

Arctic Research Impact



Introduction

NordForsk has together with the national research funders in the Nordics financed four large Nordic Centres of Excellence on Arctic research. This report summarises the results from the centres. The number of publications, disseminations and other outcomes are impressive. The report also demonstrates that collaborations across the Nordics create great Nordic added value.

The Nordic Council of Ministers 2030 vision states that *The Nordic Region will become the most sustainable and integrated region in the world in 2030*. All Nordic countries are Arctic nations, and the 2030 vision cannot be met without a strong focus on sustainable development in the High North. Sustainable development requires production of new knowledge, and much of this new knowledge must come from research.

The effects of climate change are more visible than before the four Arctic centres started in 2016. Moreover, the geopolitical situation in the region has changed dramatically, and the international interest for presence, and extraction of resources, has increased significantly.

Research based on Nordic values addressing Nordic needs related to climate change, oceans, energy production, security, tourism, land and resource management, will help us secure a more sustainable future of the Arctic. However, sustainability will not be achieved without addressing the needs of the people living in the region, and we have a special obligation to involve and include the indigenous groups in the research process.

Pathways to Action in the Arctic

Responsible Development of the Arctic: Opportunities and Challenges - Pathways to Action was a collaborative effort between the Research Council of Norway, the Academy of Finland, the Swedish Research Council, the Icelandic Centre for Research, the Danish Ministry for Higher Education and Science, and NordForsk.

The Programme was initiated at a seminar during the last meeting of the International Polar Year in 2012 in Montreal, Canada. Participants were research funding organisations from the Nordic countries and Canada, and the US. After a preparatory phase, the NordForsk Board decided in 2013 to start a joint Nordic initiative. As a result, four Nordic Centres of Excellence (NCoEs) were funded by 30 MNOK each under the Programme in 2016.

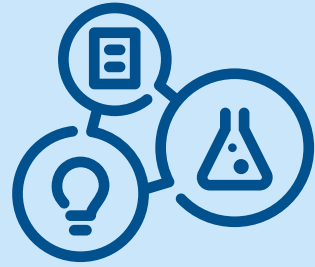
The Programme has produced integrative new knowledge of past and current change and projections for future change that informs the societal discourse on possible or desirable directions of change in the Arctic.

The initiative has developed and strengthened pathways to action in the Arctic by enhancing the knowledge base for political decision-making, education, and industrial and human development. The four Nordic Centres of Excellence have invited NGOs, local communities, public sector officials, educators and industrial actors to actively create new integrative knowledge for tangible actions and the common good.

The initiative has integrated research with monitoring and data collection on climate and the environment, social and economic statistics, education, and public health. In addition, it has supported the joint use of existing archives, scientific collections and other research infrastructures.

The impact report shows that the Nordic Centres of Excellence have a strong position in the Arctic research environments, well-developed networks with key players in the Arctic civil society and clear messages to political decision-makers to protect Arctic environments and inhabitants.

Key figures



173

Researchers



96

**Dissemination
Activities**



14

**Countries
and Regions**



4

**Nordic Centres
of Excellence in
Arctic research**



2 432

Publications



33

Policy influence

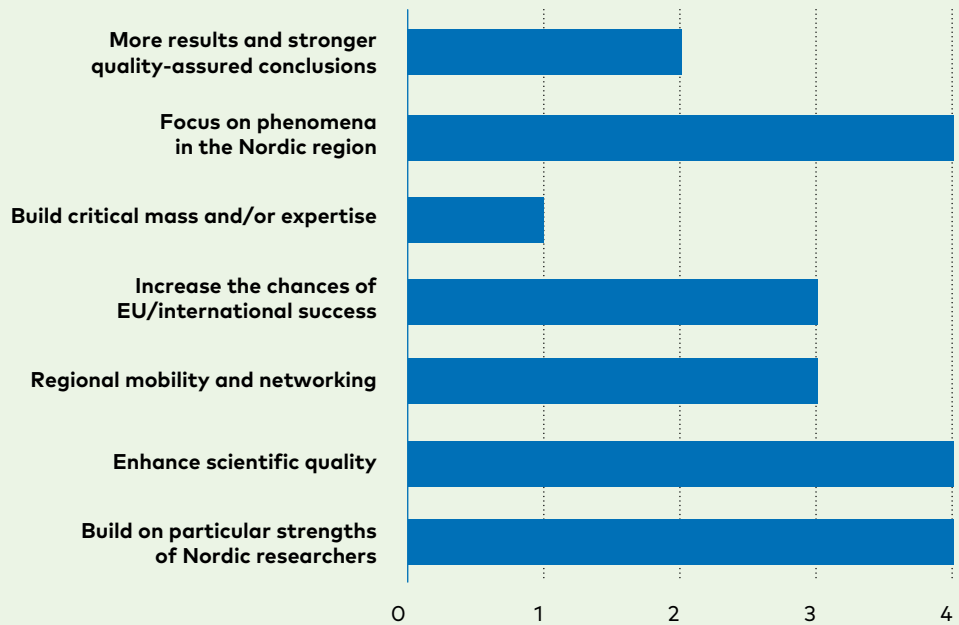
Nordic added value

NordForsk funded projects create Nordic added value in a number of ways. For example, by enhancing the scientific quality and building critical expertise at the Nordic level.

We have devised our own definition of Nordic added value to be used when developing programmes, designing calls for proposals, assessing grant applications and reporting impact.

Read more about Nordic added value at nordforsk.org.

Nordic added value in the four Nordic Centres of Excellence in Arctic research



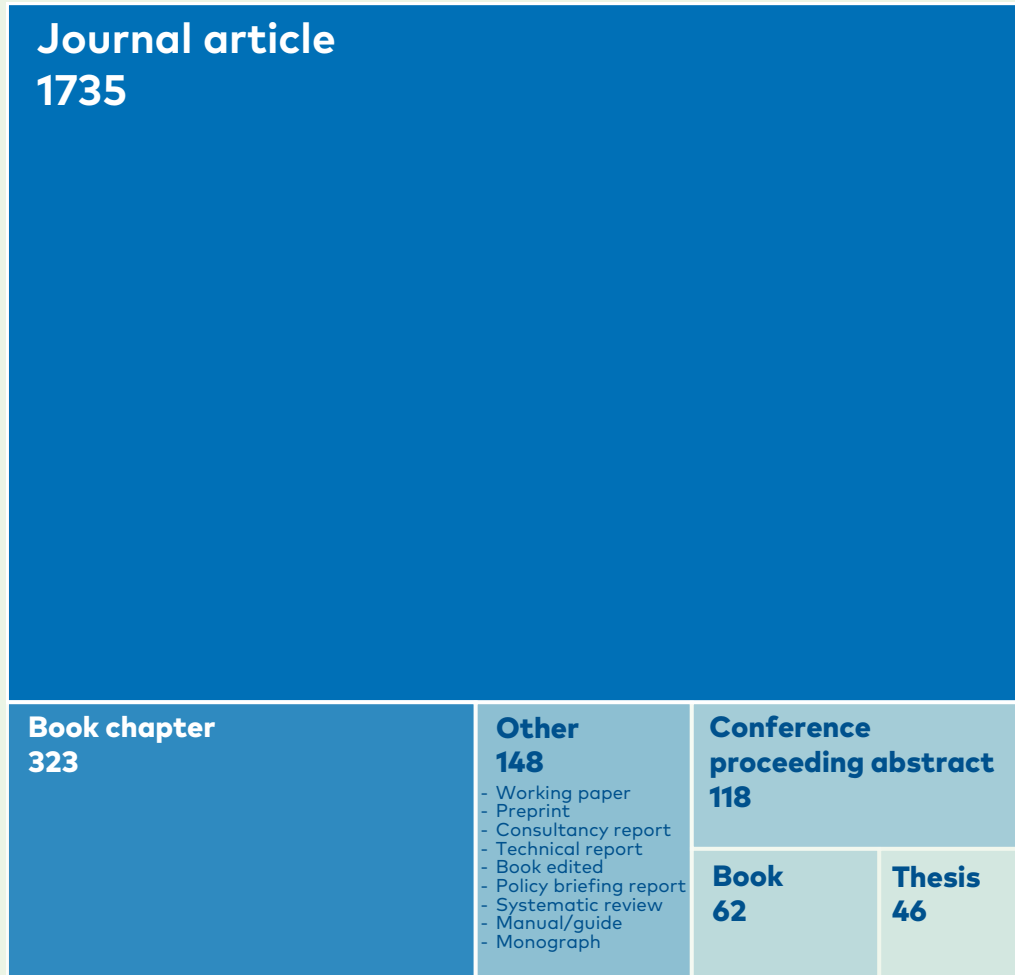
Total number of projects having reported Nordic added value: 4

Publications

Research outcome can be presented in various ways. Of the many different outcome types the funded NordForsk projects can register in Researchfish, publications are among the most commonly reported.

The researchers can choose among 16 different publication types, such as book chapters, monograph, technical reports and conference papers.

Number of Publications by Type



Policy influence

Influence on political processes and decisions is an important indicator of impact. Therefore, we ask the projects to report on policy influence, more specifically the amount and what kind of influence.

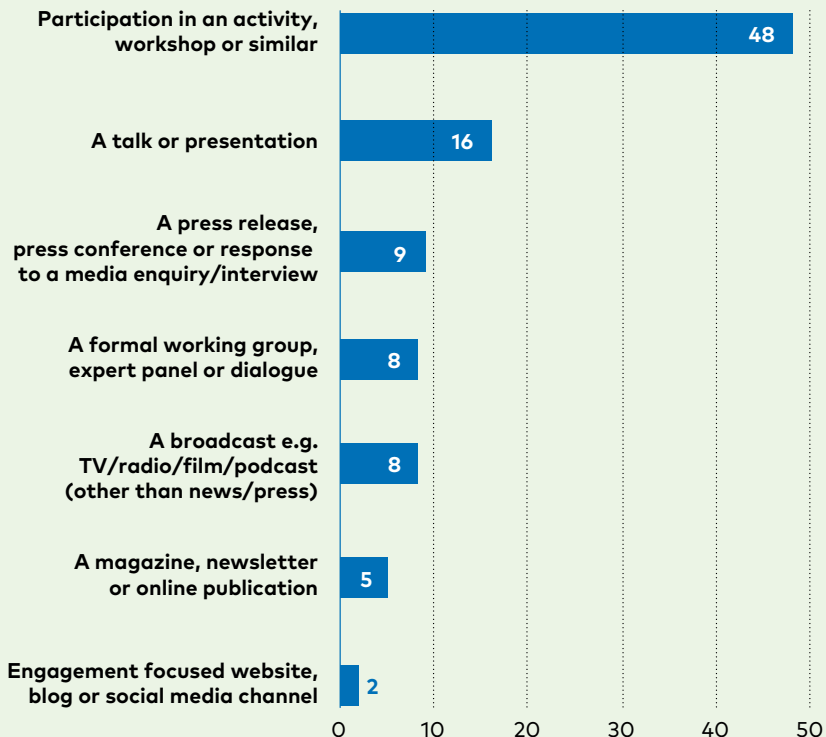
Policy Influence by Type

Influenced training of practitioners or researchers 16	
Contribution to new or improved professional practice 6	Gave evidence to a government review 6
	Other 5

Dissemination activities

Researchers must communicate beyond professional journals, books and other scientific publications. They must tell the public what they do, why, and what results they produce. Because communication can build support for and understanding of science. It can promote understanding of the wider relevance of research to society, and encourage more informed decision-making at all levels. At NordForsk, all projects must have a communication plan, and all projects must report on how they communicate. Here are the results.

Dissemination Activities by Type

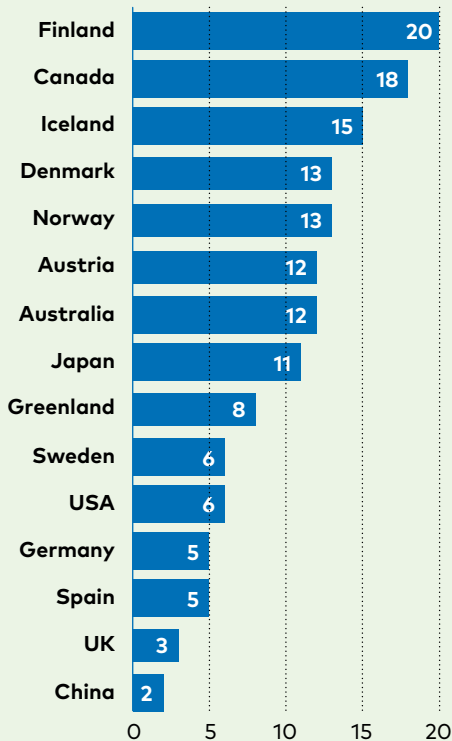


Mobility

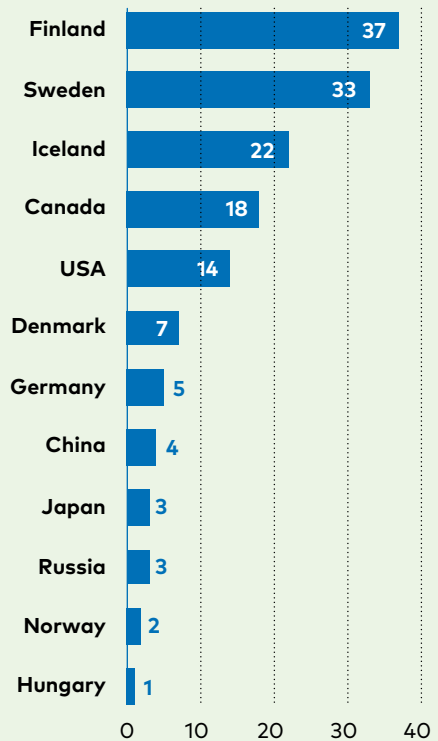
Researchers need a wide range of experience from working in different research environments to be able to increase their independence. By working in different kinds of research groups or in other research-related positions, researchers can further strengthen their personal networks and improve their chances of securing research positions or other expert tasks. For today's researchers, it is also important to be able to acquire new methodological skills and adopt new means of communicating with people with different backgrounds.

Here are the results of mobility between the partner countries in the Arctic programme.

Mobility to the partner countries (months)



Mobility from the partner countries (months)

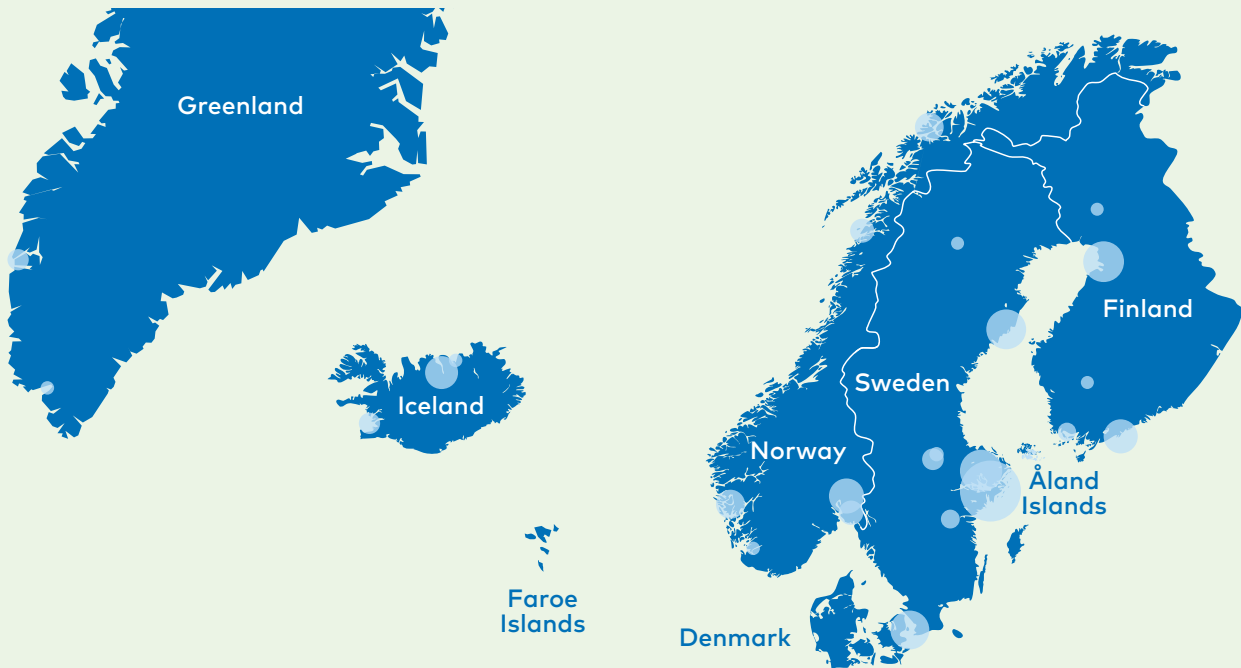


Arctic research by geography

One of the criteria for Nordic added value in research is 'regional mobility and networking among the Nordic countries'. A benchmark for assessing whether this succeeds is to look at the geographical location of the projects.

The map shows the location and number of participants in the Arctic research programme. The bigger the circle, the more project participants.

The programme has had a total of 173 participants. 150 from the Nordic region, the others from Australia, Canada, China, New Zealand, Russia, Scotland, the United Kingdom and the USA.



Key insights from the Nordic Centres of Excellence

Arctic Climate Predictions: Pathways to Resilient, Sustainable Societies (ARCPATH)

**Project Leader: François Counillon,
Nansen Environmental and Remote Sensing Center, Norway**

Project Co-Leader: Dr Astrid Ogilvie, Stefansson Arctic Institute, Iceland

Analyses of changes in both Arctic and global climate have formed a significant and highly successful component of ARCPATH. One major highlight is improved understanding of mechanisms of variability driving multidecadal climate variability in the Arctic. Historical observations have shown that Arctic climate has varied on multi-decadal timescales. The analysis of historical records of climate change, in particular the past sea-ice record for Iceland, in terms of correlation with the North Atlantic Oscillation (NAO) index and Atlantic and Pacific multi-decadal variability is a significant example of project synthesis. A related highlight is that it was possible to demonstrate that oceanic variations in both the Pacific and Atlantic contributed to these variations through changes in atmospheric and oceanic circulation, which influence the movement of warm air and water to high latitudes. In particular, it has been demonstrated that up to 50% of the warming during the 1940s may have been driven by changes in the Pacific. Furthermore, in contrast to previous work by others, our research has shown the importance of natural climate variability, as opposed to greenhouse gas warming and cooling caused by aerosol emissions.

A further related highlight is that ARCPATH has been able to provide improved ability to predict near-term variation of the Arctic climate and on spatial scales more relevant to society. Developments focused on the use of joint ocean and sea-ice data and advanced statistical schemes to enhance prediction skill. We were able to show that this led to better predictions of regional Arctic sea-ice on seasonal-to decadal-time scales. Our findings indicate that improving representation of oceanic processes is key to improving predictions in this region, and that ocean-atmosphere interaction and teleconnections act to shape Arctic regional climate change. This research serves to meet the demands of the societies and stakeholders in the ARCPATH focus region for a more nuanced picture of how rapidly their climate will shift up to 2030. An added highlight regarding this work is the EmblA project, also funded by NordForsk, which has built on the foundation of the data assimilation method used for the prediction system in ARCPATH.

The project has had a specific and integrative focus on marine changes in the Arctic, with particular regard to linkages between environmental changes and variations in cetacean populations and migrations and development of whale-watching tourism. Over the life of the project, social, economic and marine biological research and fieldwork has taken place in Iceland, Greenland and the seas around Norway and the Svalbard archipelago. A noteworthy project highlight is the overall success related to working with an interdisciplinary research team and combining different scientific approaches and theories to examine human-nature interactions. Outcomes of this approach are the highlights related to the project focus on ecosystem services (ES). The rich data collected for the project allowed this to expand from ES identification and valuation to information on governance and co-production. This work was greatly enhanced by interviews with different stakeholders and ES users and co-producers that revealed aspects of Arctic marine resource governance that would not have been known otherwise.

While focusing initially on whale ES, the concept was also applied to previously unexplored areas in this regard, such as glaciers, and volcanic areas. This work went beyond just classifying and valuing ES monetarily, but investigated how these important services are formed, governed, and

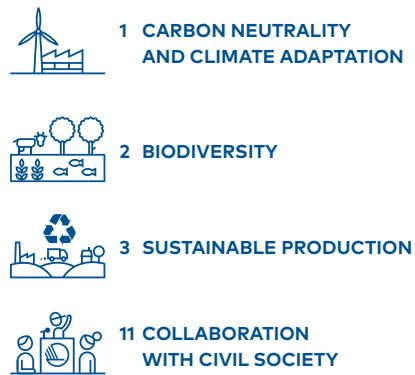
potentially affected by climate change in the future. A related highlight is that the data collected for this research extend beyond just ES resources, but also provide interesting information concerning the risks pertaining to, and resilience of, Arctic coastal communities and how they relate to their local marine ecosystems. Furthermore, it has been established that, taking into consideration different local cultural contexts, sophisticated ecosystem services assessments can be highly useful for evaluating multiple uses of marine mammals and provide informed policy advice.

ARCPATH contributes to:

The UN Sustainable Development Goals



The Nordic Council of Ministers' Objectives



Climate-change effects on the epidemiology of infectious diseases and the impacts on Northern societies (CLINF)

Project Coordinator: Birgitta Evengård, Umeå University, Sweden

Project Co-Coordinator: Tomas Thierfelder, Swedish University of Agricultural Sciences, Sweden

The rate and magnitude of climate change is greater in the northern regions than elsewhere in the world. What happens in the Arctic will have an impact on the rest of the world, but with feedback mechanisms from the southern regions as well. In a changing climate, ecological alterations will affect the geographical boundaries of microorganisms with the capacity to cause infectious disease in humans and animals. Most of such climate sensitive infections are zoonoses – transmitted between animals and humans. Important vector and reservoir animals such as ticks, badgers and roe deer are expanding their geographical distribution because of the direct and indirect effects of climate change as well as socio-economic changes such as management and policies.

Many northern societies depend on animal husbandry, such as sheep and reindeer herding, hunting, fishing and tourism for their livelihoods. Animals also play a central role in culture, art and world views. Therefore, these societies will have to deal with the challenges that climate change poses concerning health but also in the view of how to make their living and to their cultural values. The CLINF Nordic Centre of Excellence has addressed these threats by contributing valuable information on strategies for socio-economic development and viable communities in the North. Climate change impact on the health of both humans and animals had not been fully studied previously. In CLINF, thirteen multidisciplinary research teams from eight countries focused on health. They analysed health statistics, potential changes in climate, hydrology and landscape, as well as the associated migration of infectious diseases, risk perception, and societal cost; with adaptive capacity, gender effects and traditional knowledge as integrating factors.

CLINF investigated the effects of climate change on the prevalence of infectious diseases in humans and animals in the northern subpolar region, following the OneHealth concept. CLINF research covered the geographic area from western Greenland to Pacific Russia and set out to predict the impact that changed risks of infections may have on northern societies, their culture, and their economies.

The overall aim was to provide incentives for harmonised OneHealth strategies across the North. CLINF had two main objectives, i) to contribute to strategies for sustainable development, and ii) to contribute to the development of surveillance programs for selected infectious diseases. In collaboration with the existing network of Arctic Field Stations an early warning system for emerging infections at the local level was recommended for implementation throughout the North.

Ecological changes may preclude infections in animals and humans. CLINF enhanced the performance of regional Earth-process models of climate change effects in the environment, developed an adequate assessment of societal risk, and produced new map and data products of current and projected geographic spread of climate sensitive infections. These results are accessible for decision makers, scientists and the public and were disseminated in lay terms.

CLINF scientists aimed for an interpretation of nature so as to predict the conditions that may lead to outbreaks of climate sensitive infections, and thus support evidence-based policy aimed at preventing or mitigating their associated consequences. CLINF researchers focused on infections that are potentially climate sensitive. Human and animal disease surveillance data was meticulously gathered from national databases of the countries in the CLINF study region. It was surprising to see how differently the data is collated and registered. One of the first tangible outcomes from CLINF work was the recommendation for more standardisation in this area in order to facilitate cross-border comparisons of health statistics as basis for (international) strategies towards sustainable societal development in the North.

Using traditional knowledge, the CLINF team revealed that reindeer herders in Nenets and Sapmi possess a reservoir of precaution and adaptation possibilities that are relevant to counteracting climate change. A documented prevention strategy from the last two centuries for avoiding disease (mainly digital necrobacillosis) is to move the reindeer to unused grazing land in early

summer and to avoid staying too long on trampled and dirty grazing areas. Calf marking on snow patches or small glaciers is a part of this strategy. Narratives about disease prevention are still vital and seem to be incorporated in Sámi herders' cultural mentality: avoid unnecessary stress and do not keep the animals too close too long. Another finding from Sapmi and Nenetsk-Komi-Yamal was that outbreaks of anthrax and other climate sensitive infections occurred during or after periods with anomalous weather.

Supplementary feeding of reindeer emerges as an adaptation strategy but also increases risk of disease. CLINF scientists studied the proxies for such diseases and the adaptive capacity. The team chose to more deeply consider tularemia, one of the most studied diseases in high-latitude regions, that recently caused large epidemics and that is likely to be affected by regional hydro-climatic changes. CLINF's newly developed methods for quantification of such shifts showed that tularemia outbreaks appear to be highly sensitive to certain combinations of hydro-climatic characteristics. By using projected hydro-climatic output scenarios from several global climate models in combination with statistical tularemia models, possible future trends could be identified.

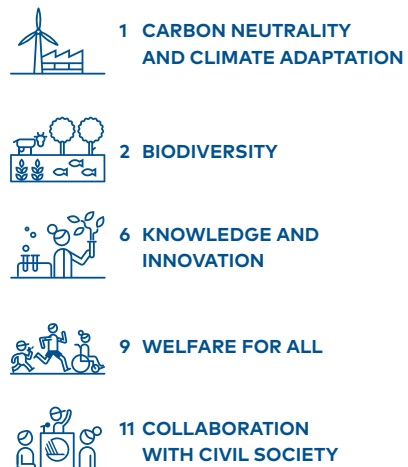
Internationally harmonized databases and forecasts like that for tularemia could lay the ground for policies aiming at keeping humans healthy and societies sustainable.

CLINF contributes to:

The UN Sustainable Development Goals



The Nordic Council of Ministers' Objectives



Reindeer husbandry in a Globalizing North – resilience, adaptations and pathways for actions (ReiGN)

**Project Leader: Øystein Holand,
Norwegian University of Life Sciences, Norway**

*ReiGN's overall aim is to contribute to a viable Fennoscandian reindeer pastoralism by contributing to a better understanding of how climate change and globalization affect this complex social-ecological system. Our comparative and synthetic approach alongside involvement of herders, have enabled us to: *identify important drivers and analyse their effects on the herders' livelihood within a Fennoscandian context.**

We have shed light on the emergence and spread of reindeer pastoralism in Fennoscandia ca. 400 – 500 years ago. The historical and cultural settings are reflected in the genetic structure of domestic reindeer in Fennoscandia. Top down governance and incentives and regulations by the different states in the 1960s transformed reindeer pastoralism into a meat production sector. In the last decades, a gradual shift in favor of Sámi herders' influence and rights has taken place. However, a goal mismatch between state governance on the one hand and reindeer herders on the other is clearly seen across all three countries. Our research shows that new and transparent governing models, fitted to reindeer herding-based understanding and functionality of the grazing land, are overdue.

We have identified how forestry and other land use forms contribute to the reduction and deterioration of pastures, especially the winter pastures. The observed trend of shrinking pastures in all three countries is caused by cumulative impacts in space and time. This is fueled by the surge for renewable energy and essential minerals to facilitate the 'green transition'. In combination with climate change, this reduction in available pastures will intensify the regional and local pressure on the remaining land. Climate change has thus a multiplier effect on the herders' rights to land and resources and their form of life. The herders need to cope with and adapt to

seasonal weather conditions and indirect impacts of climate change. Most notably, the herders point out that the increased frequency of rain on snow events severely deteriorates winter grazing conditions. These challenges have been the driving forces behind the increase in supplementary feeding and challenges the herders' visions for sustainable herding. In sum, we identified several pathways towards tipping point: a land-use, a climate change, and a governance-driven pathway, and the inter-dependence between them.

We have identified phenotypic plasticity of reindeer in response to climate. Indeed, we found no evidence for the much discussed mismatch between parturition time and the earlier emergence of spring. Instead, we found a directional and stabilizing selection towards a combination of earlier birth date and heavier birth mass. This indicates a process of adaptive evolution and advances the question if reindeer can adapt fast enough to maintain an optimal phenotype as the environment changes. Besides the processes of natural selection, we have contributed to the mapping of the reindeer genome and described potential avenues and information necessary for establishing functional breeding programs.

Varying herding conditions within and between Fennoscandia countries require different herd structures, slaughtering strategies, reindeer densities, feeding strategies and pasture use. In our bioeconomic research, we show how economic incentives may affect the herders' strategies in Finland, Sweden and Norway differently. Further expansion of the model including a multifunctional forestry model indicates that continuous cover forestry, which better preserves winter pastures, yielded optimal solutions rather than clear felling, also in terms of carbon storage. Adapting to predation pressure includes increasing the size of the reindeer winter population and changing the slaughtering age of males towards young adults but implies high costs.

We have identified the need for revitalization of reindeer herders' customary institutions and their traditional knowledge in resource management and land use planning to increase the resilience of the system. Cooperation between herders in different herding groups (*siidas*) suggests that perceived norms allow network structures to emerge and be maintained. Reindeer herd size is important to buffer against adverse conditions as well as unforeseen events. However, comparative studies have shown regional differences in risk management strategies, probably because of different external and internal resource competition.

The unforeseen outbreak of Chronic Wasting Disease (CWD) in wild reindeer populations in southern Norway was met with great concerns. Our finding of increased risk in reindeer carrying certain alleles to develop CWD has been applied in breeding experiments for reduced CWD susceptibility.

Our work has resulted not only in new scientific knowledge about main challenges faced by reindeer pastoralism – it also helped us to increase collaboration with the reindeer herding communities and to generate best knowledge. Indeed, the integration of reindeer herders' knowledge in cumulative impacts assessments is essential to understand ecosystem vulnerability. This has contributed to a policy-relevant knowledgebase of adaptation strategies in reindeer pastoralism.

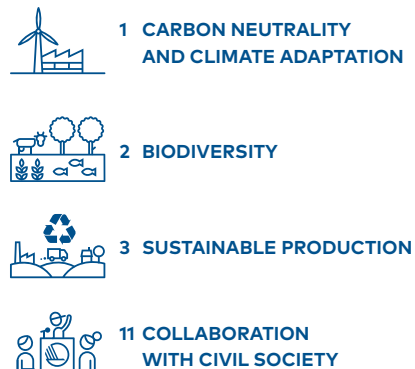
The book *"Reindeer Husbandry and Global Environmental Change – Pastoralism in Fennoscandia"* summarizes much of our findings. We demonstrate how reindeer husbandry is affected by aforementioned challenges. These challenges are often connected with each other. Indeed, an overall picture is required to understand reindeer husbandry as a socio-ecological system. The book offers a holistic understanding of the environmental and societal challenges that affect reindeer husbandry in Fennoscandia and highlights viable pathways to maintaining reindeer husbandry for the future. Thus, having a strong forward-looking perspective. The book is freely available on the publisher's [Routledge website](#).

ReiGN contributes to:

The UN Sustainable Development Goals



The Nordic Council of Ministers' Objectives



Resource Extraction and Sustainable Arctic Communities (REXSAC)

Co-Director: Dag Avango, Luleå University of Technology and KTH, Sweden

Co-Director: Gunhild Rosqvist, Stockholm University, Sweden

Extractive industries are entwined in social processes that link expectations of global actors with national and local expectations related to sustainable development. Different notions of sustainability play an important role, including different emphasis on economic, environmental and social dimensions. For companies and state actors, economic dimensions often play a central role. Environmental dimensions are increasingly highlighted as central motivations for extraction, particularly in relation to the green transformation with demands for metals for electrification and renewable energy. While corporate actors in mining emphasize their work to comply with environmental legislation and procedures, including precautions beyond legal requirements, environmental dimensions are also framed as a hindrance to development. In our studies of environmental impact assessments, it has become clear that the environmental focus is often limited to issues that are regulated by law, including EU directives, while other aspects receive limited attention. Moreover, there is a lack of attention to multiple pressures on the landscape and other users of the space for planned mines, including the impacts of climate change.

Extractive industries make up large systems of linked technological, societal and environmental components stretching over vast geographies and long timespans. REXSAC has also defined them as socioecological-technological systems. Increasing resource interests in the Arctic together with the legacies of systems constructed in the past and the impacts of climate change result in multiple pressures on some communities and environments in the region.

REXSAC research highlights how reindeer herding is squeezed from multiple pressures from different new land uses, including expanded mining and wind power, that fragment the landscape, together with shifting weather and snow conditions in the wake of climate change.

Current processes for assessing potential impacts of mining are often not considered legitimate and there have been calls for more holistic approaches. REXSAC has addressed this need by developing an analytical framework to be used in the context of co-producing knowledge about the place in which mining is planned together with a wide range of actors and knowledge holders, with the aim of better understanding the local/regional social-ecological-technological system and how it might develop over time, with or without the proposed mine. REXSAC research, in Greenland as well as in Arctic Sweden, Norway and Finland, also shows how different interests and ontologies affect how mining is seen. For some it is an agent of hope, while for others it is the destroyer of their livelihood.

As assessments of impacts from individual industrial projects tend to focus on the local environment, cumulative effects on the larger land- and seascape level are therefore often missed. Therefore, cumulative effects often remain overlooked in land use planning and natural resource management despite their potential severity. We note that effects of climate change are not yet incorporated in impact assessments in a satisfactory manner. We argue that cumulative environmental and social impacts should be assessed and evaluated in the early stages of decision-making regarding new extractive industries, to meet environmental and social development goals. Improvement is urgent as the demand is now increasing rapidly for further extraction of minerals and for production of renewable energy driven by the 'green' transition.

REXSAC has analyzed the role of mining legacies in settlements and regions that have been subject to mine closures and socio-economic transformation, and have identified different processes in which mining legacies are transformed into new roles, affecting posterity environmentally as well as socially. These are environmental remediation, re-economization, re-purposing and heritage making. There are remains from hundreds of mining sites

and their associated systems in the Arctic that never been subject to any research on their environmental impacts, nor any attempts to deal with them. Multidisciplinary case studies of REXSAC have revealed that environmental legacies of past extraction still impact local environments and consequently local livelihoods dependent on those environments in the Nordic Arctic. A related conclusion from REXSAC's research is that the development, success or failure of environmental remediation efforts are not solely dependent on technology and soil treatment. Environmental remediation always takes place in societal contexts, where complexities in institutional frameworks as well as the interests of actors and power relations between actors, heavily influence the outcomes of remediation efforts. Moreover, current institutions and practices for environmental remediation are not making use of the potential for new value making in post-mining transformations of landscapes and built environments. Neither do they pay sufficient attention to the perspectives of communities who live near and use the lands affected by past mining operations.

REXSAC's research has shown that post-extraction value making is possible in a wide variety of ways – with former settlements and infrastructures for mining gaining new functions within new economic or other everyday activities of Arctic communities. Where state policies and legislation provide the means and actors are interested, former mining systems are often re-defined as cultural heritage – corporate heritage, official heritage or unofficial heritage. In this respect, mining legacies can be transformed in ways that can support quality of living, support national and/or regional cultural policies or corporate interests. As heritage, mining legacies have also played a role as tools for political mobilization against colonialism and new resource extraction.

REXSAC has analyzed sustainability as different discourses. This approach provides a useful tool for understanding the conflicts between sustainability goals and related conflicts over land use, and how this can affect the Nordic Arctic in coming years. These conflicts already manifest themselves in protests against new mining ventures but also in social tensions between those who may benefit from extractive industries because of job opportunities and potential incomes, and those whose livelihoods may suffer because they lose out in the competition for land. Those livelihoods are often connected to

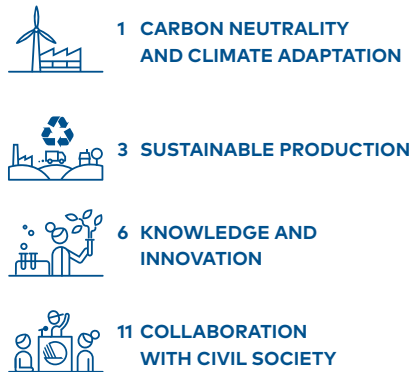
local identities, including Indigenous cultures and national minorities, where REXSAC research has shown how rights and perspectives from different groups have been disregarded in decisions about new mining ventures. REXSAC has used participatory scenario methods to engage local actors in envisioning possible futures in the context of a rapidly changing and uncertain global development. This work has informed an analysis of the regional implementation of the SDGs.

REXSAC contributes to:

The UN Sustainable Development Goals



The Nordic Council of Ministers' Objectives





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