in Sápmi." *Debates Indígenas*, November 12, 2022. [Online] Available at: https://debatesindigenas.org/ENG/ns/191-green-colonialism-wind-energy-climate-justice-sapmi.html. [Accessed 10 February 2023]

Fölster, Jens, Øyvind Garmo, Peter Carlson, Richard Johnson, Gaute Velle, Kari Austnes, Simon Hallstan, et al. "Acidified or Not? A Comparison of Nordic Systems for Classification of Physicochemical Acidification Status and Suggestions towards a Harmonised System," January 1, 2021.

Forbes, Bruce C., Minna T. Turunen, Päivi Soppela, Sirpa Rasmus, Terhi Vuojala-Magga, and Heidi Kitti. "Changes in Mountain Birch Forests and Reindeer Management: Comparing Different Knowledge Systems in Sápmi, Northern Fennoscandia." *Polar Record* 55, no. 6 (2019): 507–21. https://doi.org/10.1017/S0032247419000834.

Hanssen-Bauer, Inger, Eirik Førland, Ingjerd Haddeland, Hege Hisdal, Deborah Lawrence, Stephanie Mayer, Atle Nesje, et al. *Climate in Norway 2100*, 2017.

Hanssen-Bauer, Inger, Rasmus E. Benestad, Julia Lutz, Dagrun Vikhamar-Schuler, Pavel Svyashchennikov, and Eirik J. Førland. "Comparative Analyses of Local Historical and Future Climate Conditions Important for Reindeer Herding in Finnmark, Norway and the Yamal Nenets Autonomous Okrug, Russia." In *Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1*, edited by Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, and Marina Tonkopeeva, 187–222. Cham: Springer International Publishing, 2023. https://doi.org/10.1007/978-3-031-17625-8_8.

Hedger, Richard, Line Sundt-Hansen, Torbjørn Forseth, Ola Ugedal, Ola Diserud, Ånund Kvambekk, and Anders Finstad. "Predicting Climate Change Effects on Subarctic–Arctic Populations of Atlantic Salmon (Salmo Salar)." *Canadian Journal of Fisheries and Aquatic Sciences* 70 (February 1, 2013): 159–68. https://doi.org/10.1139/cjfas-2012-0205.

Hock, R., G. Rasul, C. Adler, B. Cáceres, S. Gruber, Y. Hirabayashi, M. Jackson, et al. "IPCC, 2019: High Mountain Areas. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate." Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2019.

Ims A. Finnmark 2100: Hva Betyr Kimaendringene for Artene På Land? *Meahcásteapmi Nuppástuvvan Meahcis*. Nanne Konferensen 2022., 2022. [Online] Available at: https://ww.fefo.no/aigeguovdil/meahcasteapmi-nuppastuvvan-meahcis.7214.aspx. [Accessed 10 February 2023]

Jaakkola, J.J.K, S. Juntunen, and K. Näkkäläjärvi. "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union." *Current Environmental Health Reports* 5, no. 4 (2018): 401–17. https://doi.org/10.1007/s40572-018-0211-2.

Jansson, Roland, Christer Nilsson, E. Carina Keskitalo, Vlasova Tatiana, Marja-Liisa Sutinen, Jon Moen, F Stuart Chapin III, et al. "Future Changes in the Supply of Goods and Services from Natural Ecosystems: Prospects for the European North." *Ecology and Society* 20 (September 14, 2015): 32. https://doi.org/10.5751/ES-07607-200332.

Jepsen, Jane U., Snorre B. Hagen, Rolf A. Ims, and Nigel G. Yoccoz. "Climate Change and Outbreaks of the Geometrids Operophtera Brumata and Epirrita Autumnata in Subarctic Birch Forest: Evidence of a Recent Outbreak Range Expansion." *Journal of Animal Ecology* 77, no. 2 (March 2008): 257–64. https://doi.org/10.1111/j.1365-2656.2007.01339.x.

Karlsen, Stein Rune, Hans Tømmervik, Bernt Johansen, and Jan Åge Riseth. "Future Forest Distribution on Finnmarksvidda, North Norway." *Climate Research* 73, no. 1 & 2 (2017): 125–33.

Käyhkö, Jukka, and Tim Horstkotte. *Reindeer Husbandry under Global Change in the Tundra Region of Northern Fennoscandia*, 2017. https://doi.org/10.13140/RG.2.2.22151.39841.

Landauer, Mia, and Sirkku Juhola. "Loss and Damage in the Rapidly Changing Arctic." In *Loss and Damage from Climate Change: Concepts, Methods and Policy Options*, edited by Reinhard Mechler, Laurens M. Bouwer, Thomas Schinko, Swenja Surminski, and Jo-Anne Linnerooth-Bayer, 425–47. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-319-72026-5_18.

Luomaranta, Anna, Juha Aalto, and Kirsti Jylhä. "Snow Cover Trends in Finland over 1961–2014 Based on Gridded Snow Depth Observations." *International Journal of Climatology* 39, no. 7 (June 15, 2019): 3147–59. https://doi.org/10.1002/joc.6007.

Ma, Yan, Arvid Bring, Zahra Kalantari, and Georgia Destouni. "Potential for Hydroclimatically Driven Shifts in Infectious Disease Outbreaks: The Case of Tularemia in High-Latitude Regions." *International Journal of Environmental Research and Public Health* 16, no. 19 (2019). https://doi.org/10.3390/ijerph16193717.

Markkula, Inkeri, Minna Turunen, and Sirpa Rasmus. "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland." *Science of The Total Environment* 692 (November 20, 2019): 1070–85. https://doi.org/10.1016/j.scitotenv.2019.07.272.

Marshall, Gareth J., Rebecca M. Vignols, and W. G. Rees. "Climate Change in the Kola Peninsula, Arctic Russia, during the Last 50 Years from Meteorological Observations." *Journal of Climate* 29, no. 18 (September 15, 2016): 6823–40. https://doi.org/10.1175/JCLI-D-16-0179.1.

Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, Y. Caud, et al. "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2021.

Meredith, M., M. Sommerkorn, S Cassotta, C Derksen, A Ekaykin, A Hollowed, G Kofinas, et al. "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate." Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2019.

Meterologisk Institutt. "Nord-Norge siden 1900." Meteorologisk institutt, 2023. [Online] Available at: https://www.met.no/vaer-og-klima/klima-siste-150-ar/regionale-kurver/nord-norge-siden-1900. [Accessed 10 February 2023]

Mikkonen, Santtu, Marko Laine, Hanna Mäkelä, Hilppa Gregow, Heikki Tuomenvirta, M. Lahtinen, and A. Laaksonen. "Trends in the Average Temperature in Finland, 1847–2013." *Stochastic Environmental Research and Risk Assessment* 29 (December 17, 2014). https://doi.org/10.1007/s00477-014-0992-2.

Miljøstatus. "Barentshavet." Miljøstatus, January 5, 2023. [Online] Available at: https://miljostatus.miljodirektoratet.no/tema/hav-og-kyst/barentshavet/. [Accessed 10 February 2023]

Miljøstatus. "Havisutbredelse i Barentshavet." Miljøstatus, January 5, 2023. [Online] Available at: https://miljostatus.miljodirektoratet.no/tema/hav-og-kyst/havindikatorer/barentshavet/havklima/havisutbredelse-i-barentshavet/. [Accessed 10 February 2023]

Moen, Jon. "Climate Change: Effects on the Ecological Basis for Reindeer Husbandry in Sweden." *Ambio* 37, no. 4 (2008): 304–11.

Multeforkomster, Klima Og Vær, January 8, 2023. [Online] Available at:

Näkkäläjärvi, K., S. Juntunen, and J.J. Jaakkola. "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland." In *Climate Cultures in Europe and North America*, 103–25. London: Routledge, 2022.

Niittynen, Pekka, Risto K. Heikkinen, and Miska Luoto. "Decreasing Snow Cover Alters Functional Composition and Diversity of Arctic Tundra." *Proceedings of the National Academy of Sciences* 117, no. 35 (September 1, 2020): 21480–87. https://doi.org/10.1073/pnas.2001254117.

Nilsson, Lena. “Some Reflections on Swedish Food Strategies from a Sami and an Arctic Perspective,” 203–18, 2020. https://doi.org/10.4324/9781003057758-15.
Olvmo, M., B. Holmer, S. Thorsson, H. Reese, and F. Lindberg. “Sub-Arctic Palsa Degradation and the Role of Climatic Drivers in the Largest Coherent Palsa Mire Complex in Sweden (Vissátvuopmi), 1955-2016.” *Scientific Reports* 10, no. 1 (June 2, 2020). https://doi.org/10.1038/s41598-020-65719-1.
Petrenya, Natalia, Guri Skeie, Marita Melhus, and Magritt Brustad. “Food in Rural Northern Norway in Relation to Sami Ethnicity: The SAMINOR 2 Clinical Survey.” *Public Health Nutrition* 21, no. 14 (2018): 2665–77. https://doi.org/10.1017/S1368980018001374.
Pörtner, H.O, D.C Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, et al. “IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, UK and New York, NY, USA.: Intergovernmental Panel on Climate Change, 2022.
Pörtner, H.O, D.C Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E.S Poloczanska, K. Mintenbeck, et al. “IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.” Intergovernmental Panel on Climate Change, 2019.
Rasmus, Sirpa, Jouni Räisänen, and Michael Lehning. “Estimating Snow Conditions in Finland in the Late 21st Century Using the SNOWPACK Model with Regional Climate Scenario Data as Input.” *Annals of Glaciology* 38 (2004): 238–44. https://doi.org/10.3189/172756404781814843.
Rasmus, Sirpa, Sonja Kivinen, and Masoud Irannezhad. “Basal Ice Formation in Snow Cover in Northern Finland between 1948 and 2016.” *Environmental Research Letters* 13, no. 11 (November 1, 2018): 114009. https://doi.org/10.1088/1748-9326/aae541.
Retter, Gunn-Britt. “Indigenous Cultures Must Not Be Forced to Bear the Brunt of Global Climate Adaptation.” *Arctic Today*, November 25, 2021.
Riseth, Jan Åge, and Hans Tømmervik. “Klimautfordringer Og Arealforvaltning for Reindrifta i Norge Kunnskapsstatus Og Forslag Til Tiltak. Eksempler Fra Troms.” Northern research institute (Norut), August 10, 2017.
Roos, Anna, Mary Gamberg, Derek Muir, Anna Karrman, Pernilla Carlsson, Christine Cuyler, Ylva Lind, Rossana Bossi, and Frank Rigét. “Perfluoroalkyl Substances in Circum-ArcticRangifer: Caribou and Reindeer.” *Environmental Science and Pollution Research* 29 (April 1, 2022). https://doi.org/10.1007/s11356-021-16729-7.
Rose, Stine K., Ole B. Andersen, Marcello Passaro, Carsten A. Ludwigsen, and Christian Schwatke. “Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era: 1991–2018.” *Remote Sensing* 11, no. 14 (2019). https://doi.org/10.3390/rs11141672.
Saami Council. “EU Has Launched Its New Arctic Strategy,” October 15, 2021. [Online] Available at: https://www.saamicouncil.net/news-archive/eu-has-launched-its-new-arctic-strategy. [Accessed 10 February 2023]
Sámi Parliament in Sweden. “Klimatanpassning. Handlingsplan För Samiska Näringar Och Samisk Kultur.” Sametinget i Sverige, 2017.
Schimanke, Semjon, Magnus Joelsson, Sandra Andersson, Thomas Carlund, Lennart Wern, Sverker Hellström, and Erik Kjellström. “Observerad Klimatförändring i Sverige 1860–2021.” Klimatologi. Sveriges meteorologiska och hydrologiska institut (SMHI), 2022.
Sirpa, R., T. Horstkotte, M. Turunen, M. Landauer, A. Löf, I. Lehtonen, G. Rosqvist, and Ø. Holand Lehtonen. “Reindeer Husbandry and Climate Change. Challenges for Adaptation.” In *Reindeer Husbandry and Global Environmental Change – Pastoralism in Fennoscandia.*, 1st ed., 99–117. London: Routledge, n.d.
SMHI. “Framtidsklimat i Sveriges Län – Enligt RCP-Scenarier.” SMHI, November 2, 2015. [Online] Available at: https://www.smhi.se/klimat/framtidens-klimat/framtidsklimat-i-sveriges-lan-enligt-rcp-scenarier-1.95384. [Accessed 10 February 2023]
Sveriges Radio. “Länsstyrelsen: Stor Okunskap Bland Fjällturister – Bryter Mot Förbud.” *Sveriges Radio*, June 20, 2021. [Online] Available at: https://sverigesradio.se/artikel/lansstyrelsen-stor-okunskap-bland-fjallturister-bryter-mot-forbud. [Accessed 10 February 2023]
SWECO 2019. ”Syntesrapport: En Sammanställning Av Fyra Samebyars Pilotprojekt Med Klimat- Och Sårbarhetsanalys Samt Handlingsplan För Klimatanpassning.” SWECO, August 15, 2019.
Tømmervik, Hans, Bernt Johansen, Ingunn Tombre, D. Thannheiser, Kjell Høgda, E. Gaare, and Frans Wielgolaski. “Vegetation Changes in the Nordic Mountain Birch Forest: The Influence OfGrazing and Climate Change.” *Arctic Antarctic and Alpine Research* 36 (August 1, 2004): 323–32. https://doi.org/10.1657/1523-0430(2004)036[0323:VCITNM]2.0.CO;2.
Vasiliev, Denis, and Sarah Greenwood. “The Role of Climate Change in Pollinator Decline across the Northern Hemisphere Is Underestimated.” *Science of The Total Environment* 775 (June 25, 2021): 145788. https://doi.org/10.1016/j.scitotenv.2021.145788.
Vikhamar-Schuler, Dagrun, Ketil Isaksen, Jan Erik Haugen, Hans Tømmervik, Bartlomiej Luks, Thomas Vikhamar Schuler, and Jarle W. Bjerke. “Changes in Winter Warming Events in the Nordic Arctic Region.” *Journal of Climate* 29, no. 17 (September 1, 2016): 6223–44. https://doi.org/10.1175/JCLI-D-15-0763.1.
Young, Nathan, Camilla Brattland, Celeste Digiovanni, Bjørn Hersoug, Jahn Johnsen, Mari Karlsen, Ingrid Kvalvik, et al. “Limitations to Growth: Social-Ecological Challenges to Aquaculture Development in Five Wealthy Nations.” *Marine Policy* 104 (February 19, 2019). https://doi.org/10.1016/j.marpol.2019.02.022.
EUR-lex. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 (‘European Climate Law’), 243 OJ L § (2021). http://data.europa.eu/eli/reg/2021/1119/oj/eng.
European Commission. “A European Green Deal.” Accessed February 18, 2023. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.
———. “European Climate Law.” Accessed February 18, 2023. https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en.
“FINLEX - Säädökset alkuperäisinä: Ilmastolaki 423/2022.” Oikeusministeriö, 2022. https://www.finlex.fi/fi/laki/alkup/2022/20220423.
“Lov Om Endringer i Klimaloven (Klimamål for 2030 Og 2050) - Lovdata,” 2021. https://lovdata.no/dokument/LTI/lov/2021-06-18-129.
“Lov Om Klimamål (Klimaloven) - Lovdata,” 2018. https://lovdata.no/dokument/NL/lov/2017-06-16-60.
Nationalgrid. “What Is Net Zero? | National Grid Group.” Accessed February 18, 2023. https://www.nationalgrid.com/stories/energy-explained/what-is-net-zero.
Naturvårdsverket. “Sweden’s Climate Act and Climate Policy Framework.” Accessed February 18, 2023. https://www.naturvardsverket.se/en/topics/climate-transition/sveriges-klimatarbete/swedens-climate-act-and-climate-policy-framework/.
Persson, Jens. “Sweden’s Long-Term Strategy for Reducing Greenhouse Gas Emissions.” Government Offices of Sweden, Ministry of the Environment, 2020.

5. Climate change and related impacts on Sámi culture and society

This chapter presents an overview of how climate change impacts Sámi society, culture and livelihoods, based on research and the workshops and written interviews carried out with Sámi knowledge holders.

> *"According to our knowledge, we follow the seasons. Nowadays it is more challenging to identify when it is time for the various activities. Even the animals are not providing weather signs. The skill of reading nature might have decreased among us. If we are to cope, we need to know how to read the signs. Nowadays when crises are rising, we need to know the traditional skills."*
>
> **– said by a Sámi knowledge holder at the workshop in Ohcejohka**

In the Sámi cosmology, humans are seen as part of nature, not above other forms of life, where maintaining harmony within the ecosystem is the core value. Guiding principles are modesty – taking only what is needed – and respect, towards other beings both as individuals and as populations. This reciprocal relationship with nature is a key value which binds people to their environment, history and heritage. While benefiting from the gifts of nature, it also brings a responsibility to maintain a balance within the ecosystem and to safeguard the healthy environment as a foundation of all life.[401] "The salmon you catch should last from the time the river freezes until it opens again", according to a Sámi saying in the Deatnu area. If you still have salmon from last summer when the new fishing season begins, your luck will not be with you–you've either taken too many fish or shared too little. To fish for salmon is called "bivdit luosa" in Northern Sámi, but the word "bivdit" can also mean "to ask for" salmon. A key lesson in Sámi culture is to never ask for more than you need.[402]

Sámi culture and livelihoods, economies and ways of life are broad and diverse. Reindeer herding, fishing, hunting, gathering, and duodji are core elements of Sámi culture. The long cultural traditions embedded within Sámi livelihoods and the knowledge related to them are passed on intergenerationally within families. Many Sámi combine traditional livelihoods and/or hold other occupations. With sustainability, árbediehtu (Sámi Indigenous knowledge), and culture serving as the foundational pillars, many Sámi businesses and enterprises today are small or micro-businesses, often in combination with several other activities and often characterized by combining non-market values and market participation.

As noted in earlier chapters, climate warming is already altering the ecological and cultural landscape in Sápmi in many ways. The Sámi participants at the larger workshop in Váhtjer highlighted their concerns on the long-term impacts on Sámi culture and ways of life in a changing environment. Special attention was given to the impacts on food security, Sámi Indigenous knowledge and its transmission, and duodji: if duodji will change as climate change might hamper access to, and use of duodji materials. Markkula et al. (2019) concluded from their study that climate change risks changing basic conditions for Sámi culture, food security, the use of the traditional Sámi area, areas for hunting and fishing and Sámi Indigenous knowledge. Changes in Sámi cultural landscapes and ecosystems already affect Sámi livelihoods, such as reindeer husbandry, salmon fishing, gathering, ptarmigan trapping and duodji–both negatively and positively–and future alterations can be expected. Further changes that enhance negative impacts consequently risk

[401] Holmberg, "«Dat lea du olbmuid, du máttuid luodda»–Sámi árvvut ja árvvoštallan ekovuogádathálddašeamis (Sámi values and valuation in ecosystem management)".

[402] Holmberg, "Bivdit Luosa – To Ask for Salmon. Saami Traditional Knowledge on Salmon and the River Deatnu: In Research and Decision-making".

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

leading to a loss of practice-based traditional knowledge and the language that describes that knowledge. Such changes will alter peoples' sense of place and erode cultural meanings, stories, memories and traditional knowledge attached to them, according to the researchers. The potential impacts on Sámi society are thus broad and diverse as cultural identity, heritage, and sense of place are embodied in cultural landscapes.[403]

Näkkäläjärvi et al. (2022) have also found that Sámi culture is subject to change as a result of rapid changes in landscape, biodiversity, and weather conditions. Climate change and adaptation together have significant and far-reaching socio-cultural consequences for what they call 'landscape memory' (the cultural core of a shared knowledge system), traditional knowledge and Sámi languages of reindeer herding communities. Climate change separates the knowledge and skills of different generations, and results in loss and replacement of some knowledge and skills due to introduction of for example new technology and changes in the livelihood models. The intergenerational effects of climate change adaptation are therefore significant, and the next generation of herders will acquire landscape memory and adopt a reindeer work model that is already climate change adapted. Furthermore, as current knowledge accumulated in landscape memory becomes less important, vulnerability increases, limiting culturally sustainable climate adaptation and the ability to respond to exceptional situations. Impacts on landscape memory may thus leave future generations with fewer options for adaptation and a smaller knowledge base. However, Näkkäläjärvi et al. (2022) also underline that climate adaptation is a process of cultural change. The shared knowledge of climate change observed in landscape memory has developed and is developing different models for working with reindeer. Even though it is highly contextual, landscape memory is a tool for perceiving and adapting to the changes in the environment, for monitoring the effects of climate change, and can also help understand how cultures develop.[404]

In the following part of the chapter, the results from the workshops and interviews with Sámi knowledge holders and relevant research will be presented in relation to various aspects of Sámi culture and livelihoods.

Fishing and fisheries in Sápmi

Fishing is important for Sámi people both inland and on the coast (fjords). In the coastal areas which this section begins with, fishing is a viable livelihood. While it is projected that changes in temperature will affect fish stocks in both coastal and freshwater systems, it is not known how these changes will influence Sámi fishing culture[405] and research on these topics is limited. Fish farming is not covered in this section.

Coastal fisheries

The Barents Sea borders most of northern Norway which is considered part of Sápmi. Sámi fisheries in the fjords can be both commercial and small-scale subsistence fisheries. Cod (gadus morhua, sám. dorski), saith (pollachius virens, sám sáidi), haddock (melanogrammus aeglefinus, sám. diksu), atlantic salmon (salmo salar, sám. luossa), halibut (reinhardtius hippoglossoides, sám. bálddis), plaice (pleuronectes platessa, sám. finddar), lumpfish (cyclopterus lumpus, sám. áhkábiddu/rundierpmis), and red king crab (paralithodes camtschaticus, sám. gonagas reabbá) are key species, either for subsistence or commercial interest. Disturbances to the fish stocks would have direct impacts on economy and life in the fjord communities, meaning that impacts on fisheries in the Barents Sea will affect Sámi culture, livelihoods and society.

> *"We base our lives on what is under the surface. In the 90's both sea urchins (trongylocentrotus droebachiensis, sám. káranasruitu) and the red king crab occurred in an invasive manner, and the seaweed disappeared. With that also the lumpfish. There used to be a great lumpfish fishery, many small vessels had a good income from it. This fishery is now all gone. The loss of seaweed is a great loss for the fjord as it is the most productive ecosystem. The growth place for juveniles disappears."*
>
> **– Sámi fisherman, northeast Sápmi**

In the workshop held in Deatnu, the group of knowledge holders shared observations and reflections on life on the fjords and discussed the shifts in species they have observed over the years. They showed a holistic approach to the ecosystem with references to the increase of one species leading to decrease of the other. There were discussions about the introduced red king crab and Pink Salmon (Oncorhŧnchus gor-

[403] Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

[404] Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

[405] Jaakkola, Juntunen, och Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union".

buscha, sám. buggeluossa) (becoming widespread, other invasive species such as a certain kind of sea urchin and harp seal (Pygophiles groenlandicus), and occurrence of presently rare species such as mackerel (Scomber scombrus). The discussions on the species raised concerns about the disturbances to the ecological balance and the authorities' management and regulations, rather than climate change as such. While weather conditions are shifting today, they underlined that shifts have occurred before. There have been periods with warm winters or very stable cold winters throughout the last 100 years, and summers have varied from being warm and cold. Extreme weather events have also occurred from time to time–for example cold spells and winters with extreme amounts of snow. In line with the findings presented in chapter four, one said: "in the 80s there were cold winters and cool summers, in the 90s there were still cold winters, and the summers were getting warmer. In the 2000s, the winters were getting warmer, and the summers were warmer." It was also emphasized that there have been severe storms and hurricanes also in the past, but that storms and even hurricane-like storms seem to occur more frequently now.

The knowledge holders described the rather simultaneous occurrence of red king crab and sea urchin in Várrjatvuotna–Varangerfjord in the 1990s, causing the disappearance of the kelp bed. In Porsanger however, the expansion of sea urchin occurred already in the 60s/70s, causing a long-time disruption in the ecosystem. The kelp bed is an important growing area for the small fish; thus the reduction of kelp affects the growing conditions of local fish stocks. It caused the reduction of among others the lumpfish stock (Cyclopterus lumpus) which had direct impacts on the local economy. Lumpfish fishery used to be an important seasonal fishery in Várjjatvuotna–Varangerfjord. The numbers of harp seals in the fjords of Finnmark in the 1980s was also perceived as invasive and causing ecological imbalance. Species such as European plaice (Pleuronectes platessa) and the Atlantic wolffish (anarhichas lupus, sám, ránesstáinnir/ránesbuovla) became rare and the small cod (those around 0.5 kilos that were present in great numbers) migrated further west. The relationship between seals disturbing plaice and cod stocks, that again would feed on sea urchins (Strongylocentrotus droebachiensis), might have caused the peak of sea urchins. The perceived reason for the seal invasion was not clear from the discussions. Some referred to overfishing of capelin (mallotus villosus, sám. šákša) in the ocean while some recalled there had been seal invasions also in the past.

At the moment, there seems to be a relatively good ecological balance in the fjords. In Deanufjord-Tanafjorden, the kelp bed has returned and there is an abundance of small fish observed. After some years with few fish, the Ráttovuonna-Smalfjord was said to be very lively this year (2022): "The salmon is jumping, harp seal is observed, harbor porpoise (Phocoena phocoena) all year round, a lot of birds and herring. A lot of small cod under the harbor, even whales have been visiting the fjord." Concerns were however raised for the future if the Atlantic mackerel (Scomber scombrus) that is occurring more often the last decade is going to establish itself in these northern waters, the mackerel might become the next disturbance to the ecological balance, as it is considered a species that feeds on almost everything. Worth noting is that white-tailed Eagles (haliaeetus albicilla, sám. mearragoaskin) have expanded a lot in the last decade and the common eider (Somateria mollissima, sám. hávda) has declined.

The knowledge holders did not unanimously regard climate change as affecting their daily lives yet. Throughout the discussions, management and regulations that did not always correspond to reality, as well as capelin overfishing, were referred to as disrupting the ecological balance. This is in line with the finding in the IPBES Global Assessment (2019) stating that fishing and other exploitation of organisms had the largest impact on the marine ecosystem. It was well established that sea use change was another factor before the multiple components of climate change and changes in the atmosphere were listed as the third most significant driver of change in marine ecosystems.[406]

Another general concern raised during the gathering was related to the Indigenous knowledge of the Sámi fisherfolks and the rights to fisheries. The traditional subsistence fisheries that are the foundation for fishing rights today, used the breadth of species available in the fjords and near coast waters through different seasons of the year. In Várjjatvuotna this includes saith net-fishing in the autumn, which has been considered as important as the spring cod fishery. One of the knowledge holders pointed to the quota system and economy in the fisheries, where commercial red king crab fisheries and cod fisheries are enough to make a sufficient income. In particular the younger generation of fishers were said to be unfamiliar with the saith net fishery in the autumn. Knowledge about this fishery is disappearing, and dependency on just a few species might make the Sámi communities more vulnerable in case fish stock shifts its geographical distribution due to climate changes. In the fjords

[406] Diaz m.fl., "IPBES 2019: Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services" Chapter 2.2. Point 11.

of Eastern Finnmark, the cod fishery has been relatively good in recent years. This is due to poleward expansion of Atlantic cod, as described in chapter 4. One of the participants, however, shared indications that it might be on the decline again. A knowledge holder described that it is in times with shortage of and competition for resources that the differences between the fleets appear, the local fleet often with smaller vessels operating in the fjord and near coast areas and the larger vessels, often belonging to the owners of larger businesses, stay far out off the coast. In the past, the smaller fleet has appeared to be most vulnerable to changes in the access to resources, the participant claimed. The quota system in Norway is very complex, you would for example lose the right to fish if you do not catch a certain amount. The crab fishing permission is tied to the cod fishery–it is a whole ecosystem of management and rights. Continuity and presence is the basis for the right to fish. Retter (2009) explained in a UNESCO series of articles on climate change and Arctic sustainable development, that the traditional Sámi fishing economy is less vulnerable to climate change due to these fisheries in the fjords being dependent on diverse fish stocks, providing flexibility to adapt to changing conditions. The coastal Sámi culture is however more vulnerable to mismanagement and centralization of power than to climate change as such, as the regulations may limit the freedom the fisherfolks need to respond to changes.[407]

A Sámi fisherman explained in AMAP's Barents report (2017) that small vessels fishing at the coast represent a good system of generation of value in the fjords where they are fishing, while contributing little to emissions releases. This economy is however at risk when facing changes. Under pressure, more chances are taken in relation to weather and distances, the safety risk increasing as there is often only one person aboard.[408]

The knowledge holders noted that if the cod fishery fails again there are many unused species available in the fjords and coastal waters. In such cases the autumn fisheries (saith and other) are needed to ensure sufficient income and save the economy. One of the knowledge holders underlined that the fishers have adapted their equipment and tools to the climatic conditions and are thus well prepared for any occasion. In a report from the Nordic Council of Ministers, Hovgaard et.al. (2022) states that having several activities is important in fishing communities, as people cannot solely rely on the fishery for a secure livelihood. Often, diversification is the key for fishing communities. On the contrary, the most evident tendency in the fisheries policies, is that transferable quotas as part of a neoliberal scheme concentrate access to resources for fewer and more specialized actors. "When fewer actors develop businesses in fisheries based on larger investments for specialized operations, there is no building of resilience, neither for those excluded nor those included."[409] The knowledge holders were in general concerned about the future of Sámi indigenous knowledge as technology replaces knowledge and the times and places where the knowledge is transferred are fewer. A serious concern for the future of sea Sámi culture was expressed, as it was claimed that the authorities do not recognize the fishers' knowledge which is not put on a map or an echo sounder. Most vessels are using the advanced navigation and mapping technology OLEX. All movements are saved by the tool. The data stemming from this is used by the authorities to monitor the movement related to fisheries activities, a participant explained. The small vessel fleet does not use this technology as much, thus their movements are not monitored to the same extent. The risk with this is that the lack of data is interpreted as a lack of presence in certain areas on the sea. Next time around the lack of activity is interpreted as lack of knowledge of the area and further affect the foundation of the right to fish.

Climatic and environmental conditions interact with management policies on fisheries. Based on the workshop focusing on Sámi fisheries, the majority of the participants did not seem to care as much about climate change as they did for fisheries management. However, warmer winters have contributed to better economic opportunities for those involved in stockfish (dried fish) sales. During the last winters in eastern Finnmark climate changes have given more favorable wind and temperature conditions for drying cod. With shorter periods of or less cold spells during spring-winter the quality of the dried cod is better. Several of the fishers reported that for the last seasons almost their entire quantum of dried cod had been classified as prima, the highest rating. Making dried cod highly economically beneficial for them.

Norwegian fisheries policies have strong impacts on Sámi culture. In recent decades, efforts to protect the wild salmon population in Norway have resulted in strict regulation of Sámi net fishing for salmon in the sea. The Norwegian gov-

407 Retter, "Norwegian Fisheries and adaptation to Climate Change".

408 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area".

409 Hovgaard m.fl., Value Chains and Resilient Coastal Communities in the Nordic Atlantic.

ernment argued that the economic contribution from sea salmon fishing is marginal. The Sámi Parliament in Norway opposed this and claimed that even though the economic impact of sea salmon fishing may be declining in Sámi areas, the activity remains of cultural importance.[410]

The knowledge holders, even though several were fishing the salmon in the sea, did not speak much to that fishing at the occasion of this workshop. A Sámi fisherman shared however, his reflections in the AMAP report from 2017[411], saying that when farming of salmon was established in the north of Norway in the 1980s, the prices for naturally caught salmon were dramatically reduced. This influenced the economy for those who were fishing salmon in the fjords for some extra income during spring-summer. These are fisherfolks in the small communities along the fjords in Finnmark. Simultaneously, the salmon fishers were challenged by several regulations limiting their fishery; fewer days to fish, limitations on equipment and complicated processes to apply for fishing permission. These same areas were offered financial support in the 1960s and 1970s to leave the villages and settle down in the coastal towns. Many villages in the fjords were abandoned. For these reasons it has been difficult to recruit new fjord salmon fishers. Nowadays, the salmon fisherfolks cannot compete on price with the farmed fish.

Lam and Borsch (2011) have reported that the population in coastal Sámi areas in Norway has changed significantly in recent decades. Nevertheless, they highlight that sea salmon fishing contributes to continued settlement and activity in traditional Sámi areas and thus to coastal Sámi culture, together with a strong Sámi tradition for hunting and gathering.[412]

The knowledge holders did not mention the ice cover in the Arctic Ocean, but it was noted that the fjords were not freezing as much as in the past, Ráttovuotna–Smalfjord was said to barely freeze anymore. In the past the Várjjatvuotna–Varangerfjord was frozen solid further out than today during winter, 7–8 km of the inner parts used to be ice covered during the coldest period of the winter (app. 1980s), then only the inner 5 km (app. 2000s) and now only the inner part freezes but rarely solidly.

Barents Sea ice

The Barents Sea freeze-up starts in the autumn, first in the northern and eastern part of the area, going into the winter the ice edge expands southwards and westwards. The largest extent of the ice usually occurs in April. During the spring melt, the ice edge retreats north and east. This melting continues until the sea ice hits its lowest extent, usually in September. Warming in the sea and air results in a reduction of sea ice cover. Satellite measuring of sea ice cover started in 1979, since then a downward trend in sea ice cover has been observed in large areas of the Arctic. Ocean currents and precipitation are other factors affecting the sea ice.[413] Species depending on the ice edge, small marine crustaceans referred to as calanus glacialis (nor. ishavsåte) follow the ice edge as it retreats and shifts. As the ice shifts further away from the Norwegian coast, the calanus glacialis goes with it and the species that feed on it such as capelin also follow, transferring the effect through the whole marine food web. This affects inshore fisheries.[414]

"When I was a child, I remember my grandmother (who passed away in 1980) referring to the ice in the Arctic Ocean. I was impatiently waiting for lasting warm summer days as soon as the snow melted in May. My grandmother replied that you can't expect stable summer weather before the ice in the Arctic Ocean has retreated. This tells me that people were relating to the Arctic ocean and the ice without ever having been there to see it or to have models showing the ice cover shifts."

– Sámi from eastern coastal area

Freshwater fishing

Another fundamental part of Sámi culture, economy and well-being is freshwater fishing in lakes and rivers. The freshwater fish is an important addition to the saltwater fish and reindeer meat diet. Salmon, as one out of many freshwater fish, is of big importance.[415] The Deatnu river, which runs along the northern border of Finland and Norway, is one of

[410] Lam och Borch, "Cultural valuing of fishery resources by the Norwegian Saami".

[411] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area".

[412] Lam och Borch, "Cultural valuing of fishery resources by the Norwegian Saami".

[413] Miljøstatus, "Havisutbredelse i Barentshavet".

[414] AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area" Chapter 2.

[415] Holmberg, "Bivdit Luosa – To Ask for Salmon. Saami Traditional Knowledge on Salmon and the River Deatnu: In Research and Decision-making".

Europe's largest salmon rivers and the largest in Sápmi. It also holds one of the world's largest populations of wild Atlantic salmon. However, the number of Atlantic salmon in Deatnu has been rapidly declining in recent years. The decline resulted in a total ban on salmon fishing by the nation states of Norway and Finland in 2021 which came with large cultural and economic impacts on Sámi living and fishing in the area. The exact cause of the decline is complex, but estimates include among others heavy exploitation (sea and/or river fishery), changes in prey availability in the Barents Sea and climate change.[416]

The complexity of, and the connectivity between ecology, species abundance, management and business was expressed by a knowledge holder at the Deatnu workshop, who said: "Scientists claim there is little Atlantic Salmon in Deatnu. They have carried out research for 50 years and have been blaming the local people for catching all the salmon. Now finally scientists are saying that the salmon is not doing well in the ocean/sea. One of the impacts is the feeding of farmed fish. There is a huge fishery for forage to fish farming. There is also a climate change impact. I heard in Alaska that the last five years they had observed that the salmon were struggling finding their way back to its river, due to climate change and warmer weather."

Research showcases that the abundance of Atlantic salmon in both Europe and North America has declined since the 1970s. Decreased marine survival is one of the major hypotheses. However, while being one of the world's most studied fish, detailed knowledge of its ocean distribution and behavior is lacking.[417]

Atlantic salmon and climate change

Studies on Atlantic salmon in relation to climate change have found that climate change is contributing to range expansions but also to change in seasonal migration timing, younger age at smolting and sexual maturity, and increased disease susceptibility and mortality. Earlier migration can mean salmon follow natural signals to migrate but when they arrive the food they were expecting is not there, threatening salmon growth and survival, which in turn can cause further food web alterations.[418] [419] Rikardsen et al. (2021) found that Atlantic salmon have extended their range further north: Atlantic salmon from Norwegian and Danish populations have reached latitudes as far north as 80° N, the farthest north any Atlantic salmon has ever been recorded. According to the researchers, salmon from other populations did not exhibit the same range of expansion which could mean that the northern populations of salmon may benefit from a shorter migration route to the main feeding areas.[420] Studies projecting future climate scenarios and their impacts on Atlantic salmon found lower parr (young fishes which have not yet migrated to the sea) abundance in Northern Norway.[421] Other studies found that ice break-ups, longer ice-free periods or loss of ice could affect winter survival of Atlantic salmon significantly, particularly in northern populations.[422]

"The Pink Salmon is a winner in climate change. Deatnu river never gets good. Salmon is gone. A report here in Finland said that climate change affects salmon quality. The salmon does not move up the river when the temperature is above 20C. We have these temperatures more and more often now."

– said by a Sámi participant at the seminar in Váhtjer

416 Working group on salmon monitoring and research in the Tana river system, "Status of the river Tana salmon populations".

417 Rikardsen m.fl., "Redefining the oceanic distribution of Atlantic salmon".

418 Otero m.fl., "Basin-scale phenology and effects of climate variability on global timing of initial seaward migration of Atlantic salmon (Salmo salar)".

419 Jonsson och Jonsson, "A review of the likely effects of climate change on anadromous Atlantic salmon Salmo salar and brown trout Salmo trutta, with particular reference to water temperature and flow".

420 Rikardsen m.fl., "Redefining the oceanic distribution of Atlantic salmon".

421 Hedger m.fl., "Predicting climate change effects on subarctic–Arctic populations of Atlantic salmon (Salmo salar)".

422 Finstad m.fl., "The importance of ice cover for energy turnover in juvenile Atlantic salmon".

A growing threat to the Atlantic salmon is the number of pink salmon. Pink salmon have increased dramatically in rivers in northern Sápmi since 2019. The exact cause of the increase is unknown, but pink salmon may benefit from the warming of the Barents Sea.[423] Research in Alaska has found that pink salmon are migrating earlier, and winter egg incubation temperature has increased, both of which are directly related to warming.[424] Pink salmon can be aggressive in large schools, displacing native Atlantic salmon and disrupting their behavior, with serious consequences for fishing. Pink salmon also die after spawning, which means that a large number of rotting fish will add a massive amount of nutrients in the water, potentially disrupting the entire ecosystem. Furthermore, pink salmon can spread diseases that infect Atlantic salmon.[425] In 2021, approximately 3,8 million pink salmon remained to spawn in the Varzuga river, southeast of Guoládatnjárga (Kola peninsula). According to researchers, Deatnu could receive more than 4 million pink salmon compared to Varzuga.[426]

One knowledge holder mentioned briefly his concern with organic material from dead pink salmon at the workshop in Deatnu. The group of knowledge holders also said that there is an increase in greenery around the Deatnu river due to the longer growing season, hindering access to the river. It was also noted that this increase of greenery and shrubs could be caused by changed ice conditions on the river. The ice floes usually drift down Deatnu with enormous power that usually brings down riparian vegetation (small young deciduous trees on the river sides). Warmer temperatures have changed the ice during spring break-up. One of the knowledge holders said: "My father used to say that a good ice slide is useful–it cleans the bottom of the river (Deatnu). Now pink salmon comes up the river to spawn, and it dies afterwards. A lot of biological material gathers. I expect soon all the sand banks will be overgrown by grass and trees. Soon we can't get to the river side without bringing a chainsaw."

The knowledge holders raised concerns about the spring floods, saying that larger floods are getting rare. Even with warmer, and sometimes snow-rich winters, there is still no serious flooding in the spring. Several reasons for rare severe flooding were discussed among the knowledge holders, for example, it is getting more usual that the ground does not freeze solidly before snow is settling, thus absorbing more of the melt water in the spring. Warmer winters cause thinner ice. Some had experienced that frost during the snow melting period dries the snow, and thus prevents large flooding. In the past, the ground used to stay frozen later into the spring-summer. Under those conditions the ice cleaned both the river bottom and the shores, the knowledge holder said.

Climate change has had observed effects on the creation and melting of ice, water and drought, and movement and quality of ice on rivers and lakes. A knowledge holder shared observations about the ice on the lake, noting the ice is not as thick as before. Previously one could go on skis to fish in the lakes on the tundra. It was not unusual to go by skis to fish on the lake ice in June. Nowadays the skiing conditions are gone much earlier, and the lake fishing season has to be given up earlier, he said. The other knowledge holders discussed the quality of ice. Fishing on the lakes in the winter is a highly appreciated activity. They had observed that when making a hole in the lake ice, even though the ice seems quite thick, it feels like the quality has deteriorated, it does not feel as hard as earlier. Another knowledge holder had been checking the ice floe on the Deatnu side /River side, noting that the floes contain some kind of fine froth, and the solid ice layer is very thin. Some suggested there might be a similarity to the insulating effect that snow has on ground, that snow on ice may keep it warmer. It was noted that the ice does not freeze solidly until in the middle of the winter.

> *"Really cold winters clean the river–in 1966, the ice got loose in the middle of May. We saw solid ice floes far out in the fjord, close to the coast. We could still see the ski tracks on the floes. It had suddenly turned warm, and what came down the river was hard ice. We had to stay in Berlevåg to wait for the ice to come out to the ocean, as it was impossible to get in Deanuvuotna–Tanfjorden with the boat due to all the hard ice floes."*
>
> **– Sámi knowledge holder staying at the coast in May 1966**

[423] YLE, "Tenojoki täyttyi vieraslajiksi luokitelluista kyttyrälohista, ja tutkijoita ja paikallisia se huolettaa – kalat uhkaavat atlantinlohta ja mätänevät jokeen."

[424] Taylor, "Climate warming causes phenological shift in Pink Salmon, Oncorhynchus gorbuscha, behavior at Auke Creek, Alaska".

[425] Sámi knowledgeholder.

[426] Muladal, "Pukkellaks – en klimavinner."

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

Golleguolli
Sámiid Riikkasearvi (SSR) and Slow Food Sápmi together ran the EU-project "Golleguolli" in 2020-2023 which aims to raise awareness about Sámi food culture and cuisine, with a particular emphasis on freshwater fishing. By recording short films and documenting traditional methods of fishing with Sámi knowledge holders, as well as food preparation techniques and food preservation, the films and webinars are to be used to educate the younger generation of Sámi and thus strengthen traditional Sámi knowledge. Slow Food Sápmi will also conduct an economic analysis and develop a model for calculating outcomes in traditional Sámi resource production (reindeer, fish, etc.) and processing. The long-term goal of the project is to increase interest in Sámi cuisine and demand for Sámi products, which can enable for increased profitability and the formation of new businesses.

Other observations that were highlighted was that in lakes which used to be predominantly composed of Arctic char (Salvelinus alpinus, sám. rávdu) it is now more common to catch trout (Salmo trutta. sám. dápmot) in some areas. While the knowledge holders suggest that there is more trout, they also underline that just because trout apparently is increasing, there might not be less Arctic char in the waters as char seek deeper water when it gets too warm. One participant suggested that since the autumns have not been as cold and frosty as they were before the 2000's, trout eggs now survive in small brooks. A reindeer herder said: "We have observed a change in the fish species and where they move in a lake in our area. Before, about 20-30 years ago, there were almost only Arctic char in the lake and the trout kept to the river that runs into the lake. Now we have started to get more and more trout in our nets, also in the lake. The last summers, the majority of fish we have caught in the lake have been trout. We sometimes put our nets in the deeper parts of the lake with cooler water to try to catch more (Arctic) char, but it has become more and more difficult. The fish in the lake, both the trout and the Arctic char, is in good quality, so we have not considered it a huge problem for us fishing for food, but it is a quite significant change. We have also observed that "seaweed" is growing on the bottom of the lake on the shallow parts of the river where it was only sand before." Another reindeer herder further south said: "Since I was 4-5 years old, I have annually fished at home in the mountain lakes, both with net and rod. When I was about 10 years old, it was about 50/50 between Arctic char and trout. Today, it is about 10/90–if we are lucky–in the same lake and the same season. Sometimes we only get trout in the nets and no char. There are many who witness this in our area. I also think I spoke to someone in the Jåhkåmåhkke area about this, so it might be the same in other areas. In my partner's area up north, there are lakes that only have char in them, which for me is absolutely incredible to hear. It feels like we are completely losing it."

The pike stock is increasing according to the Sámi knowledge holders. Climate change is perceived as the reason for this as warmer waters and fewer spring floods are suggested as success factors for northern pike (esox lucius, sám. hávga). In addition, due to increased warming and a longer growing season, some brooks are now almost inaccessible due to overgrowth and the increased greenery become great hiding spaces for northern pike, one of the knowledge holders said.
Changes in water levels and temperatures are bound to have impacts on fish and fishing, these affect fish behavior, migration and fishing conditions. Cold-water fishes such as whitefish (Coregonus Lavaretus, sám. čuovža) and Arctic char are found likely to be disadvantaged in the future. Hein et al. (2012) estimate a range loss of 73% for Arctic char in Sweden by 2100 which could be attributed to both simulated temperature increases and projected pike increases.[427]

Hunting and gathering

The following section will briefly touch upon willow grouse and ptarmigan (Lagopus lagopus/Lagopus mutus, sám. rievssat ja giron) hunting and trapping, moose (Alces alces, sám. ealga) hunting, and berry picking. Willow grouse/ptarmigan hunting and trapping and moose hunting are important subsistence activities for Sámi and provide important income. Berry picking is also an important source of income (cloudberries in particular) and a natural part of knowledge transfer.

Willow grouse and ptarmigan hunting and trapping

Many grouse species, including the ptarmigan, are experiencing population declines around the world.[428] Willow grouse/ptarmigan populations are also declining in Sápmi, and several important factors are thought to be interacting. Increased nest predation in more productive vegetation, as well as more frequent snow-free springs and autumns, are

[427] Hein, Öhlund, och Englund, "Future Distribution of Arctic Char Salvelinus alpinus in Sweden under Climate Change: Effects of Temperature, Lake Size and Species Interactions".

[428] Henden m.fl., "Changed Arctic-alpine food web interactions under rapid climate warming: Implication for Ptarmigan Research".

thought to be major contributors to the declines, but reindeer and moose over-browsing on willow shrubs, which ptarmigan rely on for food and shelter, is also thought to contribute. Habitat fragmentation and collisions with power lines and fences are also factors. Willow ptarmigan population declines locally have also been linked to moth outbreaks in mountain birch forests.[429] [430] [431] Some of the knowledge holders sharing their observations pointed to 2007/2008 as the year of ptarmigan collapse (eastern Finnmark). This might be due to the fact that Sweden stopped allowing Norwegian hunters to travel to Sweden to hunt, causing an increase in hunters coming up to northern Norway. The collapse was believed to coincide with the ongoing moth peaks in the same region, where grass was dominating the ground where there were berries before, according to the group of knowledge holders.

"The mosquitoes came early; the greening came early. The birds come early and leave late. Autumn destroys the reindeer grazing for Nov – Dec. You are stuck. Ptarmigan snaring is not worthwhile–it is windy and rainy in the winters."

– said by a Sámi participant at the seminar in Váhtjer

Climate change is likely to alter traditional subsistence activities such as hunting and fishing in Norway in the future, according to the Norwegian research project Sustainable management of renewable resources in a changing environment: an integrated approach across ecosystems (SUSTAIN). Marine and terrestrial ecosystems are affected by human-caused stressors, such as climate change and harvesting, and what was previously sustainable harvesting and knowledge-based management is no longer necessary as ecosystems change. Because of the obvious interactions between climate change and harvesting, a sustainable taxation strategy in a changing climate must consider these relationships.[432]

Apart from the population decline, the knowledge holders said traditional trapping with snares has been complicated due to environmental factors. Some pointed to the winds, while others drew connections to the small amount of winter snow. Similar to the Sámi fishers, there was experience of more winds, and the winds are perceived to be stronger. Wind directions matter when setting up a snare. An elder said that during spring-winter, since the days of his youth, the wind has changed to south-west. The knowledge holders also commented, on a general basis, that there is a mismatch between the hunting and fishing times in the past compared with today, in some cases the national regulations and local conditions are out of tune, too. This mismatch is expected to expand decade by decade, disturbing the subsistence activities, according to the group.

"Climatic changes have led to the absence of thick ice in December–one cannot juoŋastit (fish with net under the ice on a lake). In January there is still little snow, and not good enough conditions to set up snares for ptarmigan/grouse. March and April come with strong winds and it is challenging to get to the tundra for fishing on ice. The traditional salmon fishing in Deatnu is related to the water level. But nowadays the regulations set the fishing times. Due to earlier ice break up, the conditions for the traditional net fishing are already poor by the time the regulation allows the fishery to start. Here the regulations and the calendar are mismatching. We are forced to adapt our lives to a calendar that does not fit the purpose. The system seems tilted/out of rhythm."

– Sámi knowledge holder, eastern Finnmark

"It is strange that we seem to simply accept the fact that the ptarmigan is vanishing. Why is that? Why has it declined? The early recreational hunting permitted through the national regulation allows hunters to come. They hunt in teams, each one with several dogs, hunting chicks for weeks in a row. Birds of prey have increased, as have crows, taking both ptarmigans and their eggs. The red fox has increased and expanded–they also take ptarmigans. Then you have wind turbines and the extraction industry. The ptarmigan needs help, and we need to support the ptarmigan."

The global effects of current and future climate change on willow grouse/ptarmigan populations are likely negative and range size is predicted to decrease. Population declines are

[429] Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

[430] Melin m.fl., "Decline of the boreal willow grouse (Lagopus lagopus) has been accelerated by more frequent snow-free springs".

[431] Ims m.fl., "Arctic greening and bird nest predation risk across tundra ecotones".

[432] Haugan, "Klimaendringene vil påvirke fremtidens jakt og fiske".

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likely to occur further in northern Europe.[433] [434] The impacts of climate change may alter predator-prey interactions but ecological factors are also critical. Ptarmigans are adapted to cold and harsh conditions and vulnerable to temperature fluctuations and increased precipitation. Higher temperatures during summer have found to be limiting their reproduction. A change in snow quality and snow conditions as a result of warmer and wetter winters will likely provide unfavorable nesting conditions for a bird like the ptarmigan, which seeks shelter in the snow cover during low temperatures (burrowing).[435]

Moose hunting

A knowledge holder in Várjjat said to the Saami Council that the moose stock expanded widely in recent decades. Due to the moth outbreak and loss of birch forest, the moose stock is now appearing to be on decline, as it is hard to find shelter in the forest. A knowledge holder and hunter from Deatnu said that in recent years, it had been much warmer than usual at the time of moose hunting. There were a lot of blackflies, which was unusual for the season. In accordance with the findings by the IPCC (see chapter 4), hunters saw a need for change in hunting practices due to the warm weather. For example, the Sámi hunters were forced to bring the meat down to the village straight away to cool room to the carcass.

The responses of moose to climate change in terms of survival and reproduction are unknown. Moose exhibit signs of heat stress when temperatures are unusually high, altering their activity and movement. Heat sensitivity has been proposed as one of the primary causes of moose population declines in its southernmost range, alongside pathogens and carnivore predation, according to research. Other than rising temperatures, population decline has been attributed to a variety of factors, but the southern edge of the moose's geographic range is expected to shift northward as the climate continues to warm and heat stress becomes more likely.[436] [437] Warming, on the other hand, has been found to benefit moose populations in the Russian Arctic.[438]

Researchers at the Swedish University of Agricultural Sciences (SLU) state that the shown northward range distribution of moose in North America[439] is also expected in Fennoscandia. Climate change has already had a negative impact on moose populations in southern Sweden, and similar trends to those seen in North America can now be seen in Sweden as the tree line has moved north. The researchers have also observed moose starving to death in Norrland County, Sweden during recent winters, indicating that access to forage through the snowpack is determined by changes in precipitation, snow amount and thus snow conditions, predicting implications from climate change also during winter.[440]

Berry picking

Cloudberries (Rubus chamaemorus, sám. luopmi), among other berries, are one of the most valuable natural products in the Sámi gathering tradition, with high economic and cultural importance. From a nutritional perspective, cloudberries are an important source of vitamins for people in Sápmi, and also an important focus for knowledge transfer between generations. A lot of cultural activity is connected to berry picking.

> *"For me, cloudberry picking has been the activity where I have wandered together with my mother, her cousin and her mother again. This has been the arena where the knowledge about the berry, the land, the weather, the place names and the surroundings have been transferred from them to my generation. Seven years of continuous moth outbreak with very little or no cloudberries in our traditional areas, caused an abrupt break in the knowledge transfer, as the trips were reduced to one to check the growth, and return home with an empty bucket. If we wanted fresh berries, these were to be searched for in areas accessible by the road in areas with no trees. Areas we had no knowledge of.*

433 Kozma m.fl., "Past and potential future population dynamics of three grouse species using ecological and whole genome coalescent modeling".

434 Jansson m.fl., "Future changes in the supply of goods and services from natural ecosystems: Prospects for the European North".

435 Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

436 Montgomery m.fl., "Movement modeling reveals the complex nature of the response of moose to ambient temperatures during summer".

437 Jansson m.fl., "Future changes in the supply of goods and services from natural ecosystems: Prospects for the European North".

438 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

439 Tape m.fl., "Range expansion of moose in Arctic Alaska linked to warming and increased shrub habitat".

440 SLU, "Klimatförändringar ett hot mot älgen".

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

Several factors need to be in place for a good berry season. The excitement related to the cloudberry season begins as soon as the snow melts in the spring and the blossoming is about to start. Observations relate to the blossoming and the potential of damage by heavy rain or strong winds. The next critical part is the pollination, insects are the main pollinator for cloudberries. For the berry to grow and become good, the right balance of rain and temperature is needed, the summer conditions also determine when the cloudberry will be ripe. After the cloudberry is ready, the next critical factor is potential for frost nights that will damage the berry."

– Sámi knowledge holder from eastern Sápmi

At the workshop in Ohcejohka, the knowledge holders discussed that berries show variety in timing of ripening and indicated earlier ripening recently. Cloudberries in northeastern Sápmi are getting ready a week, sometimes two weeks earlier in recent years. This is likely due to early snow melting, and warm summers, one knowledge holder noted. Another knowledge holder explained that cloudberries used to ripen at different times at different locations, so one can stretch the season over weeks: first in the low land, near fjord mires, then further out the fjord towards the coastal areas and latest up in higher altitudes. Due to earlier ripening as referred to above, there have been years when most berries get ripe at all locations at the same time. This is challenging for those that try to get them at all different locations. The high-altitude mires had most berries compared to the lower altitude smaller mires in tree growing areas. The recent years have been quite the opposite–with loads of berries in the forest areas. (Eastern Finnmark)

The knowledge holders also observed that several years in the 2000-2010 decade have had many seasons in a row with little to no berries in the areas Várjjat – Ohcejohka – Deatnu after three different moth species peaked several years in a row. It was noted that berries are heavily affected by the damaged forest and the temporarily dominant grass growth. Várjjat Sámi Musea (VSM), Árran, Mearrasiida and Norsk institutt for naturforskning are partners in a project called "Making Knowledge Visible". VSM has gathered some local observations in Unjárga–Nesseby that are presented online. They report observations noting that the cloudberries get ready at least a week earlier than in the 1990s. Usually in Várjjat, the high season of cloudberries is in August–in recent years the season has started 18 July and even 12 July. In general, the berries ripen earlier. They are also edible later into the fall, as the night frost is also setting in later than 2-3 decades ago.[441] [442]

As also described in chapter four, knowledge holders in the Ohcajohka workshop noted to the Saami Council that the large bálssat/bovdna (palsas) have disappeared. Cloudberries were a very important resource in the past (in the1960s-70s). They taught the children and bought vehicles. Cloudberries are no longer abundant, the bálsa/bovdna has disappeared.[443] This is also described in the section on permafrost in chapter four.

Markkula et al. (2019) state that a decline in cloudberry abundance has been reported from Finland and other parts of the Arctic. Warmer springs and summers have contributed to berry damage, and research in Swedish Sápmi has discovered that warmer springs have contributed to changes in flowering time. Temperature swings in the spring can cause a mismatch between the timing of flowering and the abundance of pollinators. Projections for the future abundance for cloudberries are mixed. On a European scale, modeled impacts of climate change on cloudberry distributions were negative, implying fewer suitable habitats for cloudberry in the future. Cloudberry is commonly found in palsa mires and related areas in Sápmi. Thawing permafrost is expected to change the distribution and abundance of cloudberries because it changes nutritional availability, and thus vegetation production and species composition. There have been studies that show increased cloudberry biomass as a result of additional nitrogen uptake and thaw, and a study from Swedish Sápmi found a slight increase in cloudberry cover in a peatland despite the area's degrading permafrost. However, as permafrost thaws in palsa areas, cloudberries may be dominated by graminoids (grassy plants) as they don't tolerate very wet conditions.[444]

Studies regarding the abundance of other berries in relation to climate change show various findings. Warming may increase edible berry production due to increased pollination

441 "Making knowledge visible", Várjjat Sámi musea/Varanger samiske museum, Árran lulesamisk senter, Mearrasiida i Porsanger, NINA (Norsk institutt for naturforskning) og Samisk høyskole.

442 "Multeforkomster, klima og vær".

443 "Multeforkomster, klima og vær".

444 Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

and earlier fruit development[445] while other studies have found that winter warming events increase the risk of shoot mortality in lingonberry (Vaccinium vitis-idaea, sám. jokŋa), bilberry (Vaccinium myrtillus, sám. sarrit), and crowberry (Empetrum hermaphroditum, sám. čáhppesmuorji)), as well as decreases in flower and berry production.[446] Experimental studies conducted in northern Sweden's sub-Arctic mountain birch forests and dwarf shrub heartlands discovered decreases in crowberry and bilberry due to winter warming, as well as increased shoot mortality for crowberry, bilberry, and lingonberry. These responses were the opposite of the increased growth and 'greening' observed in some Arctic regions. As extreme events are predicted to become more frequent and given that the Arctic is warming more in winter time, this generates large uncertainty in current understandings of Arctic ecosystem responses to climate change, according to the researchers.[447] [448] Another experimental study conducted in a Swedish sub-Arctic birch forest found that bilberry and crowberry abundance increased under long-term warming conditions, but that warming also resulted in a shift in lingonberry dominance over bilberry.[449] In birch forests, bilberries are especially vulnerable to frost, drought, and moth outbreaks. Absence of winter snow and rapid loss of freeze tolerance due to budding during a winter warming event, combined with leaf defoliation, can increase the risk of bilberry decline. Bilberries have, on the other hand, demonstrated their adaptability by extensive re-growth of shoots to compensate for the damage caused by winter warming. Bilberries therefore appear to have a good capacity to compensate for the damage. As a result, the frequency and timing of extreme warming events are expected to be critical factors in how these berries interact with the environment, and potential changes.[450]

Markkula et al. (2019) state that there are limited studies regarding the effects of climate change on traditional Sámi plants such as garden angelica (Angelica archangelica, sám. boska/båsskå). Garden angelica is of high cultural and nutritional importance for Sámi as it traditionally is used for food and medicine.[451] Kaarlejärvi and Olofsson (2014) suggest that garden angelica may expand to higher altitudes and latitudes due to warming. The effects of warming might however be reduced by competition with other species and herbivore grazing.[452] [453]

Moth outbreaks

> *"My experience is that with the moth outbreak, there was so much nutrition on the ground, and green grass became dominant and we did not even see the bilberry plant for years. The bilberry was not damaged as such, it was simply out-competed. It's getting back normal now"*
>
> **– Sámi knowledge holder from eastern Sápmi**

Birch forests, and mountain birch forests in particular, are culturally significant as part of the Sámi cultural landscape. The forests have been used for centuries in a variety of ways, including as reindeer pasture–particularly during the summer–hunting, trapping, fishing, food and fuel gathering, raw material for handicrafts and construction, and spiritual purposes.[454] Moth outbreaks can cause severe damage to birch forests. Research highlights that in the 1960s, autumnal moth (Epirrita autumnata) defoliated large areas of mountain birch in Ohcejohka and these areas were reported to regenerate extremely slowly afterwards. Between 2002 and 2006, there was a significant moth outbreak in Fennoscandia, spreading from region to re-

445 Jansson m.fl., "Future changes in the supply of goods and services from natural ecosystems: Prospects for the European North".

446 Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

447 Bokhorst m.fl., "Impacts of extreme winter warming in the sub-Arctic: Growing season responses of dwarf shrub heathland".

448 Bokhorst m.fl., "Impacts of multiple extreme winter warming events on sub-Arctic heathland: Phenology, reproduction, growth, and CO2 flux responses".

449 Svensson, Carlsson, och Melillo, "Changes in species abundance after seven years of elevated atmospheric CO 2 and warming in a Subarctic birch forest understorey, as modified by rodent and moth outbreaks".

450 Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

451 Fjellström, "Fjällkvannen (Angelica archangelica) i samisk tradition".

452 Kaarlejärvi, Hoset, och Olofsson, "Mammalian herbivores confer resilience of Arctic shrub-dominated ecosystems to changing climate".

453 Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

454 Markkula, Turunen, och Rasmus.

gion. During this time, both autumnal and winter moths (Operopthera brumata) caused spatially variable defoliation in the Ohcejohka area again, and in Finnmark large areas of birch forests were damaged, and in some places, dead. Researchers report that herders interviewed in Guovdageaidnu and Máze observed that even the leaves of cloudberries were eaten by moths in summer 2008. Autumn moths have a long presence in Finnmark, and peak regularly about every 10 years. Warmer temperatures that facilitate increased winter survival of moth eggs and range expansion are thought to be causing an increase in the winter and autumn moths.[455] [456] During the last 15 years, the umber moth (Agriopis aurantiaria) has also invaded the coastal regions of northern Norway and established itself as a serious pest in the coastal birch forest. Higher spring temperatures suggest that a further expansion of the outbreak range of the umber moth can be expected in the future, as well as more frequent outbreak events from the winter and autumn moth due to fewer days of extreme cold.[457] [458]

The issue of moth outbreaks was the first to be brought up by knowledge holders in the Ohcejohka workshop. It was observed that the moth has caused particular damage to forests on harsh areas/barren land (guorba guovlu) close to the tree line. The area is greening as grass is taking over, grass plants are winning, there is less jeagil (lichen–Cladonia). It was also noticed that riversides were less affected by the moth. The experience after the moth outbreak during the1960s is that the grass is not staying permanently–it is just dominating some years following the moth outbreak. For the reindeer, grass is also good to feed on. When there are fewer trees, there will be less snow build-up, which could be good for winter grazing, the knowledge holder underlined. Näkkäläjärvi et al. (2022) highlight that some observations that were previously not known by scientists, for example that defoliation by moths has resulted in the disappearance of mushrooms but also that it has contributed to lichen spreading to birch forests even though it does not thrive there.[459] While reindeer grazing can benefit biodiversity and prevent overgrowth, recovery of birch forests from geometrid moth-caused damage has been shown to be more difficult in reindeer summer grazing areas, preventing birch forest renewal.[460]

A knowledge holder noted that a previous moth outbreak left very straight lines where the trees were damaged and where they were not, wondering what the reason for this might be. There was awareness of the two moth species. Both have eggs that are vulnerable to frost and will die at -37C. Now these colder winters are disappearing, we do not have those kinds of winters any more. In valleys it is colder than on the hilltops, that might be why the moth has not been eating off the trees in the valleys. When the grass takes over it dominates and there will not be any berries. Where there are no berries, there are no ptarmigan either. The grass is disturbing many things, the knowledge holders concluded.

Referring to the moth outbreak in the 1960s, a knowledge holder at the Ohcejohka workshop, noted that in Buolbmátjávri only a small area was affected by moth and it did not expand beyond this area. The moths seemed to do less damage to trees in the valleys and had more impact on barren areas with thin soil. "We can still see the boundary of the damaged and not impacted area there today, and the forest is still not all recovered", one of the knowledge holders said. The importance of birch forests for Sámi culture has previously been underlined by research.[461] The birch tree was highlighted by one of the knowledge holders as being among the most important trees for the Sámi, at least in the past. Birch is good both for making skis and sledges but moth outbreaks have had an impact on the quality of the wood, the knowledge holder said. Markkula et al (2018) suggest that moth outbreaks and forestry can change the landscape, which can affect Sámi culture in multiple ways.[462] The

[455] Forbes m.fl., ”Changes in mountain birch forests and reindeer management: Comparing different knowledge systems in Sápmi, northern Fennoscandia”.

[456] Jepsen m.fl., ”Climate Change and Outbreaks of the Geometrids Operophtera Brumata and Epirrita Autumnata in Subarctic Birch Forest”.

[457] Jepsen m.fl., ”Rapid northwards expansion of a forest insect pest attributed to spring phenology matching with sub-Arctic birch”.

[458] Jepsen m.fl., ”Climate Change and Outbreaks of the Geometrids Operophtera Brumata and Epirrita Autumnata in Subarctic Birch Forest”.

[459] Näkkäläjärvi, Juntunen, och Jaakkola, ”Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland”.

[460] Markkula, Turunen, och Rasmus, ”A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland”.

[461] Markkula, Turunen, och Rasmus.

[462] Markkula, Turunen, och Rasmus.

knowledge holders also noted that with fewer trees, there will be more erosion, since the birch does not hold the earth anymore. Willow thickets have died in many places, indicating that the land has dried up, as willows need wet places. The participants also turned to comment on the precipitation, saying that the summer rains have changed. In the 1950s there was more drizzle that could last for days. Nowadays there are rain spells, heavy ones, like those usually in the south in the 1990s.

Duodji

Even though research on climate change impacts in relation to duodji is limited, climate change has a number of implications for duodji, including changes in landscape, species distribution, and/or reindeer herding practices. Duodji will be directly impacted if the availability of handicraft materials decreases or if handicraft materials in nature must be taken at a different time than usual for the season. One of the knowledge holders expressed his concerns about climate change impacts on duodji at the workshop in Ohcejohka. "if there are bad grazing conditions in the spring, the antlers are really bad in the autumn. It goes straight to the bin." Concerns about the future of duodji was also discussed by participants at the seminar in Váhtjer. Participants were concerned not only about the effects of climate change, but also about the cultural changes that may result from changes in weather and landscape, as well as changes in access to and use of traditional materials. "These potential changes come with large cultural impacts", one participant said.

Markkula et al. (2019) highlight in their study that because reindeer are central to duodji practices and a large portion of the materials used in duodji are derived from reindeer, impacts on reindeer and reindeer husbandry have direct consequences for duodji. Furthermore, moth outbreaks can have a significant impact on birch forests, thus potentially challenging access and quality of wood material. Another factor emphasized in their article was the link between climate change and increased pressure from external land-use and development; many areas where materials for handicrafts are traditionally gathered are now open to exploitation by external actors, risking that possibilities for duodji practices may diminish, they concluded.[463]

Reindeer husbandry

Reindeer are of major cultural and economic significance for Sámi culture as part of social-ecological systems incorporating social, cultural, ecological, and economic values. Reindeer husbandry is dependent on functioning ecosystems and the annual cycle of reindeer ecology that determines the seasonal herding activities.[464] The fundamental resource is access to pastures: reindeer herding depends on the quantity and quality of pastures to secure the health and welfare of the reindeer.[465] Climate strongly influences pasture resources, for example from competition between different vegetation communities, but also access to the pasture. Connectivity and flexibility–the option to choose and move between different areas that hold variation in vegetation and topography–is particularly important to allow for responses to changes in grazing conditions or other disturbances.[466] Adaptive capacity and resilience is thus founded on Sámi Indigenous knowledge and the experience of herders, which is evident in practices, language, and husbandry institutions.[467] [468]

> **Reindeer herding practices in their very nature represent a model for the sustainable exploitation and management of northern terrestrial ecosystems that is based on generations of experience accumulated, conserved, developed and adapted to the climatic and administrative systems of the North.[469]**–Eira et al. (2018)

Climate change impacts on reindeer and reindeer herding stem from both slow-onset changes and extreme weather events. Changes in vegetation and plant community composition pose risks to the quality and availability

[463] Markkula, Turunen, och Rasmus.

[464] Eira, Turi, och Turi, "Sámi Traditional Reindeer Herding Knowledge Throughout a Year: Herding Periods on Snow-Covered Ground".

[465] Tonkopeeva m.fl., "Framing Adaptation to Rapid Change in the Arctic".

[466] Horstkotte m.fl., "Pastures under pressure. Effects of other land users and the environment."

[467] Mathiesen m.fl., "Strategies to enhance the resilience of Sami reindeer husbandry to rapid changes in the Arctic. In: Arctic Resilience Interim Report 2013."

[468] Eira, Turi, och Turi, "Sámi Traditional Reindeer Herding Knowledge Throughout a Year: Herding Periods on Snow-Covered Ground".

[469] Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

of pasture, which reduces reindeer health and survival.[470] Events related to winter precipitation, with extreme snowfall and increased occurrences of rain-on-snow and thawing-freezing due to shifting temperatures, have already resulted in losses in herds in Sápmi due to thick snow cover and ice barriers over lichens and mosses starving reindeer.[471] However, ecosystem responses to the changing climate, such as vegetation shifts, also come with impacts on geographic distribution of species and epidemiology. This increases risks for the spread of parasites and climate-sensitive infectious diseases, many of which are zoonotic (spread to humans from animals).[472] Other impacts related to climate change include political or cultural consequences related to changes in use of Sámi Indigenous knowledge and skills.[473] [474] but also the consequences from the significant burden added on herders from increased workload, financial costs and stress from adaptive herding practices undertaken – with resources, workforce, time and overall adaptation options that have limits. These impacts are further amplified by multiple pressures, such as competing forms of land use, and predators, which constrain herders' adaptation options–with impacts both on herder and reindeer. Flexibility and geographical space are fundamental to the ability to make adjustments, but fragmented, shrinking landscapes and predation are making the adaptive capacity of herders and the resilience of reindeer herding challenging, or even impossible. These factors have been highlighted in research as factors that reduce psycho-social health and increase suicidal thoughts among herders.[475] [476] [477] [478] [479]

A study published in 2022 highlights that only 4% of reindeer grazing areas are untouched by human activities such as forestry, mining, tourism, roads and railways in Norway, Sweden and Finland.[480] Grazing lands in Finnmark have reportedly lost about 50% of their biodiversity in calving grounds and the scenario for 2030 anticipates another 10%will be lost. Herders indicated that while loss of biodiversity is a serious issue and concern, the threats behind biodiversity loss cause the largest problems–i.e. the change in land use from the expansion of urban and industrial areas, and recreational cabin areas, that cause an increase of human disturbances in or near the calving grounds and migration routes.[481] In its most recent assessment cycle, IPCC (2022) highlighted that climate change in combination with the cumulative effects of land use already has increased vulnerability and reduced the adaptive capacity of reindeer herding to the extent that its long-term sustainability is threatened.[482] This is eight years after their previous report which stated that protecting grazing lands would be the most important adaptation measure for reindeer herders under climate change.[483]

470 Mallory och Boyce, ”Observed and predicted effects of climate change on Arctic caribou and reindeer”.

471 AMAP 2021, ”Arctic Climate Change update 2021: Key trends and impacts. Summary for policy-makers”.

472 Sirpa m.fl., ”Reindeer husbandry and climate change. Challenges for adaptation.”

473 Magga m.fl., ”Reindeer Herding, Traditional Knowledge and Adaptation to Climate Change and Loss of Grazing Land”.

474 Turi, ”State Steering and Traditional Ecological Knowledge in Reindeer-Herding Governance : Cases from Western Finnmark, Norway and Yamal, Russia”.

475 Näkkäläjärvi, Juntunen, och Jaakkola, ”Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland”.

476 Kaiser och Renberg, ”Suicidal Expressions among the Swedish Reindeer-Herding Sami Population”.

477 Kaiser m.fl., ”Depression and anxiety in the reindeer-herding Sami population of Sweden”.

478 Furberg, Evengård, och Nilsson, ”Facing the limit of resilience: perceptions of climate change among reindeer herding Sami in Sweden”.

479 Jaakkola, Juntunen, och Näkkäläjärvi, ”The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union”.

480 Stoessel, Moen, och Lindborg, ”Mapping cumulative pressures on the grazing lands of northern Fennoscandia”.

481 Rooij m.fl., ”Loss of Reindeer Grazing Land in Finnmark, Norway, and Effects on Biodiversity: GLOBIO3 as Decision Support Tool at Arctic Local Level”.

482 Bednar-Friedl m.fl., ”IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change”13.8.1.3 Loss and Damage to Vulnerable Livelihoods in Europe.

483 Hodgson m.fl., ”IPCC, 2014: Polar regions. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change”.

"The worry is there before every winter about how it will be. Also before calving starts–if it will be a cold and hard spring where there is no thawing and no bare spots. Worry before each calf-marking if it will be hot and dry. It affects you long before these seasons come since you start thinking about how it all will go this time. A calf-marking is no longer something I look forward to in the same way because of this."

– reindeer herder in Saami Council interview

In line with climatic data and reporting, research made including observations from reindeer herders in Norway, Sweden and Finland note that the weather has become more variable and unpredictable in all seasons, making predictions on grazing conditions more difficult. Higher temperatures, a decrease in long periods of extreme cold, increased windiness, more frequent rainfall, and increased snow-loads on trees in winter are examples of noted change.[484] [485] [486] Increased snow depth and extreme snowfall, but also later snow cover formation and earlier snowmelt are also observed.[487] [488] [489] The same observations were reported by the knowledge holders and herders in the making of this report.

While Arctic studies on climate change have primarily focused on extreme temperature and precipitation there are relatively few analyses of high-wind events.[490] Results reported in climate- and vulnerability analyses for climate adaptation made by four reindeer herding communities in Swedish Sápmi, show that herders experience more and harder winds, especially during the snow-free season, compared to recent years.[491] Similar to these findings, and the observations from other Sámi knowledge holders presented earlier in this chapter, increase of winds is reported by all reindeer herders that Saami Council has interviewed when asked if they have experienced any difference in the weather patterns from before.

"The weather has become much more unpredictable and extreme. It is always windy and the wind is stronger."

– reindeer herder from the northern part of Sápmi

"There is an increase of heavy winds and bad snow conditions for reindeer. Temperatures change rapidly."

– reindeer herder in northern part of Sápmi

"Many say that the winds in the past were not as rough as they are nowadays. There are more southerly winds nowadays. The weather used to be much more stable and did not switch as fast as now. Even though there was a lot of snow, the cold made it seakŋaš (a snow condition with loose snow structure) in order for the grazing condition to still be good.In the winter of 2020 there were strong winds and heavy snow falls and mild weather. The 2021 fall-winter with strong wind threw down kilometres of the border fence between Norway and Finland, in several places. We have not experienced that before. Then there had been rain after snowfall, so the fence was maybe so iced up that strong winds actually threw it down."

– reindeer herder in northern part of Sápmi

"We have felt a lot of changes in the climate in recent years. There is much more extreme weather with lots of wind and rain. It storms very often. Nowadays, winter doesn't come until January. It even rains in January. It can rain for large parts of December as well. If you are to see the positive in the strong winds: the wind dries the ground so that they are not full of water before the cold comes and freezes everything to ice."

– reindeer herder in southern part of Sápmi

484 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

485 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

486 Forbes m.fl., "Changes in mountain birch forests and reindeer management: Comparing different knowledge systems in Sápmi, northern Fennoscandia".

487 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

488 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts".

489 Risvoll och Hovelsrud, "Pasture access and adaptive capacity in reindeer herding districts in Nordland, Northern Norway".

490 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 4.

491 "SWECO, 2019: Syntesrapport: En sammanställning av fyra samebyars pilotprojekt med klimat- och sårbarhetsanalys samt handlingsplan för klimatanpassning".

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

Giđđadálvi ja giđđa

Herders in Sápmi testify to increasingly unstable weather in spring with sudden changes–of course with local variations. Some examples are early snowmelt, slushy weather, a lot of deep snow, increased winds, increased snowfall in April/May and longer winter in some mountain areas. A reindeer herder operating in north said to the Saami Council that: "*In the spring there might not be bievla (bare ground) until June.*" Another herder said: *"spring is totally gone–it is čakčadálvi (spring-winter) with a lot of snow and hard winds, then suddenly it becomes very hot and pre-summer instantly. Our elders have told us about their experiences from some strange winters during the 60's and 90's for example, but that everything turned back into normal. Now the change is constant, and one becomes confused. It is now hard to trust our own knowledge on reindeer behaviour and grazing conditions.*" 100 kilometres south, a reindeer herder operating in a forest reindeer herding community said, *"in general, it feels like we have more snow during winter, and spring and the timing of snowmelt shifts from year to year."*

The timing of calving in spring is critical for the calf's survival and growth. The timing of calving is determined by the timing of the rut in the previous autumn, as well as the weather and grazing conditions in the winter and spring.[492] The timing of spring snowmelt varies greatly from year to year and snow accumulation or delayed green-up during the calving season can contribute to malnutrition and have a negative impact on reindeer health and reproductive success. Thawing, wet snow can also be stressful during the calving season because it makes it difficult for the cow to keep the calf dry.[493] In northern Finland, calving reportedly happens approximately one week earlier than in the 1970s.[494] Research suggests that warmer temperatures, which result in earlier snowmelt and an earlier start to the growing season, can help reindeer recover from a difficult winter and be particularly favorable for lactating reindeer cows and their newborn calves. This could be beneficial as it could result in earlier discontinuation of supplementary feeding and lower expenses. An early spring with early snowmelt can however force herders to move their herds earlier up to spring pastures with risks of facing difficult snow conditions, but also challenge the spring migration in general due to thawing and weak ice on lakes and rivers.[495] [496] [497] [498] Coastal areas in Nord-Trøndelag and Nordland in Norway experience an average of 15 days earlier start of spring compared to the 1980's which has resulted in herders having to move earlier from coastal winter pastures up to the mountains to avoid conflicts with agriculture.[499] For reindeer herding communities in these areas, spring pastures are most often located at higher elevations and mountain areas do not show the same trend of early spring and snowmelt. Increased winter precipitation may delay snowmelt in these areas[500] thus making the snow season long.

> *"During the calving season, it is extra stressful as you do not know what the climate will be like. There may be metres of snow and no bare spot where the aaltoe (female reindeer) can calve. Or it can suddenly become many minus degrees with slush snow so that reindeer freeze to death. What is extra stressful about this is that with increased tourism and the amount of predators, the reindeer cannot rest. Especially in cases with the climate, it is extra important that the calf is allowed to lie down next to the aaltoe to keep warm. But if there is unrest, the aaltoe can run away from the calf and it will become food for predators or freeze to death."*
>
> **– reindeer herder in southern Sápmi**

"2019/2020 was an extremely long winter, and with lots of ice layers in the snow"

The winter of 2019/2021 was extreme for herders and spring was long in many places throughout Sápmi. An unusually thick snow cover combined with a late spring disrupted migration, and calves were born on top of the snow cover, with

492 Magga m.fl., "Reindeer Herding, Traditional Knowledge and Adaptation to Climate Change and Loss of Grazing Land".

493 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

494 Paoli m.fl., "Winter and spring climatic conditions influence timing and synchrony of calving in reindeer".

495 Turunen m.fl., "Does climate change influence the availability and quality of reindeer forage plants?"

496 Vuojala-Magga m.fl., "Resonance Strategies of Sámi Reindeer Herders in Northernmost Finland during Climatically Extreme Years".

497 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

498 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

499 Riseth och Tømmervik, "Klimautfordringer og arealforvaltning for reindrifta i norge kunnskapsstatus og forslag til tiltak. Eksempler fra Troms."

500 Beniston m.fl., "The European mountain cryosphere: A review of its current state, trends, and future challenges".

many of them not surviving their first days. In northern Norway, the situation was mitigated by governmental crisis funds of 43 million kroner for transporting fodder to the herds, but the Covid-19 pandemic made herding and transport even more difficult by limiting the use of extra labor.[501] [502] See more about the grazing crisis in Norway section Health and well-being in Sápmi.

A young reindeer herder in western part of Sápmi reported to Saami Council that: *"winter and Easter 2019/2020 was extreme. There were maybe two or three storms in December-January and it was snowing and raining over each other. And in April a lot of snow came, and Easter was a real crisis. It felt like the snow would never go away. We drove snowmobiles in the mountains that summer."* A reindeer herder operating in the northern part Sápmi said *"for us the snow came early in the winter of 2019–approximately 50 cm of wet snow in September that didn't melt until June 2020."* 600 kilometres south, a reindeer herder reported similarly, *"During spring 2020, the snow never wanted to melt, and it was wet, thawy snow and bad weather during the calving period. There were no bare spots as it usually is and the aaltoe (female reindeer) had do deliver their calves into the deep snow."*

Reindeer grazing and vegetation

Reindeer are one of the most important herbivores in Northern Fennoscandia. Reindeer grazing affects the competition between different plant groups and vegetation communities in different ways – all depending on the conditions of the land, such as its vegetation type and nutrient productivity, and the amount of time reindeer graze at the site. Reindeer grazing has been found to both increase the amount of nutrients in the soil and decrease it, but most often the amount of nutrition increases.[503] [504] Research has also found that reindeer grazing in particular has the potential to counteract climate-induced shrubification as grazing facilitates maintaining the openness of tundra areas – a precondition for the survival of many Arctic plants and species.[505] [506] Thus, reindeer husbandry represents an efficient environmental management strategy and conservation tool for maintaining open tundra landscapes in the face of rapid climate change.[507]

Climate change will affect forage resources differently depending on the season, and changes may be species-specific. While greening, or increased plant growth, is one of the key findings and estimates with a changing climate it is still unclear how climate change will affect forage quality. A warmer climate is expected to expand and increase the abundance, height, and cover of shrubs and grasses at the expense of mosses and lichens, but while the quality of reindeer forage plants has been found to increase with warmer soil temperature on sites with rich soils, it is not yet known how a warmer climate will affect the nutrient-poor soils that dominate northern Fennoscandia. Productivity interacts with other complex factors, and it has been demonstrated that productivity declines in some areas as a result of extreme weather events, disease, herbivore outbreaks, wildfire, flooding, or erosion.[508] [509] Moen suggested in 2008 that climate change may impact forage quality in both positive and negative ways. An extension of the growing season mainly affects summer grazing in the mountain areas as production of the pasture can increase due to higher temperatures and faster nutrient turnover in the soils. However, a longer growing season can also lead to reduced nutrient content as the season progresses and plants that are adapted to shorter seasons are thus at risk of wilting.[510] In addition, general benefits gained from early green-up could also be counteracted by the adverse impacts of dryer summers and the effects of haymaking.[511]

501 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

502 Johnsen m.fl., "'Leaving No One Behind' – Sustainable Development of Sámi Reindeer Husbandry in Norway".

503 Käyhkö och Horstkotte, *Reindeer husbandry under global change in the tundra region of Northern Fennoscandia.*

504 Tunón och Sjaggo, "Ájddo – reflektioner kring biologisk mångfald i renarnas spår".

505 Käyhkö och Horstkotte, *Reindeer husbandry under global change in the tundra region of Northern Fennoscandia.*

506 Cairns och Moen, "Herbivory Influences Tree Lines".

507 Verma m.fl., "Can reindeer husbandry management slow down the shrubification of the Arctic?"

508 Käyhkö och Horstkotte, *Reindeer husbandry under global change in the tundra region of Northern Fennoscandia.*

509 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

510 Moen, "Climate change: effects on the ecological basis for reindeer husbandry in Sweden."

511 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 7.

Lichen

Reindeer forage over 300 different plants in addition to fungi, but the most important diet for reindeer during the winter are terrestrial ground lichens of all types. Lichens have variable responses to warmer temperatures and increased precipitation, but they are generally sensitive to environmental changes. Ground lichens thrive in dry, low-productivity soils and only grow when wet. The proportion of light strongly affects their growth, and they are out-competed in moist and fertile soils.[512] Tree lichens and their growing conditions are highly dependent on the conditions within the forest canopy. Humidity, light, temperature, and wind exposure are important environmental factors, but their abundance is also affected by forest age and the continuity of key habitats.[513] The growth of ground lichens increases with precipitation. Warmer temperatures can result in a shorter time of lichen being in a moist state that is so crucial for its growth. Increased precipitation may also favor growth of mushrooms, but warm and late autumns with unfrozen soils can also result in the growth of molds (mycotoxin-producing microfungi) below the snow, negatively affecting forage resources and lichen.[514] [515] Above the treeline, earlier springs, longer growing seasons and the increase in abundance of other plants tend to reduce lichen abundance due to competition. In boreal forests, other plants and the increased density of the tree layer decrease ground lichen growth. Managed forests tend to be much denser than naturally regenerated forests, thus affecting light reaching to the ground. Warmer temperatures during summer can improve growing conditions for some tree lichens but have a negative effect on those that grow in exposed parts of the canopy.[516]

Herders in Sweden and Finland who have their primary winter grazing areas located in boreal forests have have found they can longer sustain the herds in the same way and have changed reindeer herding practices. Forestry has changed the age structure and composition of forests, with direct consequences for ground and tree lichens. For example, data shows a 71 % decline of lichen-abundant forests in Sweden over the last 60 years[517] compounding the negative impacts of climate change for herders. In combination with shrinking grazing areas, it is difficult or even impossible for herders to access alternative grazing sites in wintertime when grazing is challenged; remaining areas must be used more intensively. This too has effects on lichen abundance as it does not allow for pastures to rest to facilitate the recovery of lichens.[518] Mathiesen (2023) however underlines that “the dominant point of view with ‘overgrazing’ should instead be seen as an institutional one – the result of public policies that created wrong incentives for reindeer husbandry in recent decades. To assign the solution to the problem of overgrazing only to the most politically weak participant in the conflict – the private reindeer herder–would be immoral.”[519]

512 Gaio-Oliveira m.fl., ”Effect of simulated reindeer grazing on the re-growth capacity of mat-forming lichens”.

513 Horstkotte m.fl., ”Pastures under pressure. Effects of other land users and the environment.”

514 Tømmervik m.fl., ”Rapid recovery of recently overexploited winter grazing pastures for reindeer in northern Norway”.

515 Jouko m.fl., ”Erratum to: Both reindeer management and several other land use factors explain the reduction in ground lichens (Cladonia spp.) in pastures grazed by semi-domesticated reindeer in Finland”.

516 Horstkotte m.fl., ”Pastures under pressure. Effects of other land users and the environment.”

517 Sandström m.fl., ”On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management”.

518 Horstkotte m.fl., ”Pastures under pressure. Effects of other land users and the environment.”

519 Mathiesen, ”Reindeer Husbandry in the Circumpolar North”.

Giđđageassi ja geassi

During summer, heat and insect harassment usually draws reindeer into large herds, e.g., on snow patches in the mountain areas. With an increasing number of hot days during summer, fell habitats–particularly snow beds and snow patches–are threatened as warmer summers mean less snow, which in turn means less protection from insects.[520] [521] This also entails increased risks for thermal stress as reindeer are cold-adapted.[522] Stressed reindeer spend less time grazing, which means less time for weaning for the calves. Long periods of hot weather and insect harassment are particularly harmful for calves as it risks affecting their weight and can increase deaths.[523] [524] [525]

> *"The early summer season and summers can be very hot with +30 C in the mountains which does not feel normal. This means late greenery and some plants even dry out. Several summers have also had so-called 'tropical nights' which means great pressure on the reindeer herd since there is no cooling for them at night. The herd becomes so vulnerable."*
>
> **– reindeer herder in southern Sápmi**

> *"Heat and drought during summer makes greenery stop and for our reindeer to stand on snow patches or glaciers most hours of the day which makes possibilities to graze decrease drastically."*
>
> **– reindeer herder in northern Sápmi**

Unlike mountain reindeer, forest reindeer usually gather on wetlands and nearby forests during chilly nights. They can graze the wetlands all day if the weather is cold enough. Wetlands and the forests that connect them are significant for forest reindeer herding communities since these systems are the foundation of the whole forest reindeer husbandry. Wetlands contain much different vegetation that is grazed from early spring when snow starts to melt, until the snow arrives again. Due to their openness wetlands facilitate gathering and controlling of the herd.[526] Heat waves usually contribute to forest reindeer separating instead of gathering which pushes reindeer into smaller herds in the forests to seek shadow. However, forestry and its infrastructure have significantly reduced many old spruce forests that can give relief from heat and insects.[527] Heavy deforestation, where old natural forests are replaced by monoculture plantations, has already changed landscapes and local biodiversity. Sámi organizations and reindeer herding communities are demanding a shift in current forestry models.[528]

A reindeer herder from a forest reindeer herding community in northern Sápmi remarked: *"For many years in a row, my sijdda has had to pause the gatherings for calf-marking due to the heatwaves in early July. The reindeer don't gather at all. But first and foremost, they need to be unbothered with their calves due to the risks that come with gathering them in the heat. Nothing is like it used to be when I was a child. Chill, windy and rainy summers that are not too cold tend to be great for the growth of the calves for us. We can see wetlands cracking during heat waves or longer periods of high temperature – periods that sometimes last longer than two weeks now. Reindeer are adaptive and we have seen that, but now I have started to think about how far they can adapt to the change, thinking about the heat especially. I have never had to think this way before."*

> *"During summer it can be very dry, like last year (2021). On the contrary, this summer has come with a lot of rain and it is good for the reindeer as there are now a lot of mushrooms. There are great variations between the years–that might be the largest impact. Our neighboring district on the other side of the border has experienced wildfires on their winter grazing land. This was an exceptional event, and bothersome for them."*
>
> **– reindeer herder in northern Sápmi**

[520] Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

[521] Markkula, Turunen, och Rasmus, "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland".

[522] Soppela, Nieminen, och Jouni, "Thermoregulation in reindeer".

[523] Weladji, Holand, och Almøy, "Use of climatic data to assess the effect of insect harassment on the autumn weight of reindeer (Rangifer tarandus) calves".

[524] Hagemoen och Reimers, "Reindeer summer activity pattern in relation to weather and insect harassment".

[525] Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

[526] Blind m.fl., *Myrens betydelse för renen och renskötseln. Biologisk mångfald på myrar i renskötselland.*

[527] Sandström m.fl., "On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management".

[528] "Standing up for forests and against the Swedish forestry model: A letter to EC policymakers".

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

Increased precipitation or heavy rains in summer are also observed in some areas in Sápmi, with mixed impacts on reindeer production. The higher precipitation and heavy rainfall could be beneficial for vegetation growth and mushroom abundance, but floods and wet ground could have adverse implications for herding.[529] [530] A cold and rainy summer can also contribute to delayed and poor development of vegetation which also can have a negative impact on grazing, and the growth of the calf.

Increased precipitation in combination with warmer temperatures also generally facilitates an increased presence of insects. Insect harassment is stressful, disturbing, and sometimes painful for the reindeer, and affects reindeer behavior.[531] [532] Herders report that some insects have indeed changed their timing and abundance. The reindeer herder from a forest reindeer herding community noted, *"We are totally dependent on the weather, but the insects too, and they have also changed their patterns. Mosquitoes help us gather the herds, but now the black flies (Simuliidae) and midges (Ceratopogonidae) come at the same time as the mosquitoes, when they previously used to come in early autumn. They have the opposite effect from the mosquitoes – they tend to make herds separate."* Further up north, a reindeer herder operating in the mountain areas said: *"The warble fly (hypoderma tarandi) has come far up in the mountains already in June. This has not happened before. Midges and black flies also arrive before the mosquitoes. And birch trees have started to grow on the highest mountains."* A reindeer herder in southern Sápmi observed: *"Some summers we have had extremely many horse flies. And there are much more insects in general, mosquitoes etc. But they can also be absent periodically when it is hot and dry. We have also had ticks on calves during calf marking and increased number of cases of eye infections in our reindeer."*

Ticks, mosquitoes and midges may act as sources for parasites, bacteria and viruses as they feed on reindeer. This can cause disease in reindeer – and some diseases can be passed to people. Ticks (ixodes ricinus) are emerging on reindeer in Nordland county, Norway[533] while studies from Sweden indicate that ticks are present in almost all the northern municipalities.[534] Warmer and wetter seasons in combination with increases in shrub and forest vegetation have shown to be beneficial for tick abundance and distribution.[535] Parasites on the skin can cause diseases and secondary infections in reindeer. A study published in 2020 indicates that deer ked (lipoptena cervi) infestations on reindeer in Finland have expanded northward during the past five years.[536] Infestations of these parasites can cause acute behavioral disturbance in reindeer and thus pose a potential threat to reindeer welfare.[537] The warble fly (hypoderma tarandi), a well-known parasite among herders, can cause myiasis (where fly larvae get into the flesh) in reindeer which can be very painful, and cases of human myiasis have also been reported in northern Norway between 2011-2016.[538]

Wetlands in Sápmi

The Saami Council, together with Stockholm Environment Institute, the Norwegian Institute for Water Research and Sámiid Riikkasearvi (SSR) is running a project called "Wetlands in Sápmi". The project focuses on forest reindeer husbandry and traditional Sámi knowledge. The project explores the past, present, and future use of traditional grazing lands, particularly wetland areas, in two forest herding communities, Vittangi and Malå forest herding communities on the Swedish side of Sápmi. The project's main aim is to explore and illustrate how land use has changed from the 1960s until now,

529 Rasmus m.fl., "Climate change and reindeer management in Finland: Co-analysis of practitioner knowledge and meteorological data for better adaptation".

530 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

531 Näkkäläjärvi, Juntunen, och Jaakkola.

532 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

533 Åhman m.fl., "Role of supplementary feeding in reindeer husbandry".

534 Jaenson m.fl., "Changes in the Geographical Distribution and Abundance of the Tick Ixodes ricinus during the Past 30 Years in Sweden".

535 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

536 Kynkäänniemi, Kortet, och Laaksonen, "Range expansion and reproduction of the ectoparasitic deer ked (Lipoptena cervi) in its novel host, the Arctic reindeer (Rangifer tarandus tarandus), in Finland".

537 Kynkäänniemi m.fl., "Acute impacts of the deer ked (Lipoptena cervi) infestation on reindeer (Rangifer tarandus tarandus) behaviour".

538 Landehag m.fl., "Human myiasis caused by the reindeer warble fly, Hypoderma tarandi, case series from Norway, 2011 to 2016".

considering the significant development of other land users and, to some extent, climate change impacts in these communities. Results from the project will be ready by spring 2023.

Herders participating in the project have highlighted the importance of wetlands but also commented that they prefer to use the wording 'wetland-rich areas' to also refer to the adjacent forest (old-spruce forest) connecting the wetlands. The combination of these two–wetlands and forests–is considered the foundation of forest reindeer husbandry, not only for food and grazing but also for shadow and resting during hot summer days when the open wetlands get too hot for the reindeer. This can be compared with the snow-covered high peaks in the mountain reindeer communities.

Warmer temperatures and longer growing seasons are projected to result in forests becoming denser, expanding northwards and to higher elevations. Research that included herders from Sweden, Norway and Finland, have reported that the growth of birches and willows on grazing grounds have made reindeer select grazing grounds at higher altitudes. Herders in Norway and Finland also report that more trees in winter grazing areas result in larger accumulation of snow, making it harder for reindeer to dig through the snow for lichen and other plants.[539] Other research highlights that the increase in birch forest also can give positive effects as the availability of fresh green forage in early summer is improved for the lactating reindeer and their calves.[540]

As climate models predict that Arctic warming may transform tundra areas into shrublands before the next century, these transformations will have consequences for reindeer husbandry and herding strategies. Exactly how and to what extent these impacts may be felt is yet unknown, but movement might be more difficult and calf-marking sites may need to be relocated.[541] [542] As noted earlier in this chapter, reindeer grazing can inhibit shrub development and help keep landscapes open. One issue connected to shrubs and birch forests is however the increased risks for outbreaks of geometrid moths that can damage mountain birches and other reindeer forage plants.

Čakčageassi ja čakča

> *"Autumn is longer and wetter now. When we were kids during the 60's we used to ice-skate on the lakes in October. The ground froze before the snow came and the snow that came was dry – today it is wet."*
>
> **– reindeer herder from a forest reindeer herding community in northern Sápmi**

Autumn is the season of slaughter and rut. The rut is a seasonal phenomenon influenced by grazing conditions in the previous spring and summer, as well as weather. Warm autumns might cause rutting to be delayed or even unsynchronized.[543] Late formation of ice and permanent snow cover in October-November due to variable weather – combined with low lichen biomasses – can make gathering and moving of herds difficult since herds might disperse. Snow hinders herds from spreading out and is a prerequisite for optimal herding circumstances. Variable weather poses general risks during migration.[544] A reindeer herder operating in northern Sápmi stated, *"The ice on the rivers and lakes does not freeze as early as before and is not so durable when finally frozen. This makes migration and driving with ATV's or snowmobiles more dangerous."* Näkkäläjärvi et. al. (2020, 2022) suggest that herding has become more dangerous due to climatic factors. Shortened periods of continuous snow cover and decreased bearing capacity of the ice on lakes and rivers make it difficult to move between different grazing

539 Käyhkö och Horstkotte, Reindeer husbandry under global change in the tundra region of Northern Fennoscandia.

540 Forbes m.fl., "Changes in mountain birch forests and reindeer management: Comparing different knowledge systems in Sápmi, northern Fennoscandia".

541 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

542 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

543 Rasmus m.fl., "Climate change and reindeer management in Finland: Co-analysis of practitioner knowledge and meteorological data for better adaptation".

544 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

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areas and sometimes pose serious risks for both reindeer and herders.[545] [546] Due to the projected longer autumns and earlier springs in the future, changing the time of migration between seasonal pastures may be necessary, and many reindeer herding communities and districts and districts have already postponed migration to winter grazing areas due to a lack of snow formation.[547] [548] A reindeer herder from the south reported, *"The snow arrives much later down in the winter grazing area, which means that we cannot move there at the time we did before. In addition, since we have major issues with predators, especially wolves, protective hunting efforts are less successful since there is no snow for tracking."*

Longer autumns and milder winters have made it easier for reindeer to find nutrition in some areas, and nutrition is available during a longer time.[549] In Finnmark, Norway, the prolonged growing season may allow longer time spent on coastal summer pastures before migration, thus preventing increased growth of shrubs and trees perceived as detrimental to both migration and valuable grazing resources. This can also spare the winter grazing areas.[550] [551] While a prolonged snow free autumn and migration to winter pastures might have positive effects on grazing opportunities for the reindeer before winter, it is not unproblematic as migration can entail risks due to unsecure environmental conditions. A newly released report by Norgga Boazosápmelaččaid Riikkasearvi highlights that September-December is in fact the period with highest reported rates of injuries. This is related to migration, uncertain ice conditions and the general seasonal activities during autumn.[552]

> *"Hydropower has already had its impacts on reindeer husbandry in our area. Dammed rivers mean that we cannot move the reindeer as we used to. The ice on these nowadays huge lakes is becoming thinner, and now with a warmer climate it will only get worse. In addition, slush flows and landslides in the mountains–we've had it at home already. What will happen to the reindeer husbandry?"*
>
> **– said by a Sámi participant at the seminar in Váhtjer**

> *"In the last 10-15 years, almost every winter has been bad for the pasture. A lot has to do with weather during the autumn. Snow falls early on unfrozen ground which either melts down to become ice or melts away completely, but if so, the water usually turns to ice on the lichens or just pure blank ice everywhere. This gives us a bad start for the long winter."*
>
> **– reindeer herder from the northern part of Sápmi**

Čakčadálvi ja dálvi

> *"Autumns are warmer and winter sets in later. The ground soil does not get to freeze before the snow sets, and then there will be milder weather again, and rain, and you get layers of hard snow and ice at the bottom. It has been like this all years since I started to work daily with reindeer."*
>
> **– reindeer herder in northern part of Sápmi**

Winter is a critical period within reindeer husbandry. Snow conditions are determined by precipitation and temperature shifts in late autumn and early winter, which have a significant impact on forage availability and access.[553] A single intense snowfall or rain-on-snow event on unfrozen ground can have a significant impact on grazing conditions for the rest of the winter, as ground vegetation can become mouldy

545 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

546 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

547 "SWECO, 2019: Syntesrapport: En sammanställning av fyra samebyars pilotprojekt med klimat- och sårbarhetsanalys samt handlingsplan för klimatanpassning".

548 Löf, "Examining Limits and Barriers to Climate Change Adaptation in an Indigenous Reindeer Herding Community".

549 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

550 Horstkotte m.fl., "Human–animal agency in reindeer management: Sami herders' perspectives on vegetation dynamics under climate change".

551 Riseth och Tømmervik, "Klimautfordringer og arealforvaltning for reindrifta i norge kunnskapsstatus og forslag til tiltak. Eksempler fra Troms."

552 Sokki Bongo, Stenfjell, och Logstein, "Helse, miljø og sikkerhet i reindrift. Funn fra kartlegging blant reindriftsutøvere".

553 Turunen m.fl., "Coping with Difficult Weather and Snow Conditions".

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or encased in ice. Locked winter grazing can have very serious consequences as it may increase reindeer mortality and reduce calving success if there are no opportunities for alternative grazing or supplementary feeding.[554] [555] [556] In addition, challenging snow conditions can also increase reindeer losses to large carnivores as deep snow does not support the reindeer's weight, making it an easy target for predators and thus more vulnerable.[557] [558]

Herders testify to an increase in unstable weather and locked grazing conditions due to shifting temperatures, freezing rain during winter and heavy snowfall. A reindeer herder operating in the southern part of Sápmi said, "When the snow does come, sometimes very large amounts of it come at the same time that makes everything difficult. The reindeer have to fight through what feels like metres of snow." A reindeer herder from a forest reindeer herding community agreed: *"There are large temperature shifts in winter. It is warmer and the cold periods are shorter – it is mild but with more snowfall. The trees are covered with snow for a long time and wet snow freezes to the trees. Some years we are far into March before the snow finally melts away from the trees."* Further north, a reindeer herder said, *"There are not those hard and long frost periods like they were in my childhood, but a lot of winds and snowstorms and mostly southerly winds. There has always been a lot of snow here in this area, but nowadays there can be several ice layers in the snow due to milder periods and rough winds, so the grazing is not that good. The winter of 2020 was really bad. Around Christmas it started to snow with wind, and it kept on almost the whole winter. The pastures have never in our lifetime been so bad as then. The reindeer started to die, and we have no tools to prevent this situation. There was no other solution than to let the reindeer wander off and wish for their survival when they go to the woods or 'forestry area'–I say that because there is no forest there really. There was no chance to find any food on the ground. My father and the neighbors his age have experienced crisis winters in the 90s as well, but in their minds the 2020 crisis was worse. We had a crisis also in 2017. It seems to happen more often than before. Seems like every second or third winter is really bad."*

Bad grazing years have periodically occurred in Sápmi. While studies of the prevalence and frequency of ground ice formation events are rare, a few studies have reported increased frequency of extensive ice formation beneath the snow.[559] [560] Events with extremely bad grazing from ice on top of or in the snow, ice on the ground and in vegetation, a lot of deep snow, or a combination of these, are called goavvi in northern Sámi, and they can cause severe impacts on reindeer husbandry. Over the last 100 years, goavvi has occurred sixteen times in Guovdageaidnu, Norway and its frequency seems to have increased. Climate change scenarios predict that the occurrences of goavvi will likely increase in the future.[561] [562]

As described in chapter 4, in northern Sweden and Norway, increased winter precipitation has been recorded during the past 30 years compared to the reference period of 1961–1990[563] and several reindeer herding districts in Sweden report a 30% increase in winter precipitation; snowpack thickness varied up to 50% between years.[564] In northern Finland, studies found that the impacts of warmer winters and fewer frost days differed depending on geography. While some herders experienced reduced access to ground lichens due to deep snow and ice formation, others experienced increased access to foraging due to a thinner snow layer and shorter cold season.[565]

554 Johansson m.fl., "Multi-Decadal Changes in Snow Characteristics in Sub-Arctic Sweden".

555 Moen, "Climate change: effects on the ecological basis for reindeer husbandry in Sweden."

556 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

557 Sirpa m.fl.

558 Turunen m.fl., "Coping with Difficult Weather and Snow Conditions".

559 Rasmus, Kivinen, och Irannezhad, "Basal ice formation in snow cover in Northern Finland between 1948 and 2016".

560 Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

561 Eira m.fl.

562 Johnsen m.fl., "'Leaving No One Behind' – Sustainable Development of Sámi Reindeer Husbandry in Norway".

563 Vikhamar-Schuler m.fl., "Changes in Winter Warming Events in the Nordic Arctic Region".

564 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

565 Rasmus m.fl., "Climate change and reindeer management in Finland: Co-analysis of practitioner knowledge and meteorological data for better adaptation".

Stable weather with continuous cold periods means stable grazing conditions for the reindeer, while reduced occurrence of these periods means increased work in moving, gathering and monitoring of herds as reindeer tend to disperse in search of grazing resources.[566 567] Difficult grazing conditions can be avoided or mitigated by making use of pasture diversity and mobility, and responses from herders vary depending on the local context, including pasture environment, herding system and culture. Some herders migrate to the coast, which for example in northern Norway usually is used for summer grazing, while some utilize local topographical diversity to find areas with less snow. Some migrate to particularly lichen-rich grazing grounds to avoid the risk that these become inaccessible later, migrate to forest regions with softer snow and arboreal lichens, or use supplementary feed. Letting reindeer roam free is also a possible choice, however, this choice is especially associated with increased stress and concern, negatively affecting herders' well-being.[568 569 570]

> *"Rain during winter makes the snow cover compact or creates ice layers which reindeer cannot dig through. Nowadays the snow also becomes icy in the trees, making tree-hanging lichen inaccessible. I have over my 22 years as an active reindeer herder had to graze with reindeer in the high mountains more winters than using the usual winter pastures located in the forest area."*
>
> **– reindeer herder from the northern part of Sápmi**

In Nordland county, Norway, coastal pastures were previously more often locked under ice compared to the inland grazing areas. Today inland pastures are more likely to become locked under ice and coastal areas are often snow-free. Some siidas have had to reverse the order of their grazing rotation from inland to coast during winter, or use pastures more alternately, while some use winter pastures further inland across the Swedish border. Using coastal pastures can, however, be far from unproblematic since coastal pastures are fragmented and shared with many other forms of land use.[571] A reindeer herder said to Saami Council that, *"We experience locked pastures more now than before. Before, we had alternative grazing areas, but these areas have now been developed by other things and the pastures are not available in the same way."*

Herders' responses to climate change and difficult grazing conditions are dependent on the geographical room for adaptation. As noted above, adaptive capacity in many cases is constrained by limited access to pastures due to other forms of land use[572]–conditions that in some cases are made worse by high numbers of predators – and herders thus experience an increase in workload, costs and stress. This in turn has resulted in impacts on the physical and mental health of herders, their families and herding communities. Read more in section Health and well-being in Sápmi.

> *"Of course, it has an impact on my everyday life. As reindeer owners, we walk with tense shoulders because we have no predictability of how autumn, winter and spring will be. When there are bad pastures, they don't want to already have a plan of what to do. If you are going to take reindeer into a corral, you have to do this quickly before the reindeer are in too bad shape, because if you take them into a corral and start feeding, a lot of reindeer will die, because they cannot tolerate the transition to the forage, they are therefore too weak for this. You also have to act smart so that you can move the reindeer to better grazing areas and you have to move while the reindeer are fit enough to be moved, if they are too weak the journey will be tough for them. With this uncertainty, you always walk with heavy shoulders because you don't know what tomorrow will be like. You don't know where you will live this winter or what you will do."*
>
> **– reindeer herder in southern Sápmi**

> *"We have to drive a lot to herd the reindeer–day and night when the conditions are bad. At least, we have not yet fed the reindeer yet and wish we don't have to start doing it."*
>
> **– reindeer herder in northern part of Sápmi**

[566] Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

[567] Forbes m.fl., "Changes in mountain birch forests and reindeer management: Comparing different knowledge systems in Sápmi, northern Fennoscandia".

[568] Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

[569] Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

[570] Rosqvist, Inga, och Eriksson, "Impacts of climate warming on reindeer herding require new land-use strategies".

[571] Risvoll och Hovelsrud, "Pasture access and adaptive capacity in reindeer herding districts in Nordland, Northern Norway".

[572] Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

Supplemental feeding with industrially produced fodder or hay etc. plays a more and more important role for herders today in adapting to changing winter conditions and keeping herds alive, even though it is not common in all areas.[573] [574] Additional economic costs from supplementary feed and increased reindeer mortality from severe winter conditions has weakened the economy of herders.[575] A reindeer herder reported to Saami Council that, "the changing climate has affected us in the way that we have been forced to start supplementary feeding the reindeer. We have also had to start earlier and earlier in recent years – usually we start in February or March but for example, in 2019 we had to start already in November, and the following year in December." Another reindeer herder further south said: "In the winter of 2020/2021, all grazing was locked, even in our area, and we had to use supplementary feeding (fodder). I can't remember that our elders have talked about that before."

Supplementary feed

Supplementary feed has always been provided for reindeer when needed, e.g., by felling lichen-rich trees, and not only related to climatic events. However, this traditional alternative is no longer possible in many forest areas because of forestry or because pastures are encroached on by extractive industries.[576] [577] In Sweden and Norway (mainly in the areas of Nordland, Troms and Finnmark), the need for emergency feeding to prevent starvation has increased during recent years due to challenging grazing conditions and loss of grazing lands.[578] It is now less problematic than previously to feed large herds of reindeer due to availability of fodder specifically formulated for reindeer, motorized transport, increased infrastructure and growing knowledge and practical experience among herders. There are also reported positive impacts on for example calf carcass weight. However, supplementary feed also comes with challenges to both herders and reindeer. Feeding reindeer costs more and also affects reindeer health.[579]

Reindeer are able to cope with very large seasonal changes in the nutritional quality and availability of forage,[580] however there are knowledge gaps in regard to supplementary feeding, i.e., how it affects the health and behavior of reindeer long-term. In addition, how feeding affects the resilience of reindeer husbandry is not yet investigated.[581] Known short-term effects of feeding include increased frequency of feed-related disease that produces stomach acid, diarrhea and bloating, resulting in death in the worst case. In combination with the direct impacts from higher temperatures, increased precipitation, insects and less access to natural grazing areas that all together might affect reindeer condition negatively, feeding might also increase reindeers' vulnerability to disease.[582] [583] [584] [585] The growing need for supplemental feeding of herds and transport of reindeer overall entails stress and increased contact be-

573 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

574 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

575 Jaakkola, Juntunen, och Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union".

576 Sandström m.fl., "On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management".

577 Horstkotte m.fl., "Pastures under pressure. Effects of other land users and the environment."

578 Åhman m.fl., "Role of supplementary feeding in reindeer husbandry".

579 Persson, "Status of supplementary feeding of reindeer in Sweden and its consequences".

580 Mathiesen m.fl., "Microbial ecology of the digestive tract in reindeer: seasonal changes".

581 Tonkopeeva m.fl., "Framing Adaptation to Rapid Change in the Arctic".

582 Tryland m.fl., "Herding conditions related to infectious keratoconjunctivitis in semi-domesticated reindeer: A questionnaire-based survey among reindeer herders".

583 Persson, "Status of supplementary feeding of reindeer in Sweden and its consequences".

584 Tryland, "Are we facing new health challenges and diseases in reindeer in Fennoscandia?

585 Tryland, M., Josefsen, T.D., Oksanen, A. & Ashfalk, A. (2001). Contagious ecthyma in Norwegian semi-domesticated reindeer (Rangifer tarandus tarandus). Veterinary Record 149, 394–395.

tween reindeer, facilitating transmission of diseases, and also increasing the contacts between animal and human.[586] Feeding on pasture – i.e., on ground vegetation – may also result in increased pressure on soil and vegetation due to trampling from high animal densities around feeding stations, and silage or hay that is left over has the potential to affect the natural vegetation.[587] At the workshop held by Saami Council in August 2022, participants shared concerns over the use of supplementary feed related to its effects on the vegetation, but also reindeer health. A reindeer herder said: "Reindeer get used to feeding which is dangerous. But also, fodder that has been on the ground–you can see the pasture and vegetation change." Another reindeer herder said: "The reindeer begin to thrive where you feed them. You stay there longer than if it would be natural grazing, where the reindeer or the herder makes the assessment about when you must move. It will now be difficult to move it, or it stays until it starts to starve. Our knowledge of reindeer husbandry is changing, and we are already there–you don't need to make these assessments anymore. The entire knowledge and needs of herding are undergoing change. However, we need knowledge about diseases that arise related to supplementary feed too. How does this affect the reindeer? Do we even talk about this collectively internally? But we also have to start looking at things other than diseases – the land is getting sick."

As gathering reindeer within enclosures increases risks of disease outbreaks and parasite transmission, it is important to raise awareness and knowledge of reindeer diseases among herders and veterinarians in order to assess and prevent diseases.

To feed the reindeer is in my mind a bad and short-term solution for the challenges in reindeer herding. This has changed the reindeer husbandry a lot, and the reindeer, and it will continue to do so if this continues. Our district (siida) has been affected a lot by many of our neighbors that gather on our pastures to feed their reindeer. These two ways of conducting reindeer husbandry can't co-exist. Or rather: These two different types of reindeer husbandry do not fit on the same land.

– reindeer herder in northern part of Sápmi

Changing winter conditions and increasing land use pressure enhance the pressure for supplementary feeding in all three Nordic countries.[588] Näkkäläjärvi et al. (2022) note that increased state control has reduced the flexibility of reindeer herding systems promoting increased use of supplementary feed, which may increase vulnerability due to becoming more dependent on the state.[589] Horstkotte et al. (2020) report from their study that supplementary feeding is not a preferred adaptation strategy by herders and that it increases vulnerability in the long-run. The growing need to feed the reindeer risks change in reindeer behavior, meat quality, use and need of traditional knowledge and long-term impacts on the reindeer husbandry management system as a whole. Herders in the study emphasized that working against reindeer's instincts is not a choice made by herders and is incompatible with their own views of what constitutes sustainable herding: herding must be based on the use of natural pastures in order to be ecologically, economically and culturally sustainable.[590] A reindeer herder said: "We compete with each other now. Will we survive? Where are we going to get money from? We work seven days a week to afford to feed them. Those trying to live on free-roaming, grazing reindeer are losing today. We must dare to talk about this. In our reindeer herding community, we try to talk openly–only we can solve this." Supplementary feeding, in combination with other factors, has increased expenses and covering the increased expenses just by selling reindeer meat might not be viable in the future, making solutions in support mechanisms important, and/or diversi-

[586] Åhman m.fl., "Role of supplementary feeding in reindeer husbandry".

[587] Åhman m.fl.

[588] Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

[589] Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

[590] Horstkotte m.fl., Supplementary feeding in reindeer husbandry. Results from a workshop with reindeer herders and researchers from Norway, Sweden and Finland.

fying livelihoods.[591] This might result in reindeer herding providing employment for an even smaller number of Sámi, says Näkkäläjärvi et al. (2022).[592] Moen et al. (2022) suggest that the increase in financial expenses has resulted in some older reindeer herders finding it difficult to motivate young people to take up, or continue with reindeer husbandry because it is so difficult to meet the costs. This could lead to a demographic tipping point with very few new herders and loss of tradition and culture.[593] For the future sustainability of reindeer husbandry and its cultural foundations, the EALÁT project especially underlined the importance of engaging reindeer herding youth directly in herding practices and providing for enhanced education.[594]

Sámi reindeer husbandry is diverse, flexible and capable of adaptation to climate change, according to Näkkäläjärvi et al (2020, 2022). However, as reindeer herding models differ regionally in Sápmi, and vary from semi-nomadic to local, the effects of climate change and adaptation possibilities thus vary significantly. There are also differences between the preparedness of different herding types, variation between regions, and inflexibility of governance that might be challenging factors.[595] [596] Adaptation measures undertaken throughout Sápmi vary–some are introducing innovations or new technology while some have the flexibility to change the pasture and migration cycle to meet new challenges. This has resulted in the emergence of new types of knowledge, including in supplementary feeding and implementation of new technology. There is a strong belief in the future of reindeer herding as a business, but there is at the same time a great concern about what will be lost in the process of adaptation.[597] While the use of supplementary feed and technology such as GPS-trackers and drones are effective means for adaptation, they also have important cultural effects. As supplementary feeding of reindeer has increased, it means that knowledge of identifying grazing conditions in some regions also has decreased as a result,[598] [599] and if pastures are not used, grazing rights may be lost.[600] The increase in use of technology might also diminish the transfer of herders' knowledge from older generations to more technology-dependent younger generations. This erosion of the cultural knowledge of herders reduces the adaptive capacity of reindeer husbandry long-term.[601] [602] [603]

> *"By feeding in enclosures during the winters, there might be consequential effects in reduced use of lands, and then the risk that our rights based on customary use will disappear in the long run. It has incalculable consequences for the entire Sámi society. It will also be easier for developers and the state to say that we don't need the land because we feed in enclosures."*
>
> **– reindeer herder in northern Sápmi**

591 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

592 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

593 Moen m.fl., "Tipping points and regime shifts in reindeer husbandry".

594 Magga m.fl., "Reindeer Herding, Traditional Knowledge and Adaptation to Climate Change and Loss of Grazing Land".

595 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

596 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

597 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

598 Näkkäläjärvi, Juntunen, och Jaakkola.

599 Jaakkola, Juntunen, och Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union".

600 Moen m.fl., "Tipping points and regime shifts in reindeer husbandry".

601 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

602 Jaakkola, Juntunen, och Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union".

603 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

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Socio-political structures, governance and external factors challenging adaptive capacity

Changes in weather and seasonality have already forced herders in Sápmi to adapt and change some herding practices and seasonal activities. Adaptation options are strongly dependent on socio-political structures, governance and legislation. Options for adaptation are not only limited by the speed of Arctic climate change and regional circumstances, but also by ongoing colonial legacies, land dispossession, landscape fragmentation, costs of adaptation, and challenges resulting from not valuing and meaningfully using Sámi Indigenous knowledge.[604] [605] [606] The cumulative effects of multiple factors such as competing land use or loss of land, and limited influence in decision making, not only hamper adaptation options but also exacerbate the impacts of a changing climate.[607] A heavy burden is placed on herders and reindeer herding communities. Socio-economic, political and cultural changes and developments create a constant demand requiring the reindeer husbandry to adapt to these transformations. A report from the Swedish part of Sápmi highlights that herding communities do not have the capacity to work progressively for the future due to the administrative burden of errands coming in. Grazing lands are lost to competing land use even with herders' efforts to prevent the loss, which is creating uncertainty and concern for the future.[608] Norgga Boazosápmelaččaid Riikkasearvi underlines in its newly released report that herders report psychological stress from unpredictability, differential treatment, and a lack of clarity when dealing with reindeer herding management and laws and regulations, making it difficult to plan herding operations. Herders also complained that they are not heard, that their professional knowledge is not valued, and that authorities' assessments and decisions are not based on the herders' expertise. This is reinforced by the authorities' lack of knowledge about reindeer husbandry in general.[609]

There are numerous legal and administrative differences in local, regional, and state governance between Finland, Norway and Sweden affecting reindeer herding. The biggest similarity between the Nordic states in regard to challenges facing reindeer herding is how the governing systems fail to accommodate them.[610] Overall, key elements of Sámi governance such as herders' traditional knowledge, diversity, flexibility and mobility–are not reflected within national legislations, policies or regulations.[611] [612] [613] Näkkäläjärvi et al. (2020) observe that there is not enough consideration of intergenerational cultural impacts from the adaptation actions that are undertaken, and inflexibility of governance is a major challenge for herders trying to adapt.[614] Sámi are not able to decide on culturally appropriate adaptation actions due to their lack of power to affect institutional decision-making processes.[615] [616]

National policies for climate change adaptation in regard to reindeer husbandry typically emphasize technical solutions, compensatory schemes or direct emergency support to alleviate the negative impacts of natural events – e.g. locked winter grazing. Holistic perspectives are lacking, and the solutions are short-term which Sirpa et al. (2022) comment, *"[…] neither*

604 Constable m.fl., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" CCP6.3.2.3.

605 Pörtner m.fl., "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" B.2.4.

606 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

607 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation.

608 "SWECO, 2019: Syntesrapport: En sammanställning av fyra samebyars pilotprojekt med klimat- och sårbarhetsanalys samt handlingsplan för klimatanpassning".

609 Sokki Bongo, Stenfjell, och Logstein, "Helse, miljø og sikkerhet i reindrift. Funn fra kartlegging blant reindriftsutøvere".

610 Löf m.fl., "Unpacking reindeer husbandry governance in Sweden, Norway and Finland. A political discursive perspective".

611 Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

612 Mathiesen m.fl., "Strategies to enhance the resilience of Sami reindeer husbandry to rapid changes in the Arctic. In: Arctic Resilience Interim Report 2013."

613 Johnsen m.fl., "'Leaving No One Behind' – Sustainable Development of Sámi Reindeer Husbandry in Norway".

614 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

615 Löf m.fl., "Unpacking reindeer husbandry governance in Sweden, Norway and Finland. A political discursive perspective".

616 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

addresses nor seeks to govern the multiple goal conflicts apparent between reindeer husbandry and competing forms of land use. The needs to balance existing power asymmetries between actors in consultation and planning processes thus remain."[617] Johnsen et al. (2023) highlight that due to the gap between the state's and herders' perceptions of 'sustainability' in Norway, the global *2030 Agenda for Sustainable Development* principle of 'leaving no one behind' in fact is leaving Sámi traditional reindeer herding knowledge and practices behind in current public management of reindeer husbandry.[618]

IPCC concluded in 2014 that protecting grazing lands would be the most important adaptation measure for reindeer herders under climate change[619] but Sámi herding communities face strong barriers to protecting their rights and halting further degradation of pastures. Policies framed by the European Union along with the respective national governments of its member states continue to promote the expansion of mining, wind energy and bioeconomy in which cumulative impacts on pastures and reindeer husbandry are not adequately assessed or recognized in planning of land-use, as highlighted by the IPCC (2022).[620] Increasingly, voices from Sámi civil society are raised, pointing at continued colonial control of Sámi territories.

> **"Lack of control over land use is the biggest and most urgent threat to the adaptive capacity of reindeer herding and the right of Sámi to their culture" (IPCC, 2022).[621]**

While climate change impacts and the projections for the future are complex, varied and partially unknown, the sustainable management of Sámi reindeer husbandry is challenged. According to researchers, a major challenge is that other forms of land use are shrinking grazing grounds, hampering adaptation options.[622] AMAP (2021) states that the general decreases of snow extent and duration in the Arctic are projected to continue through the remainder of the 21st century due to warmer temperatures.[623] Winters with longer snowless periods or thin snow cover can provide better opportunities for grazing, and warmer weather can help reindeer maintain good body condition before winter.[624] Future changes in heavy snowfall in northern high latitudes are expected to differ across the north. Warmer winter temperatures and an expected increase in precipitation bring an increased risk of thawing-freezing and rain-on-snow events will result in reduction of seaŋaš, thus likely hampering reindeer access to grazing under the snowpack.[625] Rain-on-snow events and rapidly shifting temperatures are not only a direct threat to reindeer survival but might also pose serious risks for both reindeer and herders due to increased risks, e.g. avalanches and landslides and weaker ice on lakes and rivers. Changes in migration routes makes transport with trucks already necessary in some areas to move between seasonal pastures due to various reasons[626] [627] and this need might increase with future climate change.

As pasture conditions, climate, and societal changes are changing reindeer husbandry's operational environment, Mathiesen et al. (2023) underline that it is essential to develop and implement adaptation strategies and practices that explicitly address the consequences of the unprecedented weather and climate changes in the Circumpolar Arctic, but also that reindeer husbandry is given the possibilities to develop its own adaptation strategies.[628] Näkkäläjärvi et al (2022) highlight that if state control and administration over

617 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

618 Johnsen m.fl., "'Leaving No One Behind' – Sustainable Development of Sámi Reindeer Husbandry in Norway".

619 Hodgson m.fl., "IPCC, 2014: Polar regions. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change".

620 Bednar-Friedl m.fl., "IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" Box 13.2.

621 Bednar-Friedl et al.

622 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

623 AMAP 2021, "AMAP Arctic Climate Change Update 2021: Key Trends and Impacts" Chapter 4.

624 Sirpa m.fl., "Reindeer husbandry and climate change. Challenges for adaptation."

625 Eira m.fl., "Snow cover and the loss of traditional indigenous knowledge."

626 Löf, "Examining Limits and Barriers to Climate Change Adaptation in an Indigenous Reindeer Herding Community".

627 Näkkäläjärvi, Juntunen, och Jaakkola, "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti".

628 Mathiesen, "Reindeer Husbandry in the Circumpolar North".

reindeer herding increases, the cultural possibilities for reindeer herders to adapt to climate change may be weakened and reindeer herding models would likely become uniform.[629] Such a development can be detrimental since adaptation possibilities, choices and options are part of a cultural process, where reindeer work models and their diversity altered to their own local conditions is at center. It is this diversity that has resulted in different reindeer work models that continue developing and adapting to new challenges, and it is this knowledge and understanding that is needed within policy and management systems. Rooij et al (2023) state that "adaptation to climate change calls for governance practices that take into account Sámi traditional knowledge, including the need for flexibility in the use of reindeer pastures. The future for reindeer herders' communities is dependent on use of their traditional knowledge and implementing risk spreading through diversity in social organization, economy, and understanding of biodiversity and flexible use of pastures."[630]

"Sámi institutions should start to work hard on finding ways to protect Sámi reindeer husbandry. I think it would be good to ask, 'how we can rescue Sámi reindeer husbandry?' Would it be possible to work more together across borders and what kind of cooperation would that be? At least the national borders are not natural."

– reindeer herder in northern Sápmi

Health and well-being in Sápmi

"I see a great increase in mental illness within the reindeer herding community I belong to. Many feel unwell during the winters. Physical health has also become worse. Many have problems with their stomach, but also increasing strain injuries from longer days on the snowmobile or from handling fodder and hay bales. There has also been greatly increased financial pressure, both for those who use supplementary feed during the winters and those who try to survive on natural grazing."

– reindeer herder in northern Sápmi

The World Health Organization (WHO) has announced climate change as the greatest threat to human health in the 21st century[631]. According to the COP26 Special Report on Climate Change and Health[632], "The climate crisis threatens to undo the last fifty years of progress in development, global health, and poverty reduction, and "...to further widen existing health inequalities between and within populations.". Human health is already affected by climate change. Extreme weather events like heat waves, storms, and floods are becoming more common. There is a food system disruption and an increase in diseases. Death, physical illness, and mental health issues are related to the abovementioned events. Social factors affecting people's health, such as livelihoods, equality, healthcare access, and social support systems, are also being undermined by climate change. These climate-related health risks disproportionately affect the most vulnerable and disadvantaged, including ethnic minorities and Indigenous Peoples.

The vulnerability of populations, their resistance to the current rate of climate change, and the breadth and pace of adaptation will all play a significant role in determining the health implications of climate change in the short- to medium-term[633]. Longer-term outcomes will greatly depend on how much transformative action is done today to decrease emissions and prevent the breaching of critical temperature thresholds and possible irreversible tipping points.[634]

629 Näkkäläjärvi, Juntunen, och Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland".

630 Rooij m.fl., "Loss of Reindeer Grazing Land in Finnmark, Norway, and Effects on Biodiversity: GLOBIO3 as Decision Support Tool at Arctic Local Level".

631 World Health Organization, «COP26 special report on climate change and health: the health argument for climate action.»

632 World Health Organization, "COP26 Special Report on Climate Change and Health: The Health Argument for Climate Action."

633 World Health Organization, "COP24 Special Report–Health & Climate Change."

634 Masson-Delmotte et al., "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change."

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For Arctic Indigenous Peoples, climate change and changing landscapes are factors contributing to increased physical and mental health challenges with widespread and cumulative impacts.[635] Research examining future health projections or evaluating the efficacy of health adaptations is rare. Climate change is associated with substantial health risks. Still, health adaptation to climate change is generally underrepresented in policies, planning, and programming in the Arctic, as discussed in the 2014 Arctic Human Development Report.[636 637] The geographical distribution of publicly available documentation on adaptation initiatives is also skewed in the Arctic, with more than three-quarters coming from Canada and USA.[638]

Grazing crises in Norway

In Sápmi, the reindeer herding community has recently experienced great challenges due to extreme and unstable weather conditions. Winter and spring of 2020 were severely challenging for the reindeer and herders in Nordland, Troms, and Finnmark county due to ice-locked pastures. 2019-2020 is considered one of the most challenging winters since 1917-1918, and it severely impacted the herders' physical and mental health. Uncertainties about the consequences for the animals and the herders' future were highlighted as great stressors.[639] Several districts in Nordland, Troms, and Finnmark declared a grazing crisis on their land. The crisis of 2020 came on top of an already pressured community as predators and the covid-19 pandemic were taking a toll on the economic and social aspects of the livelihood. As a result of these coinciding events, Sámi našuvnnalaš gealbobálvalus–psyhkalaš dearvvašvuođasuddjen ja gárrendilli (SÁNAG) and Norgga Boazosápmelaččaid Riikkasearvi (NBR) established a telephone hot-line service for children, youth and adults.[640]

The reindeer herding community experienced another grazing crisis during the winter of 2021 and spring of 2022. Reindeer herders reported working all hours of the day to keep the herds alive. For some, expenses doubled compared to previous years due to increased gasoline prices. Siidas, hit hard by the crisis of 2020, had barely recovered financially, if at all. Guovdageaidnu is the biggest reindeer herding municipality in Norway and is also the municipality that has the highest number of reindeer herders affected by the grazing crises. The heavy workload and psychosocial stress during such a crisis affect not only herders but also their families. When herders have to be out on the land, their families are left to take care of everyday life for a longer period. The situation made the Guovdageaidnu municipality doctor alert local authorities, the Sámi Parliament, and the chief medical officer of Troms and Finnmark county about the situation as Sámi families increasingly found themselves in physical, psychosocial, and financial stress.[641 642] The doctors' office reported an increase in appointments from the reindeer herding community as they sought help for health issues that occurred during the grazing crisis they experienced. Both men and women reached out to the doctor's office. The reindeer herding community reported health issues such as mental stress, sleep deprivation, muscular and skeletal pain, acute injuries, and fatigue. On top of health issues directly related to the extreme conditions on their grazing land, herders also expressed great fear for their finances due to the additional costs related to the grazing crisis. Many also expressed concern and uncertainty for the future of the reindeer herding community, concerns about the family waiting for them at home, including their children whom they hadn't been able to see over a long period of time due to the extra need to be out with the herd during the crisis. The doctors' office also met many physically exhausted herders due to the great physical strain of transportation of large fodder bales of 800 kilos

[635] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change."

[636] Meredith et al., "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate" See 3.5.2.8 Arctic Human Health and Well Being.

[637] Meredith et al. See 3.5.2.8 Arctic Human Health and Well Being.

[638] Meredith et al. See 3.5.2.8 Arctic Human Health and Well Being.

[639] Landbruksdirektoratet, "Gjennomgang Av Beitekrisen i Reindriften 2020."

[640] Landbruksdirektoratet.

[641] Marie Elise Nystad et al., "Familiefar Johan Anders Har Knapt Sett Barna i Vinter."

[642] Landbruksdirektoratet, "En Styrket Beredskap i Reindriften."

for long distances on snowmobiles. Many siidas also did not have the proper equipment to lift and rearrange the fodder bales, causing more physical strain. Many herders did not show up for medical consultations and postponed planned health treatment during the winter.[643]

The Sámi parliament called for an emergency meeting with relevant actors to discuss the burdens experienced by herders and the toll on individuals and families.[644] One of the measures put into action increased capacity at SÁNAG to help children and teenagers under the age of 18 from families who were affected by the grazing crisis. Unlike the grazing crisis in 2020, SÁNAG was not able to staff an emergency service for adults in 2022. SÁNAG is currently trying to develop the capacity to organize an emergency team for similar circumstances in the future.[645]

Physical health and climate change

Changes in exposure to pollutants, parasites, viruses, and bacteria may be some of the most significant effects of climate change on physical health. The Arctic is experiencing an increase in the transmission of infectious and vector-borne illnesses, including Lyme disease and tick-borne encephalitis, as the weather becomes milder and the snow cover less. Permafrost melting creates a growing risk of hazardous materials and live spores of extremely virulent illnesses (anthrax, tuberculosis) emerging from abandoned livestock burial grounds and trash disposal sites. A rise in waterborne illnesses is one of the primary concerns in the Arctic, including Fennoscandia. Floods, hurricanes, and wildfires are examples of extreme weather events that can hasten the spread of illness by destroying waste systems, infrastructure, and buildings.[646]

Reduced snow days and more precipitation might expose people to toxins stored in the Arctic snow cover, which contains contaminants and heavy metal pollution.[647] In the Pechenga region, mushrooms and wild berries have been discovered to contain significant amounts of cadmium, nickel, and copper.[648] In Finland, reindeer calves grazing on natural grasslands had meat with elevated concentrations of dioxins and PCBs[649]. There is therefore a need for more esearch on how toxins affect the health of the Sámi people.
Indigenous societies are increasingly dependent on store-bought foods, which are frequently expensive and less healthy, increasing the incidence of modern diseases like diabetes, cardiovascular disease, dental problems, and obesity if they are forced to give up traditional hunting and fishing due to climate impacts or due to contamination of subsistence foods.[650] Livelihood changes due to climate change have been identified by Jaakkola, Juntunen, and Näkkäläjärvi[651] as having direct effects on the physical health of the Sámi. As Sámi traditional lifestyles and diet, which include reindeer meat, fish, and berries, may become increasingly constrained by climate change and changes in land use, there is growing concern that chronic diseases, such as diabetes, which are more common for a western lifestyle, will become an increased problem for Sámi people. There are signs that the Sámi way of life is changing as physical activity is in decline, and traditional Sámi food is being partially or entirely replaced by a more western diet, particularly outside of Sámi core areas.[652]

Extreme weather events and changes in environmental conditions are linked to injury and death and create safety concerns for those who access land, water, and ice for food, cultural, and recreational purposes (see for example Chapter 4–climate hazards). Some demographic groups thought to be particularly at risk, such as children and the elderly, may encounter health issues if temperatures rise significantly (such as effects from excessive sun exposure). A 1°C rise in

643 Landbruksdirektoratet.

644 Sámediggi, “Nødvendig å Slå Alarm.”

645 Landbruksdirektoratet, “En Styrket Beredskap i Reindriften.”

646 AMAP 2017, “Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area.”

647 Callaghan et al., “Multiple Effects of Changes in Arctic Snow Cover.”

648 Dudarev et al., “Food and Water Security Issues in Russia I.”

649 Holma-Suutari et al., “Persistent Organic Pollutant Levels in Semi-Domesticated Reindeer (Rangifer Tarandus Tarandus L.), Feed, Lichen, Blood, Milk, Placenta, Foetus and Calf.”

650 AMAP 2017, “Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area.”

651 Jaakkola, Juntunen, and Näkkäläjärvi, “The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union.”

652 Jaakkola, Juntunen, and Näkkäläjärvi.

temperature in northern Sweden between 1991 and 2007 was associated with a sharp increase in the number of non-fatal heart attacks (the Northern Sweden MONICA Project),[653] and reindeer herders in Sweden report, among other things that the sun feels hotter, and that they experience more sunburn[654].

> *"It is a constant worry, especially during the autumns before winter arrives. The workload has become much heavier in winter, with longer days and a constant feeling of being insufficient."*
>
> **– reindeer herder in northern Sápmi**

As also described earlier in this chapter, weather-related accidents during winter are predicted to increase[655]. Conditions on the land that may influence the likelihood of an incident occurring include difficult weather, poor visibility, chilly temperatures, and challenging terrain. Transport-related incidents are anticipated to become more common as a result of changes in the carrying capacity of ice, snow quality, snow formation, and increased risk for avalanches in mountainous areas. Sámi reindeer herders are therefore anticipated to see an increase in health consequences of climate change.[656] The reindeer herding community is already vulnerable to injuries and accidents and is considered one of the most dangerous occupations[657]. According to Norgga Boazosápmelaččaid Riikkasearvi, 43% of reindeer herders participating in a survey focusing on health, environment, and security reported experiencing one or more accidents causing injury during the last five years. 40% of these had accident(s) during herding activity with a motorized vehicle. Almost half of the reported accidents occurred during the autumn. In the same survey, the reindeer herders were asked to assess the injury risk of different activities. The activities considered the riskiest were in ascending order: autumn migration, use of snowmobile with dark/poor visibility, use of motorbikes/ATV when herding, use of snowmobile on light snow/bare ground, and crossing thin ice.[658] All the activities mentioned are associated with herding activities during autumn when weather conditions are shifting. The snowmobile is crucial for modern reindeer husbandry, but it is also harmful to the health of the reindeer herders, resulting in musculoskeletal problems and pain.[659]

Mental health and climate change

Worldwide mental illnesses are expected to grow[660], and the potential for climate change to alter critical factors that affect people's psychological health and well-being has been identified as a crucial interaction in developing research.[661] [662] [663] According to the IPCC (2022), mental health challenges related to climate change are complex. Climate change is understood to affect mental health and well-being directly and indirectly[664]. Acute environmental conditions such as major storms, flooding, and wildfires directly affect mental health, and so do chronic environmental conditions such as temperature increases, permafrost thaw, changing seasonal and environmental norms, changes in wildlife and vegetation, and changes in place. Indirectly climate health affects mental health through changing environmental conditions resulting in disruptions to livelihoods, culture, food systems, social connections, health systems, and economies, which in turn result in negative mental health outcomes. These outcomes can take forms such as loss of cultural knowledge and

653 AMAP 2017, "Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area."

654 Furberg, Evengård, and Nilsson, "Facing the Limit of Resilience: Perceptions of Climate Change among Reindeer Herding Sami in Sweden."

655 Turunen et al., "Coping with Difficult Weather and Snow Conditions."

656 Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

657 Hassler et al., "Fatal Accidents and Suicide among Reindeer Herding Sami in Sweden."

658 Sokki Bongo, Stenfjell, and Logstein, "Helse, Miljø Og Sikkerhet i Reindrift. Funn Fra Kartlegging Blant Reindriftsutøvere."

659 Furberg, Evengård, and Nilsson, "Facing the Limit of Resilience: Perceptions of Climate Change among Reindeer Herding Sami in Sweden."

660 Vigo, Thornicroft, and Atun, "Estimating the True Global Burden of Mental Illness."

661 Berry, Bowen, and Kjellstrom, "Climate Change and Mental Health: A Causal Pathways Framework."

662 Bourque and Willoc, "Climate Change: The next Challenge for Public Mental Health?"

663 Swim et al., "Psychology's Contributions to Understanding and Addressing Global Climate Change."

664 Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change."

continuity, disruptions to the transfer of intergenerational knowledge, deterioration, and loss of place-based identities and connections. These disruptions and losses can prompt emotional reactions (e.g., sadness, fear, anger, distress, and anxiety); psychosocial outcomes (e.g., depression, post-traumatic stress disorder, and generalized anxiety); ecological grief [665]; increased drug and alcohol usage, family stress, and domestic violence; increased suicide ideation and suicide, among others.[666] Cultural losses, in general, threaten adaptive capacity and may accumulate into intergenerational trauma and irrevocable losses of sense of belonging, valued cultural practices, identity, and home.[667] However, as noted in chapter 3, assessments of non-economic losses and damages–including loss of societal beliefs and values, cultural heritage, and identity–are lacking, and aggregate losses and damages would be higher if such values were considered. Cultural and spiritual meanings of ecosystems, species, and landscapes are rarely included in scientific research regarding ecosystems and the services they provide. They are often given less weight in decision-making in the Arctic and elsewhere than the economic benefits provided by ecosystems. According to Markkula et al., there is a need to pay more attention to ecosystems and their services in relation to culture and cultural continuity, particularly for Indigenous Peoples, because ecosystem services also are cultural services and a prerequisite for a meaningful life.[668]

> *"It brings a lot of grief, and people get low spirits when the reindeer are not doing well. People's life's work can be gone during one winter. It can also eradicate the whole traditional reindeer husbandry and culture."*
>
> **– reindeer herder in northern Sápmi**

Research suggests that the impact of climate change on Indigenous Peoples and their communities goes beyond the projected rates of incidence and prevalence of mental illness. The indirect consequences of climate change have the potential to be severely harmful to Indigenous Peoples' socio-cultural well-being. Therefore Indigenous Peoples are among those most at risk from the negative effects of climate change on mental health worldwide.[669]

The impact of climate change on Indigenous Peoples' mental health has not received adequate attention in Sápmi or globally. Only 23 research articles that specifically investigate the topic have been published in English as of 2021, and they are dispersed throughout regions from the Arctic, to the southern half of Africa, and to Australia in Asia. However, the Arctic region, and Canada in particular, dominate the studies in terms of geography.[670] It must be noted that socio-economic conditions and access to education and health care vary greatly in the Indigenous world, and therefore findings cannot be directly compared. However, other cultural aspects are similar, such as the strong connection to nature and animals, experience with colonialism, and loss of language and culture. We therefore find it valuable to also look to other Indigenous societies to better understand how climate change may affect our health and well-being and what vulnerabilities may be made worse if no action is taken to intercept the societal impacts of climate change.

Direct impacts on mental health

> *"It adds a lot of stress when you can't trust the future for even a second in addition to all other problems."*
>
> **– young reindeer herder in northern Sápmi**

In general, Indigenous Peoples report that direct physical observation of a change in, among other things, the abundance, quality, and stability of ice and snow, and changes in the animal and insect population are linked with decreased mental well-being through the expression of sadness, worry, fear, reduced sense of self-worth and emotional distress.[671] In Rigolet, Canada, anger and frustration are reported as a

[665] For deeper insight into ecological grief we recommend reading "Ecological grief as a mental health respons to climate change-related loss" by AshleeCunsolo and Neville R. Ellis https://doi.org/10.1038/s41558-018-0092-2

[666] Constable et al. See CCP6.2.6.

[667] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" See TS.B.1.6.

[668] Markkula, Turunen, and Rasmus, "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland."

[669] Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

[670] Vecchio, Dickson, and Zhang.

[671] Vecchio, Dickson, and Zhang.

These quotes were provided during interviews and workshops with Sámi knowledge holders in 2022. Please note that the observations shared by the knowledge holders in this report are pieces of collective knowledge owned by the Sámi people. This collectively owned knowledge cannot be moved from its context.

response to climate change.[672] [673] Aggression, as well as both community and domestic violence, were also reported as emotional responses to climate change in Australia[674] [675] [676]. Findings in Indigenous communities in Australia also showed that long-term exposure to extreme weather events such as drought revealed linkages to substance abuse, decreased mental health, and threats of self-harm or suicide[677]. A direct link between suicide and climate change in the Arctic has not been established.[678] However, suicide in Sápmi should be understood in a greater political context, where climate change is one factor[679] [680]. Other Indigenous communities also report direct responses to climate change-induced weather events ranging from confusion, boredom, sadness, increased alcohol and substance abuse, and post-traumatic stress disorder symptoms[681]. Sámi reindeer herders in Sweden have reported that they experienced significant distress as a result of climate change and previously unknown weather events, such as precipitation during extremely cold temperatures.[682] [683] Other changes in their grazing areas were also reported to be distressing, such as changes in vegetation. In addition, the grazing land is under outside pressure and constantly shrinking due to land encroachments for hydropower, mining, forest roads, logging operations, wind turbines, tourist resorts, etc. The change in the grazing lands due to climate change comes as an addition to existing pressures. The combination of environmental changes on grazing land and land encroachment from other sources has decreased mental well-being among reindeer herders.[684]

The potential for increased need for mental health services has been identified as a response to the multiple stressors affecting Indigenous peoples.[685] [686] Mental health has been identified as a climate-sensitive health priority in the region of Nunatsiavut, Canada[687]. During the grazing land crisis of 2020 and 2022, reindeer herders in Norway reported having increased mental stress, sleep deprivation, concern and fears for the economy, family and children, as well as for the future of reindeer herding. The need for a permanent response to herding families' mental health needs has been discussed (see box on Grazing crisis in Norway for more). Landbruksdirektoratet developed a report on the grazing crisis and followed up on this with a 2022 report addressing the new grazing crisis and reindeer husbandry's preparedness.[688] [689] Both reports covered physical and mental health topics; however, few recommendations directly related to mental health were made.

Indirect impacts on mental health

Indigenous Peoples worldwide describe strong place attachment to their homelands through cultural and spiritual connection.[690] Place attachment is characterized by feelings of

672 Cunsolo Willox et al., ""From This Place and of This Place."

673 Cunsolo Willox et al., "The Land Enriches the Soul."

674 Pearce et al., "Cut From 'Country': The Impact of Climate Change on the Mental Health of Aboriginal Pastoralists."

675 Green and Martin, "Maintaining the Healthy Country–Healthy People Nexus through Sociocultural and Environmental Transformations."

676 Rigby et al., "If the Land's Sick, We're Sick."

677 Rigby et al.

678 Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

679 Stoor, "Suicide among Sámi – Cultural Meanings of Suicide and Interventions for Suicide Prevention in Nordic Parts of Sápmi."

680 Stoor et al., "'We Are like Lemmings.'"

681 Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

682 Furberg, Evengård, and Nilsson, "Facing the Limit of Resilience: Perceptions of Climate Change among Reindeer Herding Sami in Sweden."

683 Stoor et al., "'We Are like Lemmings.'"

684 Stoor et al.

685 Harper et al., "Climate-Sensitive Health Priorities in Nunatsiavut, Canada."

686 Cunsolo Willox et al., "Climate Change and Mental Health."

687 Harper et al., "Climate-Sensitive Health Priorities in Nunatsiavut, Canada."

688 Landbruksdirektoratet, "Gjennomgang Av Beitekrisen i Reindriften 2020."

689 Landbruksdirektoratet, "En Styrket Beredskap i Reindriften."

690 Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

affection, belonging, and a sense of identity with a particular location and can significantly impact a person's well-being and sense of self. In a discussion paper Holmberg (2020) describes how Sámi elders view the relationship Sámi have with their respective ecosystems: *"The relationship in itself is a key value, which binds a person to their environment, its history and heritage. The relationship is reciprocal – people benefit from the gifts of nature, which brings a responsibility to maintain a balance within the ecosystem and to safeguard the healthy environment as a foundation of all life. Learning of indigenous knowledge, gaining a feeling of beloning, self-sufficiency, spirituality, mental and physical wellness and social connections are some of the most valued aspects in the Sámi relationship with the environment."* [691]

Time spent on the land in Indigenous communities is identified as a positive psychological factor, where reduction in anxiety and opportunity for clarity of thought is highlighted.[692 693 694] Access to land is also linked to greater self-worth and more engagement in important cultural traditions, including fishing, hunting, socializing, and maintaining social connections, which all are favorably related to mental health.[695 696 697 698] Less time spent on the land as a result of a changing climate is associated with disruption to Indigenous culture and negative impacts on mental well-being, with depressive symptoms on both personal and community level being most notable.[699] Disruption of time spent on the land is also associated with feelings of boredom, fear of loss of cultural identity, increased alcohol consumption, and family violence.[700 701 702]

"The uncertain situation makes it increasingly difficult for young Sámi people to continue reindeer herding."

– reindeer herder in north west Sápmi

Indigenous communities report increased worries about the disruption of the intergenerational transfer of Indigenous knowledge as a result of reduced time on the land, as well as increased worries and fears among Indigenous youth about their culture and future identities[703 704]. In a recent research report by Hansen and Skaar (2021), many young Sámi assert that they have a strong bond with nature and that spending time in nature improves their physical and mental health. This strong bond is tightly connected to their upbringing and family culture, being outside on the land with their parents and extended family. For Sámi youth, threats to the natural environment may also be a source of stress. Due to conflicts between new industries (e.g., mines and wind turbines projects) and traditional Sami lands and reindeer grazing areas, Sami youth may endure significant health, financial, and societal burdens. The constant pressure from external actors on the Sámi way of life is experienced by many as extremely exhausting, and a loss of hope for the future is reported by many Sámi youth.[705] Sámi reindeer herders also express concern for the future of their culture and way of life, as well as the disappearance of Sámi Indigenous knowledge and traditions as their land changes. According to Swedish research, despite the importance of their traditional cultural practices and Indigenous Knowledge to them personally and within their communities, this experi-

691 Holmberg, "Sámi Values and Valuation in Ecosystem Management. English Summary of a Discussion Paper: «Dat Lea Du Olbmuid, Du Máttuid Luodda»–Sámi Árvvut Ja Árvvoštallan Ekovuogádathálddašeamis."

692 Harper et al., "Climate-Sensitive Health Priorities in Nunatsiavut, Canada."

693 Bunce et al., "Vulnerability and Adaptive Capacity of Inuit Women to Climate Change."

694 Durkalec et al., "Climate Change Influences on Environment as a Determinant of Indigenous Health."

695 Cunsolo Willox et al., "The Land Enriches the Soul."

696 Borish et al., "'Caribou Was the Reason, and Everything Else Happened After.'"

697 Durkalec et al., "Climate Change Influences on Environment as a Determinant of Indigenous Health."

698 Green and Martin, "Maintaining the Healthy Country–Healthy People Nexus through Sociocultural and Environmental Transformations."

699 Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

700 Pearce et al., "Cut From 'Country': The Impact of Climate Change on the Mental Health of Aboriginal Pastoralists."

701 McMichael and Powell, "Planned Relocation and Health."

702 McNamara, Westoby, and Parnell, "Elders' and Aunties' Experiences of Climate on Erub Island, Torres Strait."

703 Petrasek MacDonald et al., "A Necessary Voice."

704 Petrasek MacDonald et al., "Protective Factors for Mental Health and Well-Being in a Changing Climate."

705 Hansen and Skaar, "Unge Samers Psykiske Helse–En Kvalitativ Og Kvantitativ Studie Av Unge Samers Psykososiale Helse."

ence is linked to a sense of deflation and frustration[706]. These concerns are added to socio-economic and governance pressures. Herders have reported increased levels of stress, anxiety, concern, and depression due to the factors mentioned above.[707] [708]

Durkalec et al. (2015) argue that in order to evaluate the complex effects of climate change on Indigenous environmental health, it is essential to take place meanings, culture, and sociohistorical context into account.[709] Moreover, chronic psychosocial stress is also linked to rapid socio-economic development, according to Jaakola et al. (2019), contributing to mental health challenges among Arctic Indigenous Peoples. Climate adaptation and mitigation measures (such as wind power or hydropower development) may be considered part of the rapid development, increasing stress and mental pressure among the Sámi. As a result, they argue that climate adaptation and mitigation measures should take into account the potential effects on Sámi health and well-being.[710]

Over the past few decades, research indicates that Sámi reindeer herders have a higher rate of suicide and mental health illnesses than the national average.[711] [712]Several researchers have argued that in order to understand suicide in Sápmi, it must be understood as dependent on cultural background in general and the difficulty of maintaining traditional livelihoods such as reindeer herding in particular.[713] [714] The combination of Sámi reindeer herding being a vital part of herders' Sámi identity and this livelihood being under immense pressure from outside actors causes mental health difficulties that correlate with suicidality among reindeer herders[715] [716] [717] [718]

Together with SÁNAG, the Saami Council published a *Plan for suicide prevention in Sápmi* in 2017[719]. The plan consists of 11 strategies focusing on improving Sámi mental health and preventing suicide. Among the 11 strategies, number three, "strengthen Sámi self-determination," specifically addresses the issue of exploitation of land and water by outsiders without proper involvement of and consent from the Sámi population resulting in strong feelings of powerlessness and hopelessness. Making suicide a possible "way out." In order to prevent this, strategy three proposes action to: "*Ensure that the Sámi are given real opportunity for self-determination through the opportunity to influence decisions that have direct or indirect consequences for their opportunity to decide on their own life situation. This includes all aspects of Sami social life such as education, culture, and language, but is particularly important for Sami working in traditional livelihoods where* ***the right to influence processes that threaten to destroy the basis of life must be recognized***" (our highlight).

Urbanization is a global phenomenon, and Sápmi is also experiencing outmigration to more urban areas[720]. With the projected future effects of climate change and traditional lifestyles and livelihoods becoming increasingly more difficult to practice, urbanization may be accelerated. Traditional Sámi

706 Furberg, Evengård, and Nilsson, "Facing the Limit of Resilience: Perceptions of Climate Change among Reindeer Herding Sami in Sweden."

707 Furberg, Evengård, and Nilsson.

708 Löf, "Examining Limits and Barriers to Climate Change Adaptation in an Indigenous Reindeer Herding Community."

709 Durkalec et al., "Climate Change Influences on Environment as a Determinant of Indigenous Health."

710 Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

711 Kaiser and Renberg, "Suicidal Expressions among the Swedish Reindeer-Herding Sami Population."

712 Omma, Sandlund, and Jacobsson, "Suicidal Expressions in Young Swedish Sami, a Cross-Sectional Study."

713 Silviken, "'Reindrift på helsa løs'. Arbeidsrelatert stress i reindriftsnæringen i lys av Mark Williams' modell 'Cry of pain.'"

714 Kaiser, "Mental Health Problems among the Swedish Reindeer- Herding Sami Population: In Perspective of Intersectionality, Organisational Culture and Acculturation."

715 Kaiser.

716 Kaiser and Renberg, "Suicidal Expressions among the Swedish Reindeer-Herding Sami Population."

717 Omma, "Ung Same i Sverige: Livsvillkor, Självvärdering Och Hälsa [Young Sami in Sweden: Life Circumstances, Self-Evaluation and Health]."

718 Stoor et al., "'We Are like Lemmings.'"

719 Stoor, Heatta, and Javo, "Plan for Suicide Prevention among the Sámi People in Norway, Sweden, and Finland."

720 Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

areas are already seeing outmigration that affects the viability, coherence, and strength of communities. Jaakola, Juntunen, and Näkkäläjärvi (2018)[721] find that there is a research gap on the potential effects of outmigration on Sámi society and culture. While this report does not dive deeper into the complex issues of urbanization and health among urban Sámi, we recommend serious consideration of the potential for climate change to accelerate urbanization and the related issues that would arise. Other aspects of increased urbanization could also include a decline in the use of the traditional Sámi homeland undermining collective rights, loss of Sámi Indigenous Knowledge, and loss of language, to mention a few.

> *"There is a big risk that many more will suffer from mental illness if it continues like this. At the same time as there are more and tougher conflicts about the pastures. For example, the so-called "green" transition threatens to take the remaining (industrially) untouched lands. Within my reindeer herding community, two new copper mines and wind farms are being planned, and the forestry is going hard on the last remaining trees. When the reindeer are in places where they don't usually stay during the winters, there are conflicts with other land users such as the tourism industry but also with cabin owners, etc. The social climate becomes harsher and even more polarized where reindeer herding is pitted against climate change; for us who represent reindeer herding, the threats to us personally are increasing, and racism gains new wings."*
>
> **– reindeer herder in northern Sápmi**

While research is limited on how climate change affects the mental health and well-being of the Sámi population, the research that exists either mainly focuses on reindeer herders or only treats climate change as a subtheme in the research. It is therefore difficult to claim that all the findings of climate change impacts on mental health and well-being in other Indigenous societies are also present, or will become present, in Sápmi. However, Sámi society does have vulnerabilities similar to those affecting Indigenous mental and community health elsewhere. In addition to what has been mentioned earlier, this also includes, among other things, high rates of discrimination, hate speech, and violence. As many as one out of three Sámi adults have experienced discrimination in Troms and Finnmark county, while Sámi youth report even higher numbers, as three out of four have experienced discrimination and hate speech based on ethnicity, gender, and place of residence.[722] [723] Being subjected to ethnic discrimination is associated with impaired health conditions and is particularly harmful to youth[724]. Sámi knowledge holder have raised the concern about increased discrimination and hate speech ,targeted towards the reindeer herders in particular, following the broader societies' expectations of the Sámi to give up traditional grazing lands for the energy transition to mitigate climate change. Furthermore, the Sámi society has higher rates of victims of sexual abuse for Sámi women (21,8%) and higher rates of experienced violence, including emotional and physical violence, for both Sámi women (49,1%) and Sámi men (39,7%) than the majority population in Norway.[725] While there is no current research into who the perpetrator of violence is and their ethnicity, the prevalence of violence in the Sámi society through its victims is of great concern as climate change continues to unfold its profound societal impacts.

Measures for well-being and resilience

To effectively reduce climate-related mental health risks, developing or enhancing access to mental health resources and infrastructure is critical, according to the IPCC (2022). Enhanced access to culturally-appropriate mental health resources and climate-specific counseling services to support individual and community psychosocial resilience, particularly among Arctic Indigenous Peoples, is central. Incorporating a climate-sensitive mental health lens into mitigation and adaptation planning holds the potential for increasing mental health and resilience in the Arctic, as well as supporting other social, economic, and cultural co-benefits.[726]

Research shows that Indigenous Knowledge, cultural identity, social ties, and family ties are crucial to creating a society more resilient to climate change. Vecchio, Dickson, and

[721] Jaakkola, Juntunen, and Näkkäläjärvi.

[722] Broderstad and Melhus, "Folkehelseundersøkelsen i Troms Og Finnmark. Tilleggsrapport Om Samisk Og Kvensk/Norskfinsk Befolkning."

[723] Hansen and Skaar, "Unge Samers Psykiske Helse–En Kvalitativ Og Kvantitativ Studie Av Unge Samers Psykososiale Helse."

[724] Hansen and Skaar.

[725] Eriksen et al., "Emotional, Physical and Sexual Violence among Sami and Non-Sami Populations in Norway."

[726] Constable et al., "IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" See CCP6.2.6 Human Health and Wellness in the Arctic.

Zhang[727] highlight that community cohesiveness and community-driven support can act as a buffer against the effects of climate change on mental health, creating a more resilient society. In order to prevent impacts of climate change from further escalating sociocultural issues, time spent on land, utilization of Indigenous knowledge, and traditional practices are highlighted as coping mechanisms.[728] [729] Such practices can be associated with decreased distress and increased community resilience.[730] Indigenous youth also emphasize that spending time on the land with family and friends and ensuring intergenerational passing of Indigenous knowledge is important to strengthen the resilience of Indigenous societies.[731] [732] [733]

Up until now, the majority of climate change initiatives have been concentrated at the national and state levels of governance; enhanced local surveillance will encourage community-based adaptations and strengthen local agency. Incorporating Indigenous knowledge in climate adaptation does not only depend on local abilities to adapt to the effects of climate change, but it also results in more efficient and culturally acceptable actions, which improves both individual and communal well-being.[734] [735]

727 Vecchio, Dickson, and Zhang, "Indigenous Mental Health and Climate Change."

728 Petheram et al., "'Strange Changes.'"

729 Green and Martin, "Maintaining the Healthy Country–Healthy People Nexus through Sociocultural and Environmental Transformations."

730 Pearce et al., "Cut From 'Country': The Impact of Climate Change on the Mental Health of Aboriginal Pastoralists."

731 Petrasek MacDonald et al., "Protective Factors for Mental Health and Well-Being in a Changing Climate."

732 Petrasek MacDonald et al., "A Necessary Voice."

733 Borish et al., "'Caribou Was the Reason, and Everything Else Happened After.'"

734 Hueffer et al., "One Health in the Circumpolar North."

735 Furgal and Seguin, "Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities."

References chapter 5

AMAP 2017. ”Adaptation Actions for a Changing Arctic: Perspectives from the Barents Area”. Oslo, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2017.

AMAP 2021. ”AMAP Arctic Climate Change Update 2021: Key Trends and Impacts”. Tromsø, Norway: Arctic Monitoring and Assessment Programme., 2021.

AMAP 2021. ”Arctic Climate Change update 2021: Key trends and impacts. Summary for policy-makers”. Tromsø, Norway: Arctic Monitoring and Assessment Programme (AMAP), 2021.

Bednar-Friedl, B., R. Biesbroek, D.N Schmidt, P. Alexander, K.Y. Børsheim, J. Carnicer, E. Georgopoulou, m.fl. ”IPCC, 2022: Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change”. Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.

Beniston, Martin, Daniel Farinotti, Liss Marie Andreassen, Erika Coppola, Nicolas Eckert, Adriano Fantini, Florie Giacona, m.fl. ”The European mountain cryosphere: A review of its current state, trends, and future challenges”. The Cryosphere 12 (01 mars 2018): 759–94. https://doi.org/10.5194/tc-12-759-2018.

Berry, Helen Louise, Kathryn Bowen, and Tord Kjellstrom. “Climate Change and Mental Health: A Causal Pathways Framework.” International Journal of Public Health 55 (2010): 123–32.

Blind, Ann-Catrin, Kajsa Kuoljok, Weronika Axelsson Linkowski, och Håkan Tunon. Myrens betydelse för renen och renskötseln. Biologisk mångfald på myrar i renskötselland, 2015. https://doi.org/10.13140/RG.2.1.4078.0242.

Bokhorst, Stef, Jarle Bjerke, F. BOWLES, Jerry Melillo, Terry Callaghan, och G. PHOENIX. ”Impacts of extreme winter warming in the sub-Arctic: Growing season responses of dwarf shrub heathland”. Global Change Biology 14 (02 september 2008): 2603–12. https://doi.org/10.1111/j.1365-2486.2008.01689.x.

Bokhorst, Stef, Jarle Bjerke, Lorna Street, Terry Callaghan, och G. PHOENIX. ”Impacts of multiple extreme winter warming events on sub-Arctic heathland: Phenology, reproduction, growth, and CO2 flux responses”. Global Change Biology 17 (13 april 2011): 2817–30. https://doi.org/10.1111/j.1365-2486.2011.02424.x

Borish, David, Ashlee Cunsolo, Jamie Snook, Inez Shiwak, Michele Wood, HERD Caribou Project Steering Committee, Ian Mauro, Cate Dewey, and Sherilee L. Harper. “‘Caribou Was the Reason, and Everything Else Happened after’: Effects of Caribou Declines on Inuit in Labrador, Canada.” Global Environmental Change 68 (May 2021): 102268. https://doi.org/10.1016/j.gloenvcha.2021.102268.

Bourque, François, and Ashlee Cunsolo Willoc. “Climate Change: The next Challenge for Public Mental Health?” International Review of Psychiatry, 26, no. 4 (2014): 415:422.

Broderstad, Ann Ragnhild, and Marita Melhus. “Folkehelseundersøkelsen i Troms Og Finnmark. Tilleggsrapport Om Samisk Og Kvensk/Norskfinsk Befolkning.” Senter for samisk helseforskning, UiT Norges arktiske universitet, 2020.

Bunce, Anna, James Ford, Sherilee Harper, and Victoria Edge. “Vulnerability and Adaptive Capacity of Inuit Women to Climate Change: A Case Study from Iqaluit, Nunavut.” Natural Hazards, June 1, 2016. https://doi.org/10.1007/s11069-016-2398-6.

Callaghan, Terry V., Margareta Johansson, Ross D. Brown, Pavel Ya. Groisman, Niklas Labba, Vladimir Radionov, Raymond S. Bradley, et al. “Multiple Effects of Changes in Arctic Snow Cover.” AMBIO 40, no. S1 (December 2011): 32–45. https://doi.org/10.1007/s13280-011-0213-x.

Cairns, David M., och Jon Moen. ”Herbivory Influences Tree Lines”. Journal of Ecology 92, nr 6 (2004): 1019–24.

Constable, A.J., S. Harper, J. Dawson, K. Holsman, T. Mustonen, D. Piepenburg, och B. Rost. ”IPCC, 2022: Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change”. Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.

Cunsolo Willox, Ashlee, Sherilee L. Harper, Victoria L. Edge, Karen Landman, Karen Houle, and James D. Ford. “The Land Enriches the Soul: On Climatic and Environmental Change, Affect, and Emotional Health and Well-Being in Rigolet, Nunatsiavut, Canada.” Emotion, Space and Society 6 (February 2013): 14–24. https://doi.org/10.1016/j.emospa.2011.08.005.

Cunsolo Willox, Ashlee, Sherilee L. Harper, James D. Ford, Victoria L. Edge, Karen Landman, Karen Houle, Sarah Blake, and Charlotte Wolfrey. “Climate Change and Mental Health: An Exploratory Case Study from Rigolet, Nunatsiavut, Canada.” Climatic Change 121, no. 2 (November 2013): 255–70. https://doi.org/10.1007/s10584-013-0875-4.

Cunsolo Willox, Ashlee, Sherilee L. Harper, James D. Ford, Karen Landman, Karen Houle, and Victoria L. Edge. “‘From This Place and of This Place:’ Climate Change, Sense of Place, and Health in Nunatsiavut, Canada.” Social Science & Medicine 75, no. 3 (August 2012): 538–47. https://doi.org/10.1016/j.socscimed.2012.03.043.

Diaz, S, J. Settele, E.S. Brondízio, H.T. Ngo, M. Guèze, J. Agard, A. Arneth, m.fl. ”IPBES 2019: Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services”. IPBES secretariat, Bonn, Germany.: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019.

Dudarev, Alexey A., Pavel R. Alloyarov, Valery S. Chupakhin, Eugenia V. Dushkina, Yuliya N. Sladkova, Vitaliy M. Dorofeyev, Tatijana A. Kolesnikova, Kirill B. Fridman, Lena Maria Nilsson, and Birgitta Evengård. “Food and Water Security Issues in Russia I: Food Security in the General Population of the Russian Arctic, Siberia and the Far East, 2000–2011.” International Journal of Circumpolar Health 72, no. 1 (January 31, 2013): 21848. https://doi.org/10.3402/ijch.v72i0.21848.

Durkalec, Agata, Chris Furgal, Mark W. Skinner, and Tom Sheldon. “Climate Change Influences on Environment as a Determinant of Indigenous Health: Relationships to Place, Sea Ice, and Health in an Inuit Community.” Social Science & Medicine 136–137 (July 2015): 17–26. https://doi.org/10.1016/j.socscimed.2015.04.026.

Eira, Inger Marie Gaup, Ellen Inga Turi, och Johan Mathis Turi. ”Sámi Traditional Reindeer Herding Knowledge Throughout a Year: Herding Periods on Snow-Covered Ground”. I Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, redigerad av Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, och Marina Tonkopeeva, 67–97. Cham: Springer International Publishing, 2023. https://doi.org/10.1007/978-3-031-17625-8_4.

Eira, Inger Marie, Anders Oskal, Inger Hanssen-Bauer, och Svein Mathiesen. ”Snow cover and the loss of traditional indigenous knowledge.” Nature Climate Change 8 (29 oktober 2018). https://doi.org/10.1038/s41558-018-0319-2.

Eriksen, Astrid M.A., Ketil Lenert Hansen, Cecilie Javo, and Berit Schei. “Emotional, Physical and Sexual Violence among Sami and Non-Sami Populations in Norway: The SAMINOR 2 Questionnaire Study.” Scandinavian Journal of Public Health 43, no. 6 (August 2015): 588–96. https://doi.org/10.1177/1403494815585936.

Finstad, Anders, Torbjørn Forseth, Tor Næsje, och Ola Ugedal. ”The importance of ice cover for energy turnover in juvenile Atlantic salmon”. Journal of Animal Ecology 73 (18 augusti 2004): 959–66. https://doi.org/10.1111/j.0021-8790.2004.00871.x.

Fjellström, Phebe. ”Fjällkvannen (Angelica archangelica) i samisk tradition”. I Samisk etnobiologi, 241–52. Stockholm, u.å.

Forbes, Bruce C., Minna T. Turunen, Päivi Soppela, Sirpa Rasmus,

Terhi Vuojala-Magga, och Heidi Kitti. ”Changes in mountain birch forests and reindeer management: Comparing different knowledge systems in Sápmi, northern Fennoscandia”. Polar Record 55, nr 6 (2019): 507–21. https://doi.org/10.1017/S0032247419000834.
Furberg, Maria, Birgitta Evengård, och Maria Nilsson. ”Facing the limit of resilience: perceptions of climate change among reindeer herding Sami in Sweden”. Global health action 4 (28 oktober 2011). https://doi.org/10.3402/gha.v4i0.8417.
Furgal, Christopher, and Jacinthe Seguin. “Climate Change, Health, and Vulnerability in Canadian Northern Aboriginal Communities.” Environmental Health Perspectives 114, no. 12 (December 2006): 1964–70. https://doi.org/10.1289/ehp.8433.
Gaio-Oliveira, Gisela, Jon Moen, Öje Danell, och Kristin Palmqvist. ”Effect of simulated reindeer grazing on the re-growth capacity of mat-forming lichens”. Basic and Applied Ecology 7, nr 2 (01 mars 2006): 109–21. https://doi.org/10.1016/j.baae.2005.05.007.
Green, Donna, and David Martin. “Maintaining the Healthy Country–Healthy People Nexus through Sociocultural and Environmental Transformations: Challenges for the Wik Aboriginal People of Aurukun, Australia.” Australian Geographer 48, no. 3 (July 3, 2017): 285–309. https://doi.org/10.1080/00049182.2016.1220898.
Hagemoen, Rolf Iver M., och Eigil Reimers. ”Reindeer summer activity pattern in relation to weather and insect harassment”. Journal of Animal Ecology 71, nr 5 (01 september 2002): 883–92. https://doi.org/10.1046/j.1365-2656.2002.00654.x.
Hansen, Ketil Lenert, and Sara With Skaar. “Unge Samers Psykiske Helse–En Kvalitativ Og Kvantitativ Studie Av Unge Samers Psykososiale Helse,” 2021.
Harper, Sherilee L., Victoria L. Edge, James Ford, Ashlee Cunsolo Willox, Michele Wood, and Scott A. McEwen. “Climate-Sensitive Health Priorities in Nunatsiavut, Canada.” BMC Public Health 15, no. 1 (December 2015): 605. https://doi.org/10.1186/s12889-015-1874-3.
Hassler, Sven, Per Sjölander, Robert Johansson, Henrik Grönberg, and Lena Damber. “Fatal Accidents and Suicide among Reindeer Herding Sami in Sweden.” International Journal of Circumpolar Health 63, no. sup2 (September 2004): 384–88. https://doi.org/10.3402/ijch.v63i0.17941.
Haugan, Siv. ”Klimaendringene vil påvirke fremtidens jakt og fiske”. Forskningsrådet, 22 april 2021. https://www.forskningsradet.no/sok-om-finansiering/hvem-kan-soke-om-finansiering/forskningsorganisasjoner/Prosjekter-forskningsorganisasjoner/klimaendringene-vil-pavirke-fremtidens-jakt-og-fiske/.
Hedger, Richard, Line Sundt-Hansen, Torbjørn Forseth, Ola Ugedal, Ola Diserud, Ånund Kvambekk, och Anders Finstad. ”Predicting climate change effects on subarctic–Arctic populations of Atlantic salmon (Salmo salar)”. Canadian Journal of Fisheries and Aquatic Sciences 70 (01 februari 2013): 159–68. https://doi.org/10.1139/cjfas-2012-0205.
Hein, Catherine, Gunnar Öhlund, och Göran Englund. ”Future Distribution of Arctic Char Salvelinus alpinus in Sweden under Climate Change: Effects of Temperature, Lake Size and Species Interactions”. Ambio 41 Suppl 3 (01 juli 2012): 303–12. https://doi.org/10.1007/s13280-012-0308-z.
Henden, John-André, Rolf Ims, Eva Fuglei, och Åshild Pedersen. ”Changed Arctic-alpine food web interactions under rapid climate warming: Implication for Ptarmigan Research”. Wildlife Biology In-Press (10 februari 2017). https://doi.org/10.2981/wlb.00240.
Hodgson, Dominic, O. Anisimov, Andrew Constable, Anne Hollowed, Nancy Maynard, P. Prestrud, T.D. Prowse, och J.M.R. Stone. ”IPCC, 2014: Polar regions. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change”. Intergovernmental Panel on Climate Change, 2014.
Holma-Suutari, A., P. Ruokojärvi, S. Laaksonen, H. Kiviranta, M. Nieminen, M. Viluksela, and A. Hallikainen. “Persistent Organic Pollutant Levels in Semi-Domesticated Reindeer (Rangifer Tarandus Tarandus L.), Feed, Lichen, Blood, Milk, Placenta, Foetus and Calf.” Science of The Total Environment 476–477 (April 2014): 125–35. https://doi.org/10.1016/j.scitotenv.2013.12.109.
Holmberg, Áslat. ”Bivdit Luosa – To Ask for Salmon. Saami Traditional Knowledge on Salmon and the River Deatnu: In Research and Decision-making”. Master Thesis, UiT Norges arktiske universitet, 2019.
Holmberg, Áslat. ”«Dat lea du olbmuid, du máttuid luodda»–Sámi árvvut ja árvvoštallan ekovuogádathálddašeamis (Sámi values and valuation in ecosystem management)”. Saami Council, 2021. https://www.saamicouncil.net/documentarchive/dat-lea-duolbmuid-du-mttuid-luodda?rq=Dat%20lea%20du%20olbmuid%2C%20du%20m%C3%A1ttuid%20luodda.
Horstkotte, Tim, Kumpula Jouko, Per Sandström, Hans Tømmervik, Sonja Kivinen, Anna Skarin, Jon Moen, och Stefan Sandström. ”Pastures under pressure. Effects of other land users and the environment.”
I Reindeer husbandry and global environmental change – pastoralism in Fennoscandia., 1:a uppl., 76–98. London: Routledge, 2022. https://doi.org/10.4324/9781003118565-7.
Horstkotte, Tim, Élise Lépy, Camilla Risvoll, Svein Eilertsen, Hannu Heikkinen, Grete Hovelsrud, Mia Landauer, m.fl. Supplementary feeding in reindeer husbandry. Results from a workshop with reindeer herders and researchers from Norway, Sweden and Finland, 2020. https://doi.org/10.13140/RG.2.2.12202.13762.
Horstkotte, Tim, Tove Utsi, A Larsson-Blind, P Burgess, Bernt Johansen, Jukka Käyhkö, Lauri Oksanen, och B Forbes. ”Human–animal agency in reindeer management: Sami herders' perspectives on vegetation dynamics under climate change”. Ecosphere 8 (31 juli 2017): 1. https://doi.org/10.1002/ecs2.1931.
Hovgaard, Gestur, Jørgen Ole Bærenholdt, Julien Lebel, Maiken Bjørkan, Amsale Kassahun Temesgen, Grétar Þór Eyþórsson, Sigríður K. Þorgrímsdóttir, m.fl. Value Chains and Resilient Coastal Communities in the Nordic Atlantic. TemaNord. Nordic Council of Ministers, 2022. https://doi.org/10.6027/temanord2022-555.
Hueffer, Karsten, Mary Ehrlander, Kathy Etz, and Arleigh Reynolds. “One Health in the Circumpolar North.” International Journal of Circumpolar Health 78, no. 1 (January 1, 2019): 1607502. https://doi.org/10.1080/22423982.2019.1607502.

Ims, Rolf, John-André Henden, Marita Strømeng, Anders Thingnes, Mari Garmo, och Jane Jepsen. ”Arctic greening and bird nest predation risk across tundra ecotones”. Nature Climate Change 9 (01 augusti 2019): 1. https://doi.org/10.1038/s41558-019-0514-9.
Jaakkola, J.J.K, S. Juntunen, och K. Näkkäläjärvi. ”The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union”. Current environmental health reports 5, nr 4 (2018): 401–17. https://doi.org/10.1007/s40572-018-0211-2.
Jaenson, Thomas, David Jaenson, Lars Eisen, Erik Petersson, och Elisabet Lindgren. ”Changes in the Geographical Distribution and Abundance of the Tick Ixodes ricinus during the Past 30 Years in Sweden”. Parasites & vectors 5 (10 januari 2012): 8. https://doi.org/10.1186/1756-3305-5-8.
Jansson, Roland, Christer Nilsson, E. Carina Keskitalo, Vlasova Tatiana, Marja-Liisa Sutinen, Jon Moen, F Stuart Chapin III, m.fl. ”Future changes in the supply of goods and services from natural ecosystems: Prospects for the European North”. Ecology and society 20 (14 september 2015): 32. https://doi.org/10.5751/ES-07607-200332.
Jepsen, Jane U., Snorre B. Hagen, Rolf A. Ims, och Nigel G. Yoccoz. ”Climate Change and Outbreaks of the Geometrids Operophtera Brumata and Epirrita Autumnata in Subarctic Birch Forest: Evidence of a Recent Outbreak Range Expansion”. Journal of Animal Ecology 77, nr 2 (mars 2008): 257–64. https://doi.org/10.1111/j.1365-2656.2007.01339.x.
Jepsen, Jane U., Lauri Kapari, Snorre B. Hagen, Tino Schott, Ole Petter L Vindstad, Arne C Nilssen, och Rolf A. Ims. ”Rapid northwards expansion of a forest insect pest attributed to spring phenology matching with sub-Arctic birch”. Global Change Biology 17, nr 6

(01 juni 2011): 2071–83. https://doi.org/10.1111/j.1365-2486.2010.02370.x.
Johansson, Cecilia, Veijo Pohjola, Christer Jonasson, och Terry Callaghan. "Multi-Decadal Changes in Snow Characteristics in Sub-Arctic Sweden". Ambio 40 (01 september 2011): 566–74. https://doi.org/10.1007/s13280-011-0164-2.
Johnsen, Kathrine, Inger Marie Eira, Svein Mathiesen, och Anders Oskal. "'Leaving No One Behind' – Sustainable Development of Sámi Reindeer Husbandry in Norway". I Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, 37–66. Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-17625-8_3.
Jonsson, Bror, och Nina Jonsson. "A review of the likely effects of climate change on anadromous Atlantic salmon Salmo salar and brown trout Salmo trutta, with particular reference to water temperature and flow". Journal of fish biology 75 (01 december 2009): 2381–2447. https://doi.org/10.1111/j.1095-8649.2009.02380.x.
Jouko, Kumpula, Mika Kurkilahti, Timo Helle, och Alfred Colpaert. "Erratum to: Both reindeer management and several other land use factors explain the reduction in ground lichens (Cladonia spp.) in pastures grazed by semi-domesticated reindeer in Finland". Regional Environmental Change 14 (01 april 2014). https://doi.org/10.1007/s10113-013-0508-5.
Kaarlejärvi, Elina, Katrine Hoset, och Johan Olofsson. "Mammalian herbivores confer resilience of Arctic shrub-dominated ecosystems to changing climate". Global Change Biology 21 (13 maj 2015). https://doi.org/10.1111/gcb.12970.
Kaiser, Niclas. "Mental Health Problems among the Swedish Reindeer- Herding Sami Population: In Perspective of Intersectionality, Organisational Culture and Acculturation." PhD dissertation, Umeå University, 2011.
Kaiser, Niclas, och Ellinor Salander Renberg. "Suicidal Expressions among the Swedish Reindeer-Herding Sami Population". Suicidology Online 3 (2012): 102–13.
Kaiser, Niclas, Per Sjölander, Annette Edin Liljegren, Lars Jacobsson, och Ellinor Salander Renberg. "Depression and anxiety in the reindeer-herding Sami population of Sweden". International Journal of Circumpolar Health 69, nr 4 (18 september 2010): 383–93. https://doi.org/10.3402/ijch.v69i4.17674.
Kozma, Radoslav, Mette Lillie, Blas M. Benito, Jens-Christian Svenning, och Jacob Höglund. "Past and potential future population dynamics of three grouse species using ecological and whole genome coalescent modeling". Ecology and Evolution 8, nr 13 (01 juli 2018): 6671–81. https://doi.org/10.1002/ece3.4163.
Kynkäänniemi, Sanna-Mari, Maria Kettu, Raine Kortet, Laura Härkönen, Arja Kaitala, Tommi Paakkonen, Anne-Mari Mustonen, m. fl. "Acute impacts of the deer ked (Lipoptena cervi) infestation on reindeer (Rangifer tarandus tarandus) behaviour". Parasitology Research 113 (01 april 2014): 1489–97. https://doi.org/10.1007/s00436-014-3790-3.
Kynkäänniemi, Sanna-Mari, Raine Kortet, och Sauli Laaksonen. "Range expansion and reproduction of the ectoparasitic deer ked (Lipoptena cervi) in its novel host, the Arctic reindeer (Rangifer tarandus tarandus), in Finland". Parasitology Research 119 (23 juli 2020). https://doi.org/10.1007/s00436-020-06817-x.
Käyhkö, Jukka, och Tim Horstkotte. Reindeer husbandry under global change in the tundra region of Northern Fennoscandia, 2017. https://doi.org/10.13140/RG.2.2.22151.39841.
Lam, Mimi, och Trude Borch. "Cultural valuing of fishery resources by the Norwegian Saami". Glob Ecol Integr Sci Int Law 361 (01 januari 2011). https://doi.org/10.5848/CSP.2833.00020.
Landbruksdirektoratet. "En Styrket Beredskap i Reindriften." Rapport fra arbeidsgruppe, 2022.
———. "Gjennomgang Av Beitekrisen i Reindriften 2020." Rapport fra arbeidsgruppe, 2020.
Landehag, Jörgen, Andreas Skogen, Åsbakk Kjetil, och Boris Kan. "Human myiasis caused by the reindeer warble fly, Hypoderma tarandi, case series from Norway, 2011 to 2016". Eurosurveillance 22 (20 juli 2017). https://doi.org/10.2807/1560-7917.ES.2017.22.29.30576.
Löf, Annette. "Examining Limits and Barriers to Climate Change Adaptation in an Indigenous Reindeer Herding Community". Climate and Development 5, nr 4 (oktober 2013): 328–39. https://doi.org/10.1080/17565529.2013.831338.
Löf, Annette, Kaisa Raitio, Bruce Forbes, Kristina Labba, Mia Landauer, Camilla Risvoll, och Simo Sarkki. "Unpacking reindeer husbandry governance in Sweden, Norway and Finland. A political discursive perspective". I Reindeer husbandry and global environmental change – pastoralism in Fennoscandia., 150–72, 2022. https://doi.org/10.4324/9781003118565-12.
Magga, Ole Henrik, Svein Disch Mathiesen, Robert Corell, och Anders Oskal. "Reindeer Herding, Traditional Knowledge and Adaptation to Climate Change and Loss of Grazing Land". EALÁT project report. Alta, Norway, 2011.
Mallory, Conor D., och Mark S. Boyce. "Observed and predicted effects of climate change on Arctic caribou and reindeer". Environmental Reviews 26 (2018): 13–25.
Markkula, Inkeri, Minna Turunen, och Sirpa Rasmus. "A review of climate change impacts on the ecosystem services in the Saami Homeland in Finland". Science of The Total Environment 692 (20 november 2019): 1070–85. https://doi.org/10.1016/j.scitotenv.2019.07.272.
Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, Y. Caud, et al. "IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA: Intergovernmental Panel on Climate Change, 2021.
Mathiesen, S.D., B. Alfthan, R Corell, R.B.M. Eira, I.M. Gaup Eira, A. Degteva, K. Johnsen, m.fl. "Strategies to enhance the resilience of Sami reindeer husbandry to rapid changes in the Arctic. In: Arctic Resilience Interim Report 2013." Stockholm: Stockholm Environment Institute and Stockholm Resilience Centre, u.å.
Mathiesen, S.D., R.I. Mackie, A. Aschfalk, E. Ringø, och M.A. Sundset. "Microbial ecology of the digestive tract in reindeer: seasonal changes". I Biology of Growing Animals, redigerad av W.H. Holzapfel, P.J. Naughton, S.G. Pierzynowski, R. Zabielski, och E. Salek, 2:75–102. Elsevier, 2005. https://doi.org/10.1016/S1877-1823(09)70037-2.
Mathiesen, Svein Disch. "Reindeer Husbandry in the Circumpolar North". I Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, redigerad av Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, och Marina Tonkopeeva, 1–13. Cham: Springer International Publishing, 2023. https://doi.org/10.1007/978-3-031-17625-8_1.
McMichael, Celia, and Teresia Powell. "Planned Relocation and Health: A Case Study from Fiji." International Journal of Environmental Research and Public Health 18, no. 8 (April 20, 2021): 4355. https://doi.org/10.3390/ijerph18084355.
McNamara, K, R. Westoby, and K Parnell. "Elders' and Aunties' Experiences of Climate on Erub Island, Torres Strait." Final Project Report to the Marine and Tropical Sciences Research Final Project Report. Cairns: Reef and Rainforest Research Centre Limited, 2010.
Melin, Markus, Lauri Mehtätalo, Pekka Helle, Katja Ikonen, och Tuula Packalen. "Decline of the boreal willow grouse (Lagopus lagopus) has been accelerated by more frequent snow-free springs". Scientific Reports 10, nr 1 (24 april 2020): 6987. https://doi.org/10.1038/s41598-020-63993-7.
Meredith, M., M. Sommerkorn, S Cassotta, C Derksen, A Ekaykin, A Hollowed, G Kofinas, et al. "IPCC, 2019: Polar Regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate." Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2019.
Miljøstatus. "Havisutbredelse i Barentshavet". Miljøstatus, 05 januari 2023. https://miljostatus.miljodirektoratet.no/tema/hav-og-kyst/havindikatorer/barentshavet/havklima/havisutbredelse-i-barent-

shavet/.
Moen, Jon. "Climate change: effects on the ecological basis for reindeer husbandry in Sweden." Ambio 37, nr 4 (2008): 304–11.
Moen, Jon, Bruce Forbes, Annette Löf, och Tim Horstkotte. "Tipping points and regime shifts in reindeer husbandry". I Reindeer husbandry and global environmental change – pastoralism in Fennoscandia., 265–77, 2022. https://doi.org/10.4324/9781003118565-20.
Montgomery, Robert A, Kyle M Redilla, Remington J Moll, Bram Van Moorter, Christer M Rolandsen, Joshua J Millspaugh, och Erling J Solberg. "Movement modeling reveals the complex nature of the response of moose to ambient temperatures during summer". Journal of Mammalogy 100, nr 1 (28 februari 2019): 169–77. https://doi.org/10.1093/jmammal/gyy185.
Muladal, Rune. "Pukkellaks – en klimavinner.", 08 februari 2022. https://ww.fefo.no/aigeguovdil/meahcasteapmi-nuppastuvvan-meahcis.7214.aspx.
"Multeforkomster, klima og vær", 08 januari 2023. https://nessebymulter.no/forekomst/multeforekomster.html.
Nystad, Marie Elise, Ronald Pulk, Marianne Boine, Biret Inga Sokki Kemi, and Mattis Wilhelmsen. "Familiefar Johan Anders Har Knapt Sett Barna i Vinter." NRK Sápmi, March 24, 2022. https://www.nrk.no/sapmi/kommunelege-slar-alarm_-beitekrisa-i-reindrifta-taerer-pa-reineiere-og-deres-familier-1.15905830.
Näkkäläjärvi, K., S. Juntunen, och J.J. Jaakkola. "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland". I Climate Cultures in Europe and North America, 103–25. London: Routledge, 2022.
Näkkäläjärvi, Klemetti, Suvi Juntunen, och Joonas Jaakkola. "SAAMI – Saamelaisten sopeutuminen ilmastonmuutokseen -hankkeen tieteellinen loppuraportti", 2020.
Omma, Lotta. "Ung Same i Sverige: Livsvillkor, Självvärdering Och Hälsa [Young Sami in Sweden: Life Circumstances, Self-Evaluation and Health]." PhD dissertation, Umeå University, 2013.
Omma, Lotta, Mikael Sandlund, and Lars Jacobsson. "Suicidal Expressions in Young Swedish Sami, a Cross-Sectional Study." International Journal of Circumpolar Health 72, no. 1 (January 31, 2013): 19862. https://doi.org/10.3402/ijch.v72i0.19862.
Otero, J, J.H L'Abée-Lund, T Castro-Santos, K Leonardsson, G.O Storvik, B Jonsson, B Dempson, m.fl. "Basin-scale phenology and effects of climate variability on global timing of initial seaward migration of Atlantic salmon (Salmo salar)". Global change biology 20, nr 1 (2014): 61–75. https://doi.org/10.1111/gcb.12363.
Paoli, Amélie, Robert Weladji, Oystein Holand, och Kumpula Jouko. "Winter and spring climatic conditions influence timing and synchrony of calving in reindeer". PLOS ONE 13 (25 april 2018): e0195603. https://doi.org/10.1371/journal.pone.0195603.
Pearce, Meryl, Lynne Eagle, David Low, and Andrea Schurmann. "Cut From 'Country': The Impact of Climate Change on the Mental Health of Aboriginal Pastoralists." Australasian Journal of Regional Studies 21, no. 1 (2015): 50–79.
Persson, Anna-Marja. "Status of supplementary feeding of reindeer in Sweden and its consequences". Master Thesis, Sveriges Lantbruks Universitet, Institutionen för vilt, fisk och miljö, 2018.
Petheram, L., K.K. Zander, B.M. Campbell, C. High, and N. Stacey. "'Strange Changes': Indigenous Perspectives of Climate Change and Adaptation in NE Arnhem Land (Australia)." Global Environmental Change 20, no. 4 (October 2010): 681–92. https://doi.org/10.1016/j.gloenvcha.2010.05.002.
Petrasek MacDonald, Joanna, Ashlee Cunsolo Willox, James D. Ford, Inez Shiwak, and Michele Wood. "Protective Factors for Mental Health and Well-Being in a Changing Climate: Perspectives from Inuit Youth in Nunatsiavut, Labrador." Social Science & Medicine 141 (September 2015): 133–41. https://doi.org/10.1016/j.socscimed.2015.07.017.
Petrasek MacDonald, Joanna, Sherilee L. Harper, Ashlee Cunsolo Willox, Victoria L. Edge, and Rigolet Inuit Community Government. "A Necessary Voice: Climate Change and Lived Experiences of Youth in Rigolet, Nunatsiavut, Canada." Global Environmental Change 23, no. 1 (February 2013): 360–71. https://doi.org/10.1016/j.gloenvcha.2012.07.010.
Pörtner, H.O, D.C Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, et al. "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change." Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.
Pörtner, H.O, D.C Roberts, E.S Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, m.fl. "IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change". Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.
Rasmus, Sirpa, Sonja Kivinen, och Masoud Irannezhad. "Basal ice formation in snow cover in Northern Finland between 1948 and 2016". Environmental Research Letters 13, nr 11 (01 november 2018): 114009. https://doi.org/10.1088/1748-9326/aae541.
Rasmus, Sirpa, Minna Turunen, Anna Luomaranta, Sonja Kivinen, Kirsti Jylhä, och Jani Räihä. "Climate change and reindeer management in Finland: Co-analysis of practitioner knowledge and meteorological data for better adaptation". Science of The Total Environment 710 (25 mars 2020): 136229. https://doi.org/10.1016/j.scitotenv.2019.136229.
Retter, Gunn-Britt. "Norwegian Fisheries and adaptation to Climate Change". I Climate change and Arctic sustainable development: scientific, social, cultural and educational challenges. UNESCO: Paris: UNESCO, 2009.
Rigby, Colin Wayne, Alan Rosen, Helen Louise Berry, and Craig Richard Hart. "If the Land's Sick, We're Sick:* The Impact of Prolonged Drought on the Social and Emotional Well-Being of Aboriginal Communities in Rural New South Wales." Australian Journal of Rural Health 19, no. 5 (October 2011): 249–54. https://doi.org/10.1111/j.1440-1584.2011.01223.x.
Rikardsen, Audun, David Righton, John Fredrik Strøm, Eva Thorstad, Patrick Gargan, Timothy Sheehan, F. Økland, m.fl. "Redefining the oceanic distribution of Atlantic salmon". Scientific Reports 11 (10 juni 2021). https://doi.org/10.1038/s41598-021-91137-y.
Riseth, Jan Åge, och Hans Tømmervik. "Klimautfordringer og arealforvaltning for reindrifta i norge kunnskapsstatus og forslag til tiltak. Eksempler fra Troms." Northern research institute (Norut), 10 augusti 2017.
Risvoll, Camilla, och Grete Hovelsrud. "Pasture access and adaptive capacity in reindeer herding districts in Nordland, Northern Norway". The Polar Journal 6 (02 januari 2016): 87–111. https://doi.org/10.1080/2154896X.2016.1173796.
Rooij, Wilbert, Iulie Aslaksen, Isak Eira, Philip Burgess, och Per Garnåsjordet. "Loss of Reindeer Grazing Land in Finnmark, Norway, and Effects on Biodiversity: GLOBIO3 as Decision Support Tool at Arctic Local Level". I Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, 223–54. Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-17625-8_9.
Rosqvist, Gunhild C., Niila Inga, och Pia Eriksson. "Impacts of climate warming on reindeer herding require new land-use strategies". Ambio 51, nr 5 (01 maj 2022): 1247–62. https://doi.org/10.1007/s13280-021-01655-2.
Sámediggi. "Nødvendig å Slå Alarm," March 25, 2022. https://sametinget.no/aktuelt/nodvendig-a-sla-alarm.20063.aspx.
Sandström, Per, Neil Cory, Johan Svensson, Henrik Hedenås, Leif Jougda, och Nanna Borchert. "On the decline of ground lichen forests in the Swedish boreal landscape: Implications for reindeer husbandry and sustainable forest management". Ambio 45 (11 januari 2016). https://doi.org/10.1007/s13280-015-0759-0.
Silviken, Anne. "'Reindrift på helsa løs'. Arbeidsrelatert stress i reindriftsnæringen i lys av Mark Williams' modell 'Cry of pain.'" Suicidologi 16, no. 3 (2011).

Sirpa, R., T. Horstkotte, M. Turunen, M. Landauer, A. Löf, I. Lehtonen, G. Rosqvist, och Ø. Holand Lehtonen. ”Reindeer husbandry and climate change. Challenges for adaptation.” I Reindeer husbandry and global environmental change – pastoralism in Fennoscandia., 1:a uppl., 99–117. London: Routledge, u.å. https://www.taylorfrancis.com/books/9781003118565.

SLU. ”Klimatförändringar ett hot mot älgen”. Swedish University of Agricultural Sciences, 17 april 2020. https://www.slu.se/ew-nyheter/2020/4/klimatforandringar-ett-hot-mot-algen/.

Sokki Bongo, Anna Kristine, Johan Martin Stenfjell, och Brit Logstein. ”Helse, miljø og sikkerhet i reindrift. Funn fra kartlegging blant reindriftsutøvere”. Trondheim: Ruralis – Institutt for Rural- og Regionalforskning, 2022.

Soppela, Päivi, Mauri Nieminen, och Timisjärvi Jouni. ”Thermoregulation in reindeer”. Rangifer 6 (01 januari 2010). https://doi.org/10.7557/2.6.2.659.

”Standing up for forests and against the Swedish forestry model: A letter to EC policymakers”, 21 mars 2021. https://forestdefenders.eu/wp-content/uploads/2021/03/Final-version.open-letter_-on-the-international-day-of-forests.pdf.

Stoessel, Marianne, Jon Moen, och Regina Lindborg. ”Mapping cumulative pressures on the grazing lands of northern Fennoscandia”. Scientific Reports 12, nr 1 (30 september 2022): 16044. https://doi.org/10.1038/s41598-022-20095-w.

Stoor, Jon Petter A. “Suicide among Sámi – Cultural Meanings of Suicide and Interventions for Suicide Prevention in Nordic Parts of Sápmi.” PhD dissertation, Faculty of Health Sciences, Department of Community Medicine, The Arctic Univeristy of Norway, 2020.

Stoor, Jon Petter A, Gunn Heatta, and Áile Javo. “Plan for Suicide Prevention among the Sámi People in Norway, Sweden, and Finland.” SANKS, 2017.

Stoor, Jon Petter A, Niclas Kaiser, Lars Jacobsson, Ellinor Salander Renberg, and Anne Silviken. “‘We Are like Lemmings’: Making Sense of the Cultural Meaning(s) of Suicide among the Indigenous Sami in Sweden.” International Journal of Circumpolar Health 74, no. 1 (January 31, 2015): 27669. https://doi.org/10.3402/ijch.v74.27669.

Svensson, Brita, Bengt Carlsson, och Jerry Melillo. ”Changes in species abundance after seven years of elevated atmospheric CO 2 and warming in a Subarctic birch forest understorey, as modified by rodent and moth outbreaks”. PeerJ 6 (29 maj 2018): e4843. https://doi.org/10.7717/peerj.4843.

”SWECO, 2019: Syntesrapport: En sammanställning av fyra samebyars pilotprojekt med klimat- och sårbarhetsanalys samt handlingsplan för klimatanpassning”. SWECO, 15 augusti 2019.

Swim, Janet K., Paul C. Stern, Thomas J. Doherty, Susan Clayton, Joseph P. Reser, Elke U. Weber, Robert Gifford, and George S. Howard. “Psychology’s Contributions to Understanding and Addressing Global Climate Change.” American Psychologist 66, no. 4 (2011): 241–50.

Tape, Ken, David Gustine, Roger Ruess, Layne Adams, och Jason Clark. ”Range expansion of moose in Arctic Alaska linked to warming and increased shrub habitat”. PloS one 11 (13 april 2016): e0152636. https://doi.org/10.1371/journal.pone.0152636.

Taylor, Sidney. ”Climate warming causes phenological shift in Pink Salmon, Oncorhynchus gorbuscha, behavior at Auke Creek, Alaska”. Global Change Biology 14 (01 februari 2008): 229–35. https://doi.org/10.1111/j.1365-2486.2007.01494.x.

Tonkopeeva, Marina, Robert W. Corell, Nancy G. Maynard, Ellen Inga Turi, Inger Marie Gaup Eira, Anders Oskal, och Svein Disch Mathiesen. ”Framing Adaptation to Rapid Change in the Arctic”. I Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, redigerad av Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, och Marina Tonkopeeva, 15–35. Cham: Springer International Publishing, u.å. https://doi.org/10.1007/978-3-031-17625-8_2.

Tryland, Morten. ”Are we facing new health challenges and diseases in reindeer in Fennoscandia?” Rangifer 32 (2013): 35–47.

Tryland, Morten, Solveig Marie Stubsjøen, Erik Agren, Bernt Johansen, och Camilla Kielland. ”Herding conditions related to infectious keratoconjunctivitis in semi-domesticated reindeer: A questionnaire-based survey among reindeer herders”. Acta Veterinaria Scandinavica 58 (12 april 2016). https://doi.org/10.1186/s13028-016-0203-x.

Tunón, Håkan, och Brita Stina Sjaggo. ”Ájddo – reflektioner kring biologisk mångfald i renarnas spår”. Uppsala: Sametinget & Centrum för biologisk mångfald, 2012.

Turi, Ellen Inga. ”State Steering and Traditional Ecological Knowledge in Reindeer-Herding Governance : Cases from Western Finnmark, Norway and Yamal, Russia”. GERUM. Doctoral thesis, comprehensive summary, Umeå University, 2016. DiVA. http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-119704.

Turunen, Minna, P. Soppela, H. Kinnunen, M.-L. Sutinen, och F. Martz. ”Does climate change influence the availability and quality of reindeer forage plants?” Polar Biology 32, nr 6 (01 juni 2009): 813–32. https://doi.org/10.1007/s00300-009-0609-2.

Turunen, Minna T., Sirpa Rasmus, Mathias Bavay, Kimmo Ruosteenoja, och Janne Heiskanen. ”Coping with Difficult Weather and Snow Conditions: Reindeer Herders’ Views on Climate Change Impacts and Coping Strategies”. Climate Risk Management 11 (2016): 15–36. https://doi.org/10.1016/j.crm.2016.01.002.

Tømmervik, Hans, Jarle W. Bjerke, Eldar Gaare, Bernt Johansen, och Dietbert Thannheiser. ”Rapid recovery of recently overexploited winter grazing pastures for reindeer in northern Norway”. Fungi and Global Change 5, nr 1 (01 februari 2012): 3–15. https://doi.org/10.1016/j.funeco.2011.08.002.

Vecchio, Emily Ann, Michelle Dickson, and Ying Zhang. “Indigenous Mental Health and Climate Change: A Systematic Literature Review.” The Journal of Climate Change and Health 6 (May 2022): 100121. https://doi.org/10.1016/j.joclim.2022.100121.

Verma, Megha, Henrike Schulte to Buehne, Mailys Lopes, Dorothee Ehrich, Svetlana Abdulmanova, Stijn Hofhuis, och Nathalie Pettorelli. ”Can reindeer husbandry management slow down the shrubification of the Arctic?” Journal of Environmental Management 267 (01 augusti 2020): 110636. https://doi.org/10.1016/j.jenvman.2020.110636.

Vigo, Daniel, Graham Thornicroft, and Rifat Atun. “Estimating the True Global Burden of Mental Illness.” The Lancet Psychiatry 3, no. 2 (2016): 171–78.

Vikhamar-Schuler, Dagrun, Ketil Isaksen, Jan Erik Haugen, Hans Tømmervik, Bartlomiej Luks, Thomas Vikhamar Schuler, och Jarle W. Bjerke. ”Changes in Winter Warming Events in the Nordic Arctic Region”. Journal of Climate 29, nr 17 (01 september 2016): 6223–44. https://doi.org/10.1175/JCLI-D-15-0763.1.

Vuojala-Magga, Terhi, Minna Turunen, T. Ryyppö, och Monica Tennberg. ”Resonance Strategies of Sámi Reindeer Herders in Northernmost Finland during Climatically Extreme Years”. ARCTIC 64 (02 juni 2011). https://doi.org/10.14430/arctic4102.

Weladji, Robert Bertrand, Øystein Holand, och Trygve Almøy. ”Use of climatic data to assess the effect of insect harassment on the autumn weight of reindeer (Rangifer tarandus) calves”. Journal of Zoology 260 (2006): 79–85.

Working group on salmon monitoring and research in the Tana river system. ”Status of the river Tana salmon populations”, 2012. https://mmm.fi/documents/1410837/1801192/Tenojoen_lohikantojen_tila_-_Status_of_the_Rive_Tana_Salmon_Population.pdf/dc7b2918-39a3-4ae1-a6f3-26dccfe2df72/Tenojoen_lohikantojen_tila_-_Status_of_the_Rive_Tana_Salmon_Population.pdf?t=1452687571000.

World Health Organization. “COP24 Special Report–Health & Climate Change,” 2018.

World Health Organization. “COP26 Special Report on Climate Change and Health: The Health Argument for Climate Action.” Geneva, 2021.

YLE. ”Tenojoki täyttyi vieraslajiksi luokitelluista kyttyrälohista, ja tutkijoita ja paikallisia se huolettaa – kalat uhkaavat atlantinlohta ja

mätänevät jokeen.” YLE, 18 augusti 2021. https://yle.fi/uutiset/3-12063733.
Åhman, Birgitta, Minna Turunen, Kumpula Jouko, Camilla Risvoll, Tim Horstkotte, Élise Lépy, och Svein Eilertsen. ”Role of supplementary feeding in reindeer husbandry”. I Reindeer husbandry and global environmental change – pastoralism in Fennoscandia., 232–48, 2022. https://doi.org/10.4324/9781003118565-17.

6. Adaptation and a path forward

In the following chapter, we highlight some of the themes and needs that we find especially relevant to address and assess further in relation to climate and other changes in Sápmi. The chapter does not aim to solve all the issues raised in previous chapters, but we hope it will serve as food for thought.

We also acknowledge that Sámi society, with its multiple institutions and organizations, has the knowledge and resilience to assess and address the existing and projected changes in Sápmi.

The full recognition of Sámi rights to self-determination in decision-making is crucial in order to build capacity for adaptation, resilience, and healthy societies. This will require transforming governance systems and ensuring full and effective participation of the Sámi people. Partnership with the Sámi people in development of national, regional, and local policies and legislation is fundamental to effective climate action.

Adaptation strategies must be sustainable, not only economically and environmentally, but also culturally and socially for Sápmi. Understanding current and future changes, how they interact with multiple drivers, and how we can strengthen adaptive capacity and resilience requires a holistic perspective and multiple ways of knowing.

Climate change in Sápmi is projected to result in far-reaching consequences for ecosystems and their composition and, therefore, for the whole Sámi cultural landscape. As we, the Sámi people, have a strong connection to the land through our cultural practices and livelihoods, changes in environmental conditions have a direct impact on our society. Earlier studies have indicated that, for people living from the land, ecological change, such as changes in species composition and diversity or landscape structure, may reduce cultural and social ties to the land.[736] Markkula et al. (2019) concluded that climate change risks changing basic conditions for food security, the use of the traditional Sámi area, areas for hunting and fishing, and Sámi traditional knowledge. Näkkäläjärvi et al. (2022) found that climate-induced changes in biodiversity and weather conditions have significant and far-reaching socio-cultural implications for Sámi reindeer communities but also that climate change adaptation is a process of cultural change in response to changes in the environment and society.[737]

> **A crucial question for the future of the Sámi is how the communities can adapt to climate change in a culturally sustainable way, mitigate the risks and losses brought by climate change, and, ultimately, how society at large can support this adaptation. Climate change adaptation requires a balancing of cultural traditions and values, administration, and legislation; it has to weigh sufficient income and survival against increasing pressures and stress.** – Näkkäläjärvi et al (2022)[738]

As seen in chapters four and five, climate change in Sápmi has already negatively impacted mental health and well-being. It has increased risks of hazards, injury, food insecurity, and disease associated with a changed diet. Climate change impacts on ecosystems and biodiversity are projected to have further consequences for species abundance and distribution, risking severe impacts on Sámi culture, livelihoods, and subsistence activities and with direct impacts on our food security. To meet and to respond to fundamental changes and risks, we find that new, cross-disciplinary measures and strategies for adaptation will be required to minimize and alleviate negative impacts on life, culture, and well-being. Meeting the projected challenges will require targeted and coordinated action from Sámi organizations and representative institutions, and national governments,

[736] Jansson et al., "Future Changes in the Supply of Goods and Services from Natural Ecosystems: Prospects for the European North."

[737] Näkkäläjärvi, Juntunen, and Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland."

[738] Näkkäläjärvi, Juntunen, and Jaakkola.

at all levels. Enabling factors needed include increased flexibility, strong Sámi institutions, and proper recognition and use of Sámi Indigenous Knowledge. This also entails greater knowledge production on how climate change impacts all aspects of Sámi society. As addressed in previous chapters, there is a knowledge gap on the consequences of these impacts in several research fields in Sápmi. Furthermore, there must be a recognition of climate action as a vital part of health policies, and health action as a vital part of climate policy.[739] Other important parts of adaptation will be emergency preparedness, addressing the knowledge gaps on issues such as emerging food safety risks and the long-term impacts associated with the potential of cultural change. Overarching and fundamental for these actions is the full recognition of Sámi rights, self-determination, and partnership with the Sámi people. The recommendations in this chapter could be considered as stepping stones toward achieving these goals.

Self-determination for Sámi society to prioritize, plan and implement solutions based on our knowledge and needs

Self-determination is essential for Sámi society to prioritize, plan, and implement solutions based on our knowledge and needs. Sámi organizations and representative institutions must have the capacity and authority required for this. This includes, among many other things, equitable access to climate finance to support actions related to mitigation and adaptation.

Climate finance' is defined by the United Nations Framework Convention on Climate Change (UNFCCC) to be "local, national, or transnational financing—drawn from public, private, and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change."

In late 2022, the International Indigenous Peoples Forum on Climate Change (IIPFCC) launched the Principles & guidelines for direct access funding for Indigenous Peoples' climate action, biodiversity conservation, and fighting desertification for a sustainable planet. Indigenous Peoples underline the imperative need for direct access to, and direct management of funding to ensure that resources effectively support self-determined needs and solutions. The document also states that "governments must also recognize the false dichotomy of developed and developing countries in regard to funding initiatives and actions directed to Indigenous Peoples."[740] Existing climate finance arrangements exclude Sámi, as well as other Indigenous Peoples in the global North, which limits the economic capacity for building a more resilient Sámi society facing major consequential climate changes. The sixth Sámi Parliamentarian Conference in May 2022 underlined in their declaration the importance of including Indigenous Peoples from all seven socio-cultural regions of the world in climate finance commitments to support "[...] Indigenous Peoples self-determination, alliance building and strengthening Indigenous Peoples local economies, governance system and resource management strategies."[741] Current financial flows and structures reveal the critical need for establishing new structures of climate finance for the Arctic and within the nation-states in Sápmi that are directly targeted to Sámi and our needs. Additionally, as crises are becoming the norm rather than the exception in Sápmi, current emergency funds offered to support livelihoods such as reindeer husbandry must be restructured to become a standard support mechanism for Sámi livelihoods to adapt to climate change. This would leave actual emergency funds to help when future crises exceeding the new normal occur.

739 World Health Organization, "COP24 Special Report–Health & Climate Change."

740 International Indigenous Peoples Forum on Climate Change, "Principles and Guidelines for Direct Access Funding for Indigenous Peoples' Climate Action, Biodiversity Conservation and Fighting Desertification for a Sustainable Planet."

741 Conference of Sámi Parliamentarians, "Declaration from the Sixth Conference of Sámi Parliamentarians in Aanaar, 19 May 2022."

Flexibility for adaptation

For Sápmi, adaptation and adaptive capacity are directly connected to flexibility. Flexibility is, and can be, many things and can also be highly locally determined, which must be properly understood. Examples of flexibility include geographical space in terms of available and ecologically intact grazing areas to enable pasture rotation for the reindeer herding and access to a diversity of species for Sámi fisheries. Besides being key for adaptation, flexibility is crucial for cultural continuity and development, as highlighted by the knowledge holder active in Sámi fisheries (see chapter five). Governance systems, management policies, and regulations must have built-in flexibility responsive to the needs of Sámi. Flexibility entails responding to changing circumstances but also responding to these changes in a timely fashion. This would require transformative change within governance systems. According to the IPCC (2022), governance systems must be flexible in order to be adaptive, which can be accomplished through capacity building, institutional reform, justice approaches, and inclusion.[742] IPBES (2022) emphasizes that "[…] achieving sustainable and just futures requires institutions that enable a recognition and integration of the diverse values of nature and nature's contributions to people." Institutions play a crucial role in shaping how nature is valued as they influence which values become socially legitimized and which ones are excluded from decision-making.[743]

Socio-political structures and legislation limit full Sámi participation and influence, which in turn limits the use of Sámi Indigenous knowledge and adaptive space. As presented in chapter five, Sámi knowledge holders and researchers in multiple fields underline that current limits to flexibility imposed by management policies and legislation are major barriers to current and future possibilities for effective adaptation. Increasing flexibility for Sámi cultural practices and subsistence livelihoods will thus be a fundamental part of maintaining and strengthening adaptive capacity in times of change.

Reindeer husbandry is facing both positive and negative implications from a changing climate. It is difficult to predict how climate change and new ecological conditions will affect reindeer husbandry in the future as it will largely depend on factors such as competing land use, management systems, regulations, legislation, predator policies, and how these factors interact with climate change. It is, therefore, clear that climate change is only one factor acting upon several others that reindeer husbandry is compelled to adapt to. The ongoing loss of lands and pastures due to other forms of land use is a key driver that is affecting, and will continue to affect, reindeer husbandry. Flexibility critical for herders' and herding systems' adaptive capacity is severely limited. Limitations in making timely adjustments on pasture rotation, or how to use governmental financial support, have far-reaching consequences since they limit the use of Sámi Indigenous knowledge, at the same time as climate change adds additional safety risks for herders and reindeer. Reindeer migration and the increased risks related to climatic changes showcase the need for making timely policy adjustments. Seasonal changes, such as later formation of safe ice and permanent snow cover during autumn (a time of year when the majority of human accidents with injuries occur– see box Grazing crisis in Norway, chapter 5), can increase the risk of injuries for both herders and reindeer if herds are forced to move earlier than conditions on the land allow for. Imposing a bureaucratic deadline on migration therefore raises the risk level for both humans and animals.[744] From a health, safety, environmental, and animal welfare perspective, regional and national governments must collaborate with reindeer herders to find solutions for safe migration. This requires better use of Sámi Indigenous Knowledge in laws and regulations.

Reindeer husbandry is, and has always been, adaptable and resilient to change, but herds and herders are now facing unprecedented challenges from a changing climate and external pressures. It should not be assumed that resilience is boundless. It is important to note that thresholds for limits to the adaptive capacity of reindeer husbandry in the Circumpolar North have not yet been identified.[745] Losing adaptive capacity risks reaching tipping points, meaning that the system of reindeer husbandry enters "[...] a state that one cannot say in advance what will happen".[746] This means that reindeer husbandry can enter into a new regime or state, one that differs from how it is practiced today. As

742 Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.E.2.

743 Pascual et al., IPBES 2022: Summary for Policymakers of the Methodological Assessment of the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

744 Nystad and Utsi, "Følte Seg Tvunget å Flytte Rein over Tynn Is."

745 Rooij et al., "Loss of Reindeer Grazing Land in Finnmark, Norway, and Effects on Biodiversity: GLOBIO3 as Decision Support Tool at Arctic Local Level."

746 Tonkopeeva et al., "Framing Adaptation to Rapid Change in the Arctic."

described by Näkkäläjärvi et al. (2020, 2022) and highlighted in chapter five, reindeer herding models differ regionally within Sápmi, meaning that the effects of climate change and adaptation possibilities also vary significantly. This must be understood by decision-makers. For example, moving earlier with herds to other pastures due to climatic impacts is possible for some while impossible for others, and for some herding communities, modifying rotational pasture use is not motivated by climate change but by avoiding conflicts with other forms of land use. Another example highlighted by Näkkäläjärvi et al. (2022) suggests that the extent of competing land uses limits climate change adaptation options, particularly in the boreal region.[747] This could suggest that forest reindeer herding communities in Sápmi might be extra challenged and thus might need more focused support.

Adjustments of management policies for fisheries and other resources that Sámi are dependent on also need increased flexibility. For Sámi fisheries, it is difficult to predict what may be expected as shifts in ecology and species' range accompany warming waters, changes in salinity, and acidification. New species in traditional fishing areas may present opportunities for Sámi fisheries but may also change the seasonal timing of existing valued species. Relocation of valuable fish resources may increase risks due to greater distances to reach them. If economically viable fish species are seeking cooler waters further off the coast of Finnmark and even outside the Norwegian economic zone, it might become a challenge for the economy of commercial fisheries. Retter (2009) suggested that subsistence Sámi fishing, which is dependent on the diversity of fish stocks, provides needed flexibility and allows Sámi fisheries to adapt to changing conditions. She also noted, however, that regulations, mismanagement, and power centralization are limiting the flexibility of Sámi fisheries and hence their adaptive capacity. Sámi fisherfolk noted some climate-related changes during the Saami Council workshops, but for the time being, regulations seem to be the most pressing current concern. Management and regulations that do not correspond with reality were identified as the primary cause of ecological imbalance in the past.

As stated above, traditional subsistence fisheries and small-scale commercial fisheries use the variety of species available in fjords and near-coast waters throughout the year. The continuity and presence of this practice is the foundation of Sámi rights to fish. Adapting to the opportunities provided through the fishing quota system changes the traditional ways of using local fish stocks and affects the transfer of knowledge connected to fisheries. If traditional fisheries practices do not match the rules of the quota system, the traditional fisheries risk being lost. Sámi knowledge holders highlighted the rapid development of technology as a concern as it can make knowledge related to fishing grounds less relevant. Yet if technology is not used, the presence of Sámi fishers on fishing grounds may not be recorded, undermining the basis of traditional fishing rights. Lack of monitoring data can be interpreted by authorities as a lack of activity and presence in certain areas, which may have an impact on the right to fish in the long term. Similar to the experience in reindeer husbandry, the inflexibility of governance has shown how important it is to make sure that adaptation efforts and measures are giving Sámi the chance to use their Sámi Indigenous knowledge. A changing climate requires a more adaptable and flexible bureaucracy directed by more flexible governance systems. Management policies that are functional, coherent, and reliable, based on multiple knowledge systems, and produced in collaboration with multiple actors are critical for the functioning of Sámi livelihoods.

As climate change continues to affect traditional Sámi subsistence economies and puts pressure on Sámi society as a whole, future measures for adaptation must also include enabling the diversification and broadening of Sámi livelihoods, subsistence activities, and businesses in order to increase stability, security, and adaptive capacity. This could include developing strategies and/or support systems to strengthen and develop, for example Sámi entrepreneurship in order to foster a strong and resilient Sámi society based on Sápmi's own resources.

Preparedness for adaptation

Adaptation includes preparing for the impacts and consequences of extreme weather events, as well as the dangers posed by more common climatic hazards. As seen in chapter four, projections for future climate change highlight increased risks for the occurrence of extreme weather events and climate hazards in Sápmi. These events can include direct threats to human life and safety, for example from heat exposure during summer[748] or avalanches during the snow season, higher expenditures for property damage, and high-

[747] Näkkäläjärvi, Juntunen, and Jaakkola, "Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland."

[748] Jaakkola, Juntunen, and Näkkäläjärvi, "The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union."

er overall expenses for society. Increased incidence of climate hazards may also raise the necessity for, and/or frequency of, search and rescue operations for which Sámi society must be prepared. AMAP highlighted that minimal research exists that focuses on the societal consequences of present and future extreme events, and that existing climate impact and risk assessments are made in silos – focusing on only one hazard at a time and how it affects one sector at a time. These findings reveal a critical need for investigating such consequences in a broad, multi-level, and cross-disciplinary Sámi context–the interactions between a changing climate, ecosystems, and society–in order to develop emergency preparedness strategies and measures in Sápmi. This also includes a need for evaluating the risks that challenge the occupational safety for Sámi working in traditional livelihoods. In addition, understanding the impact and significance of multiple climate change drivers is critical when assessing vulnerability, risks, and adaptive strategies. Sámi knowledge holders must be allowed to contribute with their own observations of changes in landscapes and seascapes, and their assessments of the implications of the changes when analyzing climate-related risks, vulnerability, and/or developing adaptation strategies. This will provide an important indication of what constitutes a risk, particularly in terms of Sámi livelihoods, and will also provide valuable information about what changes can already be discerned and what strategic adaptation measures are thus required.

Recommendations:

- Increase knowledge and competence about the conditions and needs of Sámi culture and livelihoods in the broader society, especially among local and regional authorities, and governmental institutions.
- Revise the governance of land use and species management to create the flexibility required for Sámi culture and livelihoods.
- Sámi customary sustainable use, values, and practices must be at the core of developing policies that affect Sámi culture, livelihoods and subsistence activities.
- Sámi organizations and representative institutions must develop long-term climate adaptation strategies that are holistic and cross-disciplinary.
- Sámi organizations and representative institutions must be equitably involved in national developments of long-term climate adaptation strategies. State authorities have an important role in initiating and supporting climate adaptation work. Active partnership with multiple actors within the Sámi society will be necessary for effective climate action and for developing adaptation strategies that are holistic and cross-disciplinary in a Sámi context.
- Emergency preparedness strategies must be developed in a context that assesses the multiple interactions between climate, ecosystems, and Sámi society.
- Climate finance must be made accessible for Sámi in order to initiate Sámi adaptation strategies.
- Introduce permanent financial mechanisms to support Sámi livelihoods, reindeer husbandry in particular, to adapt to climate change.
- Compile additional information on how Sámi culture and livelihoods (fishing and fisheries, hunting and gathering, and duodji in particular, but also reindeer husbandry) are affected by and coping with climate change and related impacts, as well as changes in land and marine use, and governance and regulation of land and marine spaces and resources. Filling these knowledge gaps is crucial in order to assess and develop future adaptation strategies.
- Develop strategies and/or support systems to enable diversification of and/or strengthening of Sámi cultural practices, livelihoods, and businesses.

Strengthening the Sámi knowledge institutions for adaptation

Sámi institutions, organizations, knowledge centers, and knowledge networks play a key role in Sámi society as they can formulate and promote Sámi Indigenous knowledge. They also represent a potential to facilitate fora where knowledge holders can meet, talk, and share observations of possible impacts of change and solutions for long-term resilience. In particular, Sámi allaskuvla (Sámi University of Applied Sciences) is a core institution in Sámi Indigenous knowledge production. Sámi åhpadusguovdásj is also an important knowledge institution as they build cultural competence and confidence in Sápmi. Other examples of existing Sámi Knowledge hubs/centers in Sápmi specifically working with Sámi Indigenous knowledge include, among others, the International Centre for Reindeer Husbandry (ICR) and Mearrasiida. ICR is located in Guovdageaidnu and focuses, among other things, on contributing to the maintenance and development of sustainable reindeer husbandry through cooperation between reindeer herding peoples. It aims to be a knowledge base for providing, exchanging, and developing information and knowledge between different reindeer peoples, national authorities, and research- and academic communities at the national and international levels, and increase knowledge about circumpolar and Sámi reindeer husbandry. A core element in ICR's commitment is to build resilience by strengthening Sámi food culture through unique leadership training and promotion of the value of traditional food systems. Mearrasiida in Porsangu/Porsanger is a competence center aiming to strengthen and revitalize sea Sámi culture through various activities such as documenting local culture, promoting Sámi placenames, record gathering- and fjord-related knowledge, and arranging boat-building courses. Mearrasiida facilitates knowledge holders partnering with scientists aiming to understand the fjord ecology, which is also relevant in understanding climate change.

Chapter three exemplifies some of the foras where the knowledge of Indigenous Peoples, and the importance of Indigenous Peoples' full and effective participation is recognized in global processes. The Nordic states have, to a certain extent, included some of these aspects in national laws, regulations, and processes, but structural barriers for full implementation still remain.

When aiming towards using the knowledge of Indigenous Peoples, one should bear in mind that the knowledge can be context-specific and tailored to the conditions of local circumstances: what is valid in one location might not be valid in another region. The knowledge of Indigenous peoples can, however, be communicated as universal lessons for effective climate action as it has proven to enhance adaptation measures and successful outcomes. There are some unwritten protocols for sharing knowledge–everything is not for sharing outside one's own community, and some might be time-sensitive knowledge-based observations. Merely writing down or documenting knowledge in papers and books is important for its own value and purpose, but at the same time, the knowledge can become static and freeze at a certain point. The nature of Indigenous Knowledge, being a systematic way of thinking, has evolved over time and is passed on between generations; thus it is still developing for new circumstances. In discussing how to make use of the knowledge of Indigenous Peoples in decision-making or management processes, equitable participation of the knowledge holder(s) is/are essential. The knowledge holder(s) are representing a collective rather than being nominated to carry the burden alone on a board or in a decision-making process. Therefore, a network is important to support their participation through an organization, a network, an institution like an institute, a competence center, or another kind of research or knowledge institution.

Arctic Indigenous Peoples' Organizations provided the definition below of Traditional Knowledge in a workshop in Canada in 2014. The Saami Council uses this definition in its work and has later decided to refer to 'the knowledge of Indigenous Peoples', rather than traditional knowledge.

"Traditional Knowledge is a systematic way of thinking and knowing that is elaborated and applied to phenomena across biological, physical, cultural and linguistic systems. Traditional Knowledge is owned by the holders of that knowledge, often collectively, and is uniquely expressed and transmitted through indigenous languages. It is a body of knowledge generated through cultural practices, lived experiences including extensive and multigenerational observations, lessons and skills. It has been developed and verified over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation."

The nation states across Sápmi all have their Arctic or high north policies. Through these, they express the need for more knowledge about the polar regions to better understand climate-related changes. The need for more knowledge is highlighted to ensure better management of the resources, but also for business development and value creation, and for some to understand and protect vulnerable Arctic ecosystems. Financing knowledge production thus fulfills a need defined by the national interests and the broader society, followed by funding to build institutions, science infrastructure, and investments in science projects. It therefore becomes obvious that the Sámi society's need for knowledge production and knowledge generation to understand climate change and its impacts, as well as building resilience in Sámi communities, is not equally prioritized.[749] [750]

Recommendations:

- Strengthen Sámi institutions and local Sámi knowledge hubs in order to respond to local needs and make Sápmi a stable and robust partner in collaborative climate governance.
- Strengthen and encourage Sámi knowledge holders to work strategically with Sámi Indigenous knowledge.
- Expand the solution space with multiple ways of knowing. Climate change and related impacts will require new knowledge, perspectives, and ways of working to deal with current and future challenges.

Food safety and adaptation

Climate change increasingly threatens traditional Sámi livelihoods and subsistence resources not only through weather and ecological change but also through increased risks for disease for both humans and ecosystems stemming from contaminants, pathogens, pests, and bacteria. In combination with other non-climate impacts that threaten biodiversity, projected future changes risk leading to major impacts on the resource foundation of Sámi culture. This will directly impact food security and food safety for the Sámi society, as well as our health.

As seen in chapter four, AMAP (2021) emphasized the low quality and quantity of evidence documenting current impacts of climate change on food security and food safety in an Arctic context. This highlights the need for further research on this topic with a Sámi perspective. Assessments and measures must include investigations on current and future risks to Sámi food safety, such as levels of contaminants and toxins in culturally important species in the Sámi diet, as well as disease risks from pathogens threatening animal welfare. This is an important part of the knowledge needed for predicting and adapting to coming change but also for preventing disease and negative health impacts.

Recommendation:

- Increase knowledge about the current and projected existence and risks of contaminants, toxins, and pathogens in subsistence resources the Sámi people depend upon.

Holistic perspectives on health and well-being for adaptation

As Sápmi's climate is projected to change, so might our cultural traditions and practices. Markkula et al. (2019) stress that the impacts on Sámi society will likely be broad and multiple as the changing cultural landscapes underpin cultural identity, heritage, and sense of place. Jaakola et al. (2018) found that livelihood changes may directly affect the physical health and cultural well-being of the Sámi, which needs to be studied further and considered in governance. Changes in environmental conditions disrupt livelihoods, culture, food systems, social connections, public health, and economies, which can result in loss of cultural knowledge, disruptions in knowledge transmission, and loss of place-based identity and connection. These cultural losses can seriously harm adaptive capacity and lead to mental distress, intergenerational trauma, and a lack of sense of belonging and identity. Assessments of these types of cultural and spiritual losses and damages are few, and social and cultural aspects of ecosystems are often overlooked in favor of the economic benefits provided by ecosystems.[751] [752] Failure of decision-makers to recognize the importance of ecosystems

[749] Saami Council, "The Sámi Arctic Strategy: Securing Enduring Influence for the Sámi People in the Arctic through Partnerships, Education and Advocacy."

[750] Saami Council, "Sápmi-EU Strategy."

[751] Markkula, Turunen, and Rasmus, "A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland."

[752] Pascual et al., IPBES 2022: Summary for Policymakers of the Methodological Assessment of the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

in relation to culture and cultural continuity is a critical issue, particularly for Indigenous Peoples. A solely political and economic view of ecosystems and a direct misrecognition of the peoples who rely on them risks releasing a cascade of socio-cultural impacts in the Arctic.

Increases in mental health issues globally are projected to be an outcome of climate change, and this will likely be the case in Sápmi as well. As described in chapter five, research has shown that physical and mental stress related to climate change have emerged as growing concerns for reindeer herders and their families. These concerns and experiences were highlighted by herders and other Sámi knowledge holders in the making of this report. Climate change has resulted in direct impacts on reindeer's natural access to grazing, increased herders' workloads, decreased occupational safety, and created an additional burden on herders' finances. These impacts have become a societal concern, as spouses, children, and extended families have been affected as well. The grazing crisis of 2022 was declared a societal crisis in Deatnu and Unjárga municipalities due to this[753], and the municipality doctor of Guovdageaidnu raised the issue to regional authorities. Research has pointed at that climate change, coupled with other pressures, has led to an increase in stress, anxiety, concern, depression, and suicidal thoughts among herders in Sápmi. While this indicates a serious health situation for herders, it is unknown how Sámi society at large is responding. However, in the Mihá[754] report, Sámi youth have reported that land encroachments in Sápmi are a source of mental distress, and research demonstrates that there is a clear connection between climate change, environmental conditions, and health and well-being. Research from other Indigenous Peoples' societies shows that climate change increases the risk of anxiety, depression, substance abuse, community violence, and domestic violence, some of which are already present in Sámi society. This suggests how comprehensive the impacts of climate change can become in Sápmi. It is of major concern that cumulative effects of climate change might result in increases of already existing societal issues if no transformative climate action is undertaken, and if the measures for adaptation outlined in this report are not taken.

As reported in earlier chapters, research examining future health projections or evaluating the efficiency of health adaptations is rare, and adaptation to climate change from a health perspective is under-represented in policies and planning. The findings in this report reveal a significant knowledge gap and a critical need for a more directed focus on health, well-being, and cultural impacts in relation to climate change, changing environments, and land use in Sápmi. Ensuring Sámi self-determination, upholding Sámi rights, and including Sámi Indigenous Knowledge in nature management, including preservation of reindeer grazing land, should be considered a health measure by the national authorities. Loss of nature is related to decreased mental health also among non-indigenous people. Health policy in the context of climate change should focus not only on responses to existent health impacts but also on measures taken to prevent health impacts, building resilience in Sápmi.

Recommendations:

- Strengthen the knowledge base on health and well-being in relation to a changing climate and environment in Sápmi.
- Mandate the consideration of socio-cultural aspects of change in any consideration of climate or other changes affecting ecosystems in Sápmi.
- Recognize climate action as a vital part of health policies, and health action as a vital part of climate policy.
- Develop a Sámi strategy for health and well-being as part of climate adaptation.
- Safeguarding of Sámi lands, territories, and resources must be a fundamental part of national-level health policies and Sámi health policies.
- Ensure Sámi health institutions' autonomy to enable them to properly respond to Sámi health needs when facing climate change and related land use change.

753 Ittelin, "– Beitekrisa er en samfunnskrise."

754 Hansen and Skaar, "Unge Samers Psykiske Helse–En Kvalitativ Og Kvantitativ Studie Av Unge Samers Psykososiale Helse."

Food security and adaptation

Research presented in chapter five emphasized that abandoning traditional subsistence activities due to climate change and/or food safety risks will likely result in Indigenous Peoples becoming more reliant on store-bought foods. These are frequently less healthy, increasing the incidence of diseases such as diabetes, cardiovascular disease, dental problems, and obesity. Apart from the obvious concern regarding how such a development might affect the health of the Sámi both short and long-term, it also demonstrates the fundamental need for maintaining and strengthening our internal food security from a health perspective, but also from a variety of other perspectives–which should be of significant importance also for broader society.

Nilsson (2020) highlighted that the Nordic countries' food self-sufficiency is inadequate and vulnerable to geopolitical processes, global crises, and trade changes (see chapter 4). Sámi culture and livelihoods, and subsistence resources have an important role to play in this context as they potentially make Sámi active in traditional subsistence livelihoods less vulnerable to outside disturbances, and increase the resilience of the food systems in their respective regions and countries. However, as Nilsson (2020) also highlighted that the relationship between Sámi culture and livelihoods and their relation to food security is not properly recognized by national governments. One could therefore ask, why is Sámi food security not of particular national interest for our nation states? Traditional Sámi livelihoods are a core part of Sámi culture, food systems, and identity, and a great part of the Sámi economy. Further, Sámi products are valuable commodities on both national and international markets. Their contributions should therefore not be underestimated on a societal level. Reindeer husbandry, as one of many examples, is of great economic importance as it creates direct income and employment but also supports other businesses within a community. This was emphasized by the County Administrative Board of Västerbotten, Sweden, in late 2022. The governor stressed the regional importance of reindeer husbandry for the county of Västerbotten, but also its importance for national Swedish food security and national cultural tradition. The governor underlined that as the COVID-19 pandemic, geopolitics, and climate change have impacts on reindeer husbandry, it should be given emergency support from the government, just like the agricultural and fisheries sectors.[755] This is one example of political leadership that is needed throughout Sápmi to strengthen the adaptive capacity and resilience of Sámi culture and livelihoods. Another important part is increased knowledge about the rich food culture of the Sámi people and how it holistically connects to our health and well-being. Knowledge about Arctic Indigenous Peoples' food cultures is critical for adapting to Arctic change, building resilience, and maintaining cultures and societies.[756]

Recommendation:

- Increase knowledge and competence about Sámi food systems in the local, regional and national governments, stressing their importance to Sámi culture, but also the benefits to food security of the broader societies.

Arctic Indigenous Peoples' led initiatives on food security responding to change

The Inuit Circumpolar Council Alaska, together with their Inuit partners, have, over the last decade, launched several reports related to Food Security and Food Sovereignty. The most recent report, Food Sovereignty and Self-Governance: Inuit Role in Managing Arctic Marine Resources, was published in 2020 with the objective of investigating present management and co-management of Arctic marine food resources in order to acquire a thorough understanding of existing and emerging frameworks supporting Inuit self-governance. Bringing Inuit together to manage their own work was a crucial part of this initiative. The report from the collaborative project elevates Inuit voices to highlight Inuit viewpoints and roles in support of equity and food sovereignty. It is based on four case studies examining management concerning salmon, walrus, beluga, and char. Inuit have through the process developed strong definitions of food security and food sovereignty from an Inuit perspective and highlighted their connection to each other.

Under the Sustainable Development Working Group (SDWG) in the Arctic Council, the Association of World Reindeer Herders (WRH) has, with their partners over the years, led projects related to food

755 Blind Persdotter, "Länsstyrelsen Föreslår Krisstöd till Rennäringen."

756 Tonkopeeva et al., "Framing Adaptation to Rapid Change in the Arctic."

knowledge, Arctic Indigenous Youth and Arctic Change. These projects are known as EALÁT and EALLU and have become widely recognized and received several awards. The overall objective is to increase resilience and work toward improving the quality of life for Arctic Indigenous reindeer herding peoples. The present SDWG project, Arctic Indigenous Youth, Food Knowledge and Arctic Change, entails sustaining and further developing sustainable and resilient reindeer husbandry in the Arctic in the face of climate change and globalization. The project emphasizes youth involvement and engagement, as well as raising awareness of Arctic change among northern Indigenous youth. By sharing and giving a voice to the Indigenous knowledge and food cultures of Arctic Indigenous Peoples, it promotes focus, awareness, and value-added of Arctic Indigenous food cultures. Additionally, it promotes knowledge development for innovation, business development, and local value addition in the societies and regions of Arctic Indigenous Peoples, in appropriate ways working in the intersections of academia and business, science and Indigenous knowledge, and "modernity" and traditions.

Sámi rights, partnership, climate action, and climate adaptation

Climate change and its related impacts are a major concern and other stressors from for example industrial developments and continued resource extraction and pollution, add to the impacts of a changing climate. As the IPCC made clear (see chapter 2), unsustainable land use and unsustainable use of natural resources are interacting with climate change and loss of biodiversity, which adversely affects ecosystems' capacities, as well as adaptation options and the capacity of societies. Climate change in Sápmi thus must be understood in a context of historical and present human-induced events and colonial patterns that have contributed to biodiversity loss and global temperature rise–all of which combined become a direct threat to Sámi culture, livelihoods, and food security. This is especially important to understand and recognize in times of rapid change that, in turn, requires transformative change in society.

Climate change facilitates and prompts a massive change in land use, and Sápmi continues to remain a resource supplier for broader society. The EU, including Finland and Sweden–and Norway, having committed itself to the EU standards–is striving to become low-emission societies by 2050. This will require a massive shift in energy production not dependent on fossil fuels. We acknowledge that not living up to the commitments of the Paris Agreement will have devastating impacts globally and for Sápmi. At the same time, there is a landslide of projects and industrial developments being established and planned for on Sámi territory to enable for this energy transition, potentially having devastating impacts for Sápmi. Sámi society welcomes the need for a shift to a more sustainable, low-emission society, however, the burden should not be disproportionately on Sámi lands and the Sámi people to enable this shift. From our perspective, the current approach is all but 'green' as it entails destroying and fragmenting intact and productive ecosystems and traditional lands that Sámi have managed for millennia. This comes with direct impacts on Sámi culture and livelihoods. In recent years consultation mechanisms have been established in Norway and Sweden with the stated aim to ensure that Sámi interests and voices are represented in policy development. However, consultations in their current format between the Sámi people and the governments are not sufficient to prevent violations of Sámi rights while striving for the transition towards low emission society when international standards for human rights, or those affirmed in the United Nations Declaration on the rights of Indigenous Peoples (UNDRIP), are not upheld. In Finland there is a specific initiative put in place aiming to ensure Sámi influence on climate policies, in particular, by establishing the Sámi Climate Change Council as an independent expert body.[757] This council will assist in the development of national climate policy and offer thoughts on them from the standpoint of the Sámi people. If proven to equitably use Sámi Indigenous knowledge and partner with Sámi people in a meaningful way, it could potentially evolve to become a pan Sámi Climate Change Council. If such a council proves to serve its purpose is yet to be found out.

The new development opportunities rising in the Arctic are likely to increase land-use competition further, and limit the possibilities for Sámi to adapt to climate change by constraining the flexibility required to maintain traditional livelihoods. While some of these developments might result in opportunities for Sápmi–tourism, for example, can bring economic opportunities, increase income for Sámi families and businesses within the tourism industry, and potentially diversify income–it is crucial to understand local contexts and conditions and how climate change, land use, legislation, and management interact with each other. While the

[757] Ministry of the Environment Finland, "New Climate Change Act into Force in July."

impact of one project or sector may appear relatively small for an entire region or area, the local and cultural impact can be very high. Increased summer tourism in the Swedish part of Sápmi has resulted in high local pressure with negative environmental impacts and disturbance to reindeer husbandry. The projected increase in tourism is just one of many examples of industries that might increase the risk of disturbance to Sámi culture and livelihoods.

While this report does not focus on Sámi rights in relation to climate change and related impacts, we are concerned about current trends and future projections of change and how these may negatively affect Sámi and violate our rights. Colonial legacies already allow broader society and governance structures to weigh Sámi culture and livelihoods against broader economic interests and sectors in land-use decision making, undermining Sámi rights. However, climate change could also add other sources of concern in relation to rights, aside from the risks of continued land grabbing under the auspices of mitigation. Climate change and its related impacts are already changing how and when we use the land and resources. If future changes make it more difficult for us to use our traditional territory, or if our adaptive practices result in periods when a particular part of the land is not used, the state may attempt to expropriate it. All these developments and concerns repeat the critical need for safeguarding Sámi rights.

Both climate mitigation efforts and adaptation raise questions about human rights for the Sámi people. It is, therefore, imperative that the Sámi people become an integral part of the decision-making–from nation-states' National Determined Contributions down to local adaptation and land use planning. Our knowledge, experience, and leadership must become a core part of joint efforts for our coming generations. Proper recognition and use of the knowledge of Indigenous Peoples is key to unlocking a more sustainable approach to resource management and effective climate action.

According to the IPCC (2022), climate action and sustainable development are inextricably linked, and sustainable development is fundamental for building capacity for climate action–including both lowering greenhouse gas emissions and increasing social and ecological resilience to climate change. To get there, new approaches to sustainable development that consider interactions between climate, human, and socio-ecological systems are needed. These new approaches must include the involvement and participation of multiple actors and will require rights-based approaches to protect Indigenous Peoples' livelihoods, and priorities, says the IPCC.[758] The preamble of the Paris Agreement states that "Parties should, when taking action to address climate change, respect, promote, and consider their respective obligations on human rights, [including] the rights of Indigenous Peoples…" and at UNFCCC COP26, states agreed on text that urges to actively involve Indigenous Peoples in designing and implementing climate action. Climate governance thus requires rights-based approaches and participatory methodologies, and the recognition of Indigenous Peoples' effective climate action must guide the development and implementation of climate policies at all levels.

Recommendations:

- Climate change and related impacts on Sámi culture and society must be recognized, assessed, and addressed holistically, and policies and regulatory measures must be developed, implemented, monitored, and enforced with the equitable, full and effective participation of the Sámi people.
- National states must uphold their international obligations to human rights and the rights of Indigenous Peoples when designing and implementing climate action. This entails including the Sámi people in shaping climate policies.
- Include Sámi representatives in national delegations within intergovernmental fora.
- Analyze and map the impacts of climate change on land use, together with how the impacts of land use coincide with climate change. This must be incorporated in local, regional, and national land use planning and management of resources.
- Recognize Sámi customary sustainable use of land, territories, and resources as a fundamental part of climate policy development.
- Require recognition, protection, and safeguarding of the rights of the Sámi people for climate action moving forward.

[758] Pörtner et al., "IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change" TS.E.2 and TS.E.2.7.

- Conduct a thorough assessment of how climate change impacts Sámi rights throughout Sápmi, including the alienation of land and marine use rights.

Sámi coordination for climate action

Through years of engagement in the United Nations and other international fora, Indigenous Peoples have raised awareness about the challenges of climate change but also demanded participation and involvement in climate governance. Indigenous Peoples are stewards of most of the remaining intact ecosystems in the world, and the knowledge and stewardship of Indigenous Peoples as effective climate action is increasingly recognized within international forums. There is, however, a need to keep up the attention on challenges faced by Indigenous Peoples and translate that attention into decisions at all governance levels to support Indigenous Peoples, also in an Arctic context. Unfortunately, many policies and projects implemented in the name of climate action disregard Indigenous Peoples' rights or ignore Indigenous Peoples' knowledge.

Local Communities and Indigenous Peoples Platform (LCIPP) - Facilitative Working Group (FWG)

In 2015, a decision to establish the Local Communities and Indigenous Peoples' Platform (LCIPP) was adopted, building on the Paris Agreement under the UNFCCC. Three years later in 2018, its Facilitative Working Group (FWG) was established to assist the Platform with its three functions related to knowledge, capacity for engagement, and climate change policies and actions (See web page). The LCIPP three-year workplan contains nine activities within the three LCIPP functions. The Facilitative Working Group is the first UN constituted body with equal representation between state Parties and Indigenous Peoples representatives, who are selected through a self-selected process by their own region. The 14 members of the FWG serve a term of three years. The Arctic caucus has agreed to rotate the representation in the FWG. Dr. Dalee Sambo Dorough, former chair of Inuit Circumpolar Council, served the first term 2019 - 2022. The Sámi caucus nominated Gunn-Britt Retter to serve during the second term 2022 - 2025.

Sámi institutions need to coordinate their work further to draw attention to Sámi and Arctic challenges and solutions in the global processes such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biodiversity (CBD). Sámi Parliaments and the Saami Council collaborate on this work; the Sámi Parliaments are parts of the national delegations of Norway, Finland, and Sweden (the two latter accessing the EU as well), while the Saami Council takes on coordination in the global Indigenous Peoples' caucuses (a caucus is the network of Indigenous Peoples' representatives present at any UN meeting coordinating the positions and strategies, and facilitating the statements presented by the Indigenous Peoples' constituency). In the United Nations system, Sámi and Inuit together represent Indigenous Peoples in the Arctic, one of the seven Indigenous socio-cultural regions recognized by the UN.

Saami Council and Sámi Parliaments have, over time, engaged in the UN negotiations. In relation to these negotiations and processes, Sámi caucuses are conducted to coordinate and develop joint positions. As Saami Council is presently holding the seat in the FWG, broader coordination in Sápmi and the Arctic region is needed. The Saami Council is seeking input beyond the usual negotiation team when contributing to the implementation of the LCIPP work plan activities and bringing the Arctic and Sámi viewpoints into relevant UNFCCC bodies. The involvement of the wider Sámi society and engaging knowledge holders and youth is a priority for the Saami Council when holding this position. Part of the current work plan of the LCIPP and its related activities is to conduct an Arctic Regional Gathering during 2023. The Arctic Regional Gathering, having its own agenda, could also serve as a launching point for an extended regional involvement of Arctic Indigenous Peoples. In the long term, if deemed efficient, such a caucus could be formalized as a regional Platform. The nature of such a platform would also mean engagement from respective Ministries. This mechanism would strengthen the Sámi society's capacity to influence climate governance.

Arctic Council cooperation

Saami Council is one of six Arctic Indigenous Peoples Organisations with Permanent Participant (PP) status to the Arctic Council.* The Sámi Parliaments can take a seat in the respective member state delegation, Norway, Finland, and Sweden. The other Permanent Participants correspond to the Aleut, the Athabascan, the Gwich'in, and the Inuit, all having their homes in more than one Arctic country. About 40 different Indigenous Peoples throughout the Russian Arctic and far east are participating through RAIPON. There are eight member states (Canada, Finland, Iceland, Norway, Sweden, the Russian Federation, and the US). Arctic Council projects, assessments, and reports are generated through six working groups. This setup creates a tri-party partnership between Member states, Indigenous Peoples, and scientists.

The Arctic Council assembles and generates a lot of Arctic knowledge within its mandate on environmental protection and sustainable development in the Arctic. Since its inception in 1996, the Arctic Indigenous Peoples Indigenous knowledge has been recognized as important together with science and research to understand the circumpolar Arctic. The Sámi participation in Arctic Council activities contributes to an increased understanding of Arctic change and, through effective participation, conveys the Sámi concerns and Indigenous knowledge to the knowledge foundation generating recommendations for decision-making about the Arctic region. Strengthening Sámi contributions to fora such as Arctic Council is a venue to increase the Sámi peoples' own knowledge generation and co-production of knowledge in the tri-party partnership through the Arctic Council.

* Due to the Russian Federation's invasion of the independent state Ukraine, the remaining seven Arctic Council member states have put their engagement in the Arctic Council on hold for the time being.

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In the UN context, the Nordic states need to enhance their capacity and knowledge about climate change to engage in the challenges Sápmi and the Arctic region are facing. It would be natural to partner with Arctic Indigenous Peoples, and the Sámi people in particular, to address this capacity-building need. Reiterating the Paris Agreement, the Nordic states must live up to their respective obligations related to the rights of Indigenous Peoples. A good first step would be to ensure the full and effective participation of the Sámi people in all climate action and policy development.

Recommendations:

- Strengthen Sámi capacities to participate in and develop national and international climate work.
- Elaborate on the possibility of developing an Arctic regional climate platform.

Indigenous Peoples are the solution

Indigenous Peoples must be included in decision-making and be actively and equitably involved in designing and implementing climate action as the stewardship, cultural practices, and knowledge of Indigenous Peoples have shown to be part of the solution needed by the world. Our experiences and perspectives can overcome siloed approaches that characterize institutional adaptation approaches. Supporting Indigenous self-determination will increase social-ecological system resilience and contribute to multiple benefits for health, well-being, and ecosystems.

To address the combined challenges of climate change and biodiversity loss in Sápmi, partnership with Sámi and self-determination of the Sámi people in ownership and management of lands, territories, and resources are fundamental pieces in building, maintaining, and strengthening resilience for the Sámi people. An important element of flexible adaptation is knowledge–the equitable use of Sámi Indigenous knowledge in decision-making, but also increased understanding of Sámi culture, livelihoods, and needs. Sámi customary sustainable use of land, territories, and resources must be a fundamental part of climate policy development. This will require structural, institutional, and legislative changes in multiple fora and sectors, as well as a philosophical shift away from the belief in boundless economic growth. A collaborative approach based on equitable co-production of knowledge could generate new knowledge that the broader society also would need for a more comprehensive understanding of the societal implications of climate change and the recognition of Indigenous Peoples' stewardship and values as a fundamental part of the solution.

This report is intended to further the conversation about how climate change is currently affecting, and threatens to affect, the Sámi society. Many questions remain unanswered, and even more have been raised. There are significant uncertainties about the larger societal impacts of climate change in Sápmi because there has been little research on that topic. Our hope is that this report sparks the interest of communities, governments, and academics in advancing the necessary research and considering the recommendations we have offered.

Sámi values and ethics, such as the concept of divdna ávkkástallan, which is concerned with fully utilizing a material and avoiding unnecessary waste, could be one part of raising awareness for material stewardship–what is gathered and how much is taken and how different materials can be used for different purposes in order to ensure divdna ávkkástallan.[759] While the Sámi people collectively are not responsible or in any way in charge of big industries or activities resulting in large carbon dioxide emissions, as individuals living in a high-emission and high-consumption society, we should exemplify our ancestors' values of fully utilizing resources and avoiding unnecessary waste. Our cultures are not based on values of constant growth but on harmony and reciprocity. These ethics should be used and valued by the broader society as they can reorient general resource and material use while also serving as a path toward a sustainable and just future.

"Luondduin ávkkástallama mearkkašupmi olbmui lea diehttelasat rievdan doložis. Ovdal olbmo ceavzin lei dan duohkin, muhto dán áigge bohtet olu resurssat eará guovlluin Sápmái. Buot ságastallanguoimmit ledje dan oaivilis, ahte dálá máilmmiekonomiija ii leat suvdilis vuođu alde. Min otná buresbirgejupmi goarida guovlluid eará sajiin máilmmis. Dat mii ii leat suvdil, ii sáhte bistit. Danin lea dehálaš doalahit min guovlluid dearvvasin ja doalahit máhtu ávkkástallat ja ovttas eallit min luonddubirrasiin. Leat unnit ah´unnit guovllut máilmmis, maid olmmoš ii leat nuoskidan. Dat ain lokte min Sámi mehciid ja čáziid árvvu, gos leat seilon dearvvas ekovuogádagat. Ealáhusvuođđu ja máhttu ávkkástallat dainna lea min divraseamos árbi."

– "Dat lea du olbmuid, du máttuid luodda" Sámi árvvut ja árvvoštallan ekovuogádathálddašeamis (2020)[760]

[759] Johnsen et al., "Displaced by Plastics: A Conversation with Sámi Knowledge Holders about the Impacts of Plastics."

[760] Holmberg, "«Dat Lea Du Olbmuid, Du Máttuid Luodda»–Sámi Árvvut Ja Árvvoštallan Ekovuogádathálddašeamis (Sámi Values and Valuation in Ecosystem Management)."

References Chapter 6

Arctic Council. “Senior Arctic Officials’ Report to Ministers 2021.” Arctic Council Secretariat, May 20, 2021.
Blind Persdotter, Anne Laila. “Länsstyrelsen Föreslår Krisstöd till Rennäringen.” Sveriges Radio, December 19, 2022. https://sverigesradio.se/artikel/lansstyrelsen-vill-se-ekonomiskt-krisstod-till-rennaringen.
Conference of Sámi Parliamentarians. “Declaration from the Sixth Conference of Sámi Parliamentarians in Aanaar, 19 May 2022,” 2022. https://www.sametinget.se/168525.
Hansen, Ketil Lenert, and Sara With Skaar. “Unge Samers Psykiske Helse–En Kvalitativ Og Kvantitativ Studie Av Unge Samers Psykososiale Helse,” 2021
Holmberg, Áslat. “«Dat Lea Du Olbmuid, Du Máttuid Luodda»–Sámi Árvvut Ja Árvvoštallan Ekovuogádathálddašeamis (Sámi Values and Valuation in Ecosystem Management).” Saami Council, 2021. https://www.saamicouncil.net/documentarchive/dat-lea-duolbmuid-du-mttuid-luodda?rq=Dat%20lea%20du%20olbmuid%2C%20du%20m%C3%A1ttuid%20luodda.
International Indigenous Peoples Forum on Climate Change. “Principles and Guidelines for Direct Access Funding for Indigenous Peoples’ Climate Action, Biodiversity Conservation and Fighting Desertification for a Sustainable Planet.” International Indigenous Peoples Forum on Climate Change (IIPFCC), 2022.
Inuit Circumpolar Council Alaska. “Inuit Food Security and Food Sovereignty.” Inuit Circumpolar Council Alaska, n.d. https://iccalaska.org/our-work/inuit-food-security-project/.
Ittelin, Torbjørn. “– Beitekrisa er en samfunnskrise.” Ságat, April 24, 2022. https://www.sagat.no/beitekrisa-er-en-samfunnskrise/19.32116.
Jaakkola, J.J.K, S. Juntunen, and K. Näkkäläjärvi. “The Holistic Effects of Climate Change on the Culture, Well-Being, and Health of the Saami, the Only Indigenous People in the European Union.” Current Environmental Health Reports 5, no. 4 (2018): 401–17. https://doi.org/10.1007/s40572-018-0211-2.
Jansson, Roland, Christer Nilsson, E. Carina Keskitalo, Vlasova Tatiana, Marja-Liisa Sutinen, Jon Moen, F Stuart Chapin III, et al. “Future Changes in the Supply of Goods and Services from Natural Ecosystems: Prospects for the European North.” Ecology and Society 20 (September 14, 2015): 32. https://doi.org/10.5751/ES-07607-200332.
Johnsen, K.I, T Schoolmeester, I.M Lillevoll, and G-B Retter. “Displaced by Plastics: A Conversation with Sámi Knowledge Holders about the Impacts of Plastics.” GRID-Arendal, Saami Council and NIVA, 2023.
Markkula, Inkeri, Minna Turunen, and Sirpa Rasmus. “A Review of Climate Change Impacts on the Ecosystem Services in the Saami Homeland in Finland.” Science of The Total Environment 692 (November 20, 2019): 1070–85. https://doi.org/10.1016/j.scitotenv.2019.07.272.
Mathiesen, Svein Disch. “Reindeer Husbandry in the Circumpolar North.” In Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, edited by Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, and Marina Tonkopeeva, 1–13. Cham: Springer International Publishing, 2023. https://doi.org/10.1007/978-3-031-17625-8_1.
Ministry of the Environment Finland. “New Climate Change Act into Force in July,” June 9, 2022. https://ym.fi/en/-/new-climate-change-act-into-force-in-july.
Näkkäläjärvi, K., S. Juntunen, and J.J. Jaakkola. “Cultural Perception and Adaptation to Climate Change among Reindeer Saami Communities in Finland.” In Climate Cultures in Europe and North America, 103–25. London: Routledge, 2022.
Nystad, Marie Elise, and Johan Ante Utsi. “Følte Seg Tvunget å Flytte Rein over Tynn Is.” NRK Sápmi, November 2, 2020. https://www.nrk.no/sapmi/abbora__a-reineiere-foler-at-de-ble-tvunget-a-flytte-over-tynn-is-1.15226177.
Pascual, Unai, Patricia Balvanera, Michael Christie, Brigitte Baptiste, David Gonzalez-Jimenez, Christopher Anderson, Simone Athayde, et al. IPBES 2022: Summary for Policymakers of the Methodological Assessment of the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2022. https://doi.org/10.5281/zenodo.6522392.
Permanent Participants of the Arctic Council. “OTTAWA TRADITIONAL KNOWLEDGE PRINCIPLES,” 2015. https://static1.squarespace.com/static/58b6de9e414fb54d6c50134e/t/5dd4097576d4226b2a894337/1574177142813/Ottawa_TK_Principles.pdf.
Pörtner, H.O, D.C Roberts, H. Adams, I. Adelekan, C. Adler, R. Adrian, P. Aldunce, et al. “IPCC, 2022: Technical Summary. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Cambridge, UK and New York, NY, USA: Intergovernmental Panel on Climate Change, 2022.
Rooij, Wilbert, Iulie Aslaksen, Isak Eira, Philip Burgess, and Per Garnåsjordet. “Loss of Reindeer Grazing Land in Finnmark, Norway, and Effects on Biodiversity: GLOBIO3 as Decision Support Tool at Arctic Local Level.” In Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, 223–54. Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-17625-8_9.
Saami Council. “Sápmi-EU Strategy,” 2022. https://www.saamicouncil.net/documentarchive/sapmi-eu-strategy.
Saami Council. “The Sámi Arctic Strategy: Securing Enduring Influence for the Sámi People in the Arctic through Partnerships, Education and Advocacy,” 2019. https://www.saamicouncil.net/documentarchive/the-smi-arctic-strategy-samisk-strategi-for-arktiske-saker-smi-rktala-igumuat.
Tonkopeeva, Marina, Robert W. Corell, Nancy G. Maynard, Ellen Inga Turi, Inger Marie Gaup Eira, Anders Oskal, and Svein Disch Mathiesen. “Framing Adaptation to Rapid Change in the Arctic.” In Reindeer Husbandry: Adaptation to the Changing Arctic, Volume 1, edited by Svein Disch Mathiesen, Inger Marie Gaup Eira, Ellen Inga Turi, Anders Oskal, Mikhail Pogodaev, and Marina Tonkopeeva, 15–35. Cham: Springer International Publishing, n.d. https://doi.org/10.1007/978-3-031-17625-8_2.
World Health Organization. “COP24 Special Report–Health & Climate Change,” 2018.