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1. Executive summary

This report has been authored by the task force of Arctic Hubs WP2 at NORCE, in connection with ArcticHubs WP2: Assessment of Environmental Impacts. This delivery report will serve as the groundwork for further work packages in ArtcticHubs that focus on strategies and adaptive measures within the Arctic region.

The D2.3 delivery report titled "Changes in the Arctic Environment as Result of Hub Activity" examines the shifts occurring in the Artic environment and its ecosystem services due to the influence of five distinct activities: forestry, aquaculture, tourism, mining, and indigenous activities. The report contains eighteen different hubs, and they are characterized as interconnected nodes, linked through geographical, infrastructural, economic networks, and flow of people, goods, capital, and power dynamics. They are situated across the Arctic region in Norway, Sweden, Finland, Greenland, Iceland, and the Faroe Island, alongside learning hubs in Canada, Austria, and Italy. An important point is that several of the different hub activities are co-located with each other in the same hub.

While the Arctic environment experiences a greater impact from climate change compared to other regions, this report aims to focus on environmental changes due to hub activities. The report addresses issues such as habitat fragmentation, loss of biodiversity and geodiversity and pollution from hub activities. Moreover, it highlights the interplay between different hub activities and how they potentially intensify local conflicts.

Further, D2.3 is organized into five chapters, covering introduction, methods, concepts, overview, and compilation of the environmental impacts of hub activities in the Arctic region. **Chapter two** provides methodological reflections. Each hub has been responsible for data collection, with varying background knowledge and focus areas influencing the collected data. In conclusion, this report is a compilation of desk research conducted by the Arctic Hubs partners (hub coordinators). This report serves as a groundwork and handbook for forthcoming work packages that employ additional, complementary co-production methodologies with local communities and stakeholders. All in all, this report compiles data material from eighteen different hubs. The data is based on a variety of sources: scientific articles, research reports, national databases, company and consultancy reports, homepages from various kinds of organisations, plans, strategies, environmental permission documents and process documents for political or administrative use, case assessments, newspaper articles and other media articles.

Chapter three serves as an introduction to fundamental concepts essential for categorizing environmental shifts and standardizing terminology that may vary across various disciplines. This conceptual toolbox is presented to establish Arctic Hubs as a multidisciplinary endeavor fostering knowledge co-production across different fields. Despite their widespread application, these concepts

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serve as a standard framework to facilitate collaborative production within the hub project's diverse array of actors. In WP2, part of the focus has been on fostering internal co-production through dialogues, workshops, seminars, and webinars, while subsequent work packages outline plans for co-production activities with local communities and stakeholders.

In Chapter four, a more detailed background is provided on the primary activities central to the Arctic Hubs project, namely forestry, aquaculture, tourism, mining, and indigenous activities.

Last, **Chapter five** delves deeper into the various hubs, each structured around six key themes: 1. State of the art, 2. Environmental Impacts, 3. Conflicts with other activities, 4. Mitigation strategies, 5. Ambitions, and 6. Perceptions. This chapter consolidates actual environmental transformations resulting from hub activities.

There are a total of six hubs engaged in **forestry activities**, with five situated in the Arctic region, and one learning hub located in Austria. Within the Arctic, two hubs are located in Finland (Kemi and Kemijärvi), while three are situated in Sweden (Gällivare, Jokkmokk, and Malå). The primary focus of the Arctic hubs is the interaction between forestry practices and reindeer husbandry, particularly examining how industrial forestry methods can impact lichens. Lichens play a crucial role in Arctic hubs. They are essential for maintaining multifunctional forests and providing winter forage for reindeer. Forestry activities in the Arctic Hubs have led to the decline of old, open pine-dominated forests, giving way to dense forests that primarily support mosses at the expense of lichens. Additionally, the forestry industry is linked to increased infrastructural development, including road construction, heightened traffic, and habitat fragmentation. In terms of mitigation, both the Finish and Swedish hubs point out the need for an inclusion of thinning techniques and the need for improved participatory dialogue between reindeer husbandry and forestry.

The project encompasses five **fish farming** hubs, distributed as follows: two in Norway (Varangerfjord and Egersund), one in Iceland, one in the Faroe Islands, and an additional learning hub in Canada. Across all Arctic hubs involved in aquaculture, there is a shared environmental apprehension, particularly concerning the escape of farmed fish and the transmission of diseases to wild fish populations. Moreover, there are concerns regarding chemical waste and its impact on the biotic fauna. Additionally, aquaculture activities in the various hubs present several potential conflict zones, including conflicts with mining, indigenous interests, recreational and traditional fishing, and tourism.

There are a total of eight hubs with **tourism activities** as listed in the report, six of which are situated within the Arctic region. Specifically, these hubs are in Norway (Svalbard, Egersund and Varangerfjord), the Westfjord in Iceland, Suðuroy in the Faroe Islands, and Inari in Finland, along with the learning hub Alagna in Italy. Tourism, being an activity, both impacting and impacted by the environment, is predominately driven by the allure of nature. However, the rapid growth in tourism traffic has led to

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environmental disturbances such as erosion, trampling of vegetation, and infrastructure development, which has several impacts on the local environment and wildlife. Of particular concern in several hubs, is the pollution and disturbance of marine water caused by cruise traffic. Additionally, common environmental impacts associated with tourism across all locations include the general carbon footprint of travel, primarily due to greenhouse gas emissions resulting from tourists traveling long distances to visit the Arctic Environment.

The report lists eight **mining hubs**, situated in Finland (Kittalä), Sweden (Malå and Gällivare), and Norway (Varangerfjord, Kvalsund-Kautokeino, Svalbard and Egersund), along with a learning hub in Italy (Germanasca Valley). These mining hubs often overlap with indigenous, forestry, and fish farming activities, particularly in Norway. Mining activities result in significant environmental changes, including water and soil pollution, habitat destruction, impacts on fish habitats, plastic waste accumulation, and heavy metal contamination. Mining activities lead to increased traffic and infrastructure development, which can further impact ecosystem services and reindeer herding, and mining is often in conflict with recreational activities, indigenous interests, environmental interests, and fishing. The primary environmental impact of mining is associated with the deposit of mine tailings, whether on land or in the sea. Additionally, the storage or release of mine wastewater, the development of mine infrastructure, and increased traffic are notable consequences. The leaching and spreading of dust from mine tailings can adversely affect vegetation by hindering photosynthetic processes. Moreover, vegetation removal and loss of habitats, including reindeer grazing lands, occur because of clearing paths for mining industries and related infrastructure.

There are four hubs encompassing **indigenous interests and activities**, situated in Finland (Inari), Sweden (Gran Sameby), Norway (Kvalsund-Kautokeino), and Greenland (Nuup Kangerlua). The hubs are predominantly characterized by traditional Sami reindeer husbandry, with the exception of the Greenlandic hub. Indigenous communities share common challenges, notably the fragmentation of traditional areas by new infrastructure and habitat loss due to various activities such as mining, wind parks, and tourism ventures like husky sledging and snowmobiling, alongside associated tourism infrastructure development. However, indigenous activities also influence the surrounding environment: reindeer husbandry impacts vegetation, predator control, and the increased use of motorized vehicles can leave traces. Reindeer grazing behaviors have multiple effects on boreal forests, including selective grazing, trampling, and fertilization. However, in Swedish cases, reindeer are acknowledged for their positive impact on biodiversity, as they help maintain open landscapes. Moreover, indigenous interests may clash with activities such as mining, certain forms of tourism, and forestry, highlighting potential conflict zones.

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2. Introduction

This document (D2.3) has been prepared by the task force of ArcticHubs WP2 at NORCE in October-December 2022, and in January-April, 2024 (Revised version) , related to ArcticHubs WP2: Assessment of environmental impacts.

The ArcticHubs WP2 has already delivered the following documents:

D2.1 Plan for further data acquisition and analysis for selected hubs: identification of knowledge gaps (dated 30/09/2021)
D2.2 Compilation of existing data on environmental impact of economic activities in the Arctic (dated Feb 22, 2022)

This delivery D2.3 provides a detailed overview about the environmental changes in the Arctic Environment as a result of hub industrial activities. Here, this report focuses on the five key industries that are highlighted by the ArcticHubs project: forestry, aquaculture, tourism, mining, and indigenous industries. This report is a compilation of desk research conducted in cooperation with the ArcticHubs partners (hub coordinators) from eighteen different hubs. This report serves as a groundwork for forthcoming work packages of the ArcticHubs that employ additional, complementary co-production methodologies with local communities and stakeholders.

Tromso & Alta

April 29, 2024

Helge Flick, Jukka Teräs, Astrid Cabrera, May-Britt Ellingsen (WP2 Task Force at NORCE)

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3. Methodology

Data sources and compiling of data

This compiled report is primarily based on desk research conducted in close cooperation with the Arctic Hubs partners (hubs coordinators). The coordinators have undertaken the responsibility for the data production process for their respective hubs, and subsequently provided it to NORCE. All in all, this report compiles data material from eighteen different hubs. It is important to note that we have not generated or directly gathered the data; rather, we have compiled it. The data is based on a variety of sources: scientific articles, research reports, national databases, company and consultancy reports, homepages from various kinds of organisations, plans, strategies, environmental permission documents and process documents for political or administrative use, case assessments, newspaper articles and other media articles. Other work packages of the Arctic Hubs project are more oriented towards the involvement of local community members and stakeholders e.g. through interviews.

In compiling this report, we acknowledge the significance of acting in a sensitive way towards the intricate power dynamics and complexities within communities, also involving indigenous stakeholders and activities. It is essential to recognize that hub coordinators, responsible for data collection and provision for this report, often possess extensive experience and knowledge concerning indigenous actors and activities within their respective hubs. Some of the coordinators originate from or are embedded in indigenous networks and communities and are well informed about the indigenous actors and activities in their respective hubs. The inclusion of data on or related to indigenous hubs was an integral aspect of the data collection process of the hub coordinators.

Further, the data provided to us from the different hub coordinators predominantly derives from desk research drawing upon statistics and data from institutional and organizational sources like municipality documents, data from destination companies, research articles and media articles. In this context, challenges arise e.g. related to dividing hub communities into "binary" categories of indigenous people and non-indigenous people, as articulated by some hub coordinators. This is relevant e.g. regarding to what degree indigenous voices are being heard and to what degree indigenous sources are represented. For instance, in Greenland, individuals residing there for approximately six months are considered Greenlandic, encompassing those with indigenous backgrounds and long-term residents, including Danes. Thus, the binary classification of indigenous and non-indigenous proves problematic, particularly when sourcing data from institutional and organizational channels as there are for example both "Danes" and indigenous people working in municipalities, media and in other institutions. Similarly, in Swedish hubs, information from indigenous sources, are in some cases developed within research settings, reflecting a coexistence of individuals

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with mixed heritage over and extended period. Further, in discussing these matters with different hub coordinators, another point has been highly addressed – the local community is diverse. "There is no single indigenous voice, and indigenous reveals the existence of "multiple axes of differentiation" (Agrawal and Gibson, 1999, s. 631). [3]

Nevertheless, we acknowledge the complexity and power dynamics within communities engaged in indigenous interests and activities. We have therefore included additional, extensive dialogues with hub coordinators in early 2024 in connection with the ArcticHubs reports D2.3 and D2.5. The additional dialogue work has functioned as complementary, value-added process, involving both the compiling and systematization of data, as well as ongoing dialogue where we have addressed e.g. questions including those related to indigenous sources. We have actively involved all participating hubs in reviewing and supplementing the collected hub specific data, as well to commemt on the key concepts and definitions use in our ArcticHubs study of compilation of data. . Specifically, we have solicited alternative perspectives on the concepts introduced in chapter, ranging from biodiversity, ecosystem services to climate change.

This report has been produced in cooperation and dialogue with the hub coordinators, also regarding indigenous groups. It is important to underline, however, that this D2.3 report primarily relies on desk research, and the subsequent work packages WP3-WP5 of the ArcticHubs focus more on fieldwork, interviews, and collaborative field work methods including also indigenous actors across diverse hub communities. Nonetheless, this report is not produced in isolation; rather, it is informed by insights shared by hub coordinators regarding indigenous groups.

The list of key concepts introduced in chapter 3 encompasses methodological and theoretical notions alongside key themes relevant to the WP2 of the ArcticHubs, like biodiversity and ecosystem dynamics. We have proactively asked input from the hub coordinators to explore alternative perspectives or additional concepts, too, that might better align with the local communities regarding the key concepts.

While primarily intended for intra-hub co-production, this report is rooted in extensive collaboration across various hub coordinators and actors with diverse backgrounds, disciplines, and geographical origins. In WP2 of the ArcticHubs, part of the focus has been on fostering internal co-production

3

Agrawal, A., & Gibson, C. C. (1999). Enchantment and disenchantment: the role of community in natural resource conservation. *World development*, *27*(4), 629-649.

ISO 690

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through dialogues, workshops, seminars, and webinars, while subsequent work packages outline plans for co-production activities with local communities and stakeholders. This report, a product of ongoing dialogue with hub coordinators who, in turn, engage with actors and stakeholders within their respective hubs, serves as a compilation of hub-specific data, laying the groundwork for forthcoming work packages, which in turn provide additional co-production methodologies, direct engagement and interviews.

Language plays a crucial role in fostering inclusion or potentially excluding diverse voices and viewpoints in the Arctic communities, too. The information received from various hub coordinators is predominantly in English, while many of the source documents which they rely on are in languages other than English. To address this issue, we extended an invitation to all participating hubs to submit documents in languages other than English where relevant. Additionally, we have followed up with each hub to ensure that they are aware of the option to incorporate non-Enligsh document into their submissions, too.

Guidelines for data collection were used and discussed with the partners in several meetings wit the hub representatives, with examples made available. The main elements in the guidelines are presented below and the guidelines for data collection, called *Arctic Hubs Task 2.1* is attached in Annex 1.

It is important to note that the degree to which the hubs have used the data collection guidelines varies. This variation has resulted in some discrepancies in the material provided to us. While some data are quite comprehensive, other data lack information of specific activities within the hubs. These disparities are due to different resources available at hubs for data collection, originating from variation in background knowledge, national legislation, degrees of environmental monitoring , and also due to differences in the focus, experience and major interest of respective hub coordinators. Some coordinators have largely focused on collecting data within their own scope of interest and expertise. Consequently, the data collected from certain hubs only partially cover information about environmental impacts within the respective hubs. To address these challenges, we have actively engaged the relevant hubs through joint webinars, hub-specific workshops, and physical meetings, aiming to gain further insights into specific themes. As a preparation for D2.6, group interviews were conducted through webinars and physical meetings with Greenland and Sweden, and with the learning cases in Italy. In parallel, while working on the Arctic Hubs WP2 DPSIR framework part, we have gained valuable additional insights from the hub coordinators to include in this report.

The WP 2 Team has compiled and analysed the data in three major categories: *Environmental Impact, Ambitions and Perceptions.*

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Environmental impact, as the main compilation of data*,* is based on scientific articles, research reports and national databases/statistics - i.e. data which is quality assured either through scientific review or as official statistics. We regard this as reliable data quantifying environmental impact. In addition, data from company reports and consultancy reports has been used where relevant, to complement the ub-specific data.

Plans, strategies, permissions, and process documents for political or administrative use and case assessments on respective hubs have been compiled as one category of documents, called *Ambitions.* Newspaper articles and other media articles are labelled as *Perceptions*. These two groups of documents are compiled first and foremost as examples of *expressions of ambitions* and *of perceptions of environmental impact.* While *Ambitions* and *Perceptions* are not in the major focus of WP2, they provide relevant input e.g. for the ArcticHubs DPSIR model, and thus have relevance for WP 3 work. Moreover, they can indicate needs for additional data to be collected. *Ambitions* relate to future possible impacts and *Perceptions* provide an opportunity to consider whether there are major differences in the *measured environmental impact* and *the perceived impact.* It is important to note that only some hubs have collected data on Ambitions and Perceptions – these data are not necessarily available for every hub.

The collected data originates from open, publicly available sources. Data available in national/native languages have been taken into account based on supply of the hubs. The vast majority of the compiled data is, however, form sources in English.

The data collection guide for D2.3

The objective of this delivery, according to 2.1 in the Annex B, project description, is:

Assessment of environmental impact: identify and quantify the effects of economic activities on the Arctic environment and its ecosystem services, including e.g., natural habitat fractionation, loss of biodiversity and geodiversity, changes in food supply, or pollution.

The analysis of changes in the Arctic terrestrial and marine environments as result of existing economic activities is based on data provided by the hubs. According to the ArcticHubs project partners, a hub serves as the local expert, and the organisations that proposed the hubs (hub coordinators) are responsible for collecting the data. The hubs are being asked to collect available **local** data on the environmental impact for their hub. In addition, any information on **regional**, **national,** or even

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international datasets that may be relevant in WP2 **is** highly appreciated. We are looking for as much as possible **quantitative data** to document actual change.

The hubs are asked to collect data based on a detailed data collection guide provided by the WP2 leader. The following subchapter presents the main elements of the data collection guide and our principles for selecting data, compiling and analyses of data, especially for D2.3. The additional guidance is necessary because it has turned out that due to the wide range of hubs across the Arctic area, there is significant variation in national legislation, environmental monitoring and research efforts, and background of the responsible hub coordinators, causing variation in both the level of details and type of the collected data.

Data collection for D2.3: Key principles and type of data requested

According to the data collection guide, the hubs should **collect data on actual and potential environmental impact in each industrial hub, based on existing data, documents, maps and/or literature, to gain understanding of:**

- spatial extent of impact
- changes in landcover, land use
- impact on marine and terrestrial animal populations
- impact on biodiversity, geodiversity
- impact on water/air/soil/sound quality

Scoping

- *Background information*: description of the activity (aquaculture, mining, multiple use forestry, tourism, indigenous), location, ownership, spatial extent, size and scale of activity, history of the activity, waste production/pollution, environmental permits, infrastructure development, resource needs (quantity, spatial extent)
- *Local/regional environment information:* environment type, ecosystem services, bio/geodiversity, natural values/level of protection, environmental quality
- *Environmental impact*: change in landcover/land use, pollution, threat to populations, habitat fractionation, impact on ecosystem services
- Conflicts with other activities or use of natural resources

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- Assess what data is lacking and would be needed to better determine current and future environmental impact. Are you planning to collect new data or conduct further investigation regarding environmental impact?

While collecting data, the hubs are asked to pay attention to **definitions**, as they are important for data comparison and to report the units, scale, extent, date of analysis etc. They are also requested to **report data sources**, including if the data is public/private and to provide references to reports, publications, databases, websites etc.

Baseline profiling shall be based on assessing (a) the background, (b) environment description, and (c) environmental impacts. The data that is available and relevant will vary for each hub activity and location, but the following four questions can be used to guide the data collection:

1. What is the current and (expected) future environmental impact of the activity?

- Has the activity changed the land use/land cover in the area? How and to what spatial extent?
- Does the activity release contaminants into the terrestrial or marine environment? How much and over what time period? What is the effect, known or potential, of this on the environment, e.g. on health of vegetation and fauna, biodiversity.
- Does the activity change the biodiversity or geodiversity in the area? How and to what extent?
- Does the activity affect migration or grazing/feeding patterns? E.g., as result of habitat fractionation, noise, or other disturbances.
- Does the activity affect any protected areas, plants or animals, or areas with recognised value (landscape, biodiversity, endangered species or ecosystem, conservation value)?

2. How does this environmental impact affect other activities?

- Does the activity change the ecosystem services, such as food availability, biodiversity?
- Does the activity disturb other uses of the area?

3. What map-based information is available that may be used in a PPGIS tool to help inform or interview people?

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- Changes in land cover and land use
- Changes in migration patterns and use
- Local and regional environmental change, change in biodiversity, natural or conservation value

Types of data

The guide also suggests types of data, including maps, that may be available and possible data sources the hub coordinators can collect**:**

- *Quantitative data on discharge, use of natural resources*: company reports, discharge permits and reports, consultancy reports.
- *Land use/land cover change*: environmental impact assessments, local development plans (local/regional council), national databases and natural resource inventories (national environmental agencies, forest inventory)
- *Changes in water/air/soil quality*: consultancy reports, company reports
- *Impact on animal populations, migration/feeding patterns*: consultancy reports, research publications
- *Long term effect of discharge, biodiversity, CO2 release:* research publications
- *Loss of biodiversity, habitat fractionation:* regional or national landcover/land use maps, historical maps from local/regional councils, national and international databases

Examples of possible available data sources:

- Environmental impact assessments often provide a good overview of most expected impacts of a planned activity.
- Company reports may include quantitative information on discharge, use of resources, landcover change, planning.
- Discharge permits and reports
- Local development plans, planning permissions from local or regional councils
- Consultancy reports. This could be reports on e.g., detailed vegetation mapping, water/soil contamination monitoring, animal populations and health.
- Research reports and publications.
- Maps and databases from National Environmental Agencies
- Water/soil/air quality data
- Natural resource inventories, e.g., forest inventory, protected area database (maps).

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- Statistical data
- Land cover maps and changes over time, e.g., CORINE landcover datasets, national vegetation maps
- Fish stock data and quality

The data collection guide provides detailed suggestions for data collection and the recommendations enable a systematic data acquisition as far as possible.

Different types of data: examples

The data provided by the hub coordinators includes variations as some hubs are very extensively mapped whereas others have delivered less data. If no environmental impact assessment is required, there can be little data on this. There is variation regarding topics that are covered by the hubs, for instance consequences for reindeer herding are being described in many articles, while other potential environmental consequences are not covered. Some hubs and topics have been comprehensively examined in scientific literature whereas some other hubs are less included in the scientific literature. The compilation by WP2 reflects this variation.

The data collected for the indigenous hubs consists dominantly of scientific research papers investigating different types of environmental impact from local industrial activities and transport infrastructure on the indigenous lifestyle, what measures can be taken to reduce these impacts and improve co-existence of industrial activities and indigenous lifestyle, and the environmental impact of indigenous activities. Other data includes national databases which contain a wealth of historical and current information on landcover/land use and changes in the past decades, reindeer husbandry and statistical information of various activities, newspaper articles and an application for whale protection.

For the industrial activities mining, forestry and fish farming, much data is available from environmental impact assessments and environmental monitoring in relation to permit/license requirements. In addition, there is a significant number of scientific research papers that have studied different aspects of environmental impact. There are often different opinons about the actual environmental impact and the consequences to other users, and the quality of environmental impact assessment is therefore often questioned. The main reasons include that 1. local and indigenous communities are not always properly represented, and 2. Planning processes can take many years and

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early assessments become outdated. These issues will be important to take into account in the further analyses that will be carried out in WP2.

Tourism hubs are affected by the environmental impact of industrial activities. The tourism hubs cause, however, environmental impacts themselves as well, particularly in terms of carbon footprint of travel, disturbance of wildlife, trampling of vegetation and the impacts of infrastructure and litter. Much of the available data here is based on statistical data, planning documents and management strategies, but particularly in some hubs: E.g. Svalbard, there exists extensive scientific data on the various impacts of tourism, and the data collected gives a good overview of the many different aspects of environmental impact from tourism and mitigation possibilities.

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4. Concepts

Arctic Hubs is a multidisciplinary project which aims at co-production of knowledge across disciplines. Co-production of knowledge makes it necessary to clarify concepts and terms as different thematic areas have and use their own language and concepts. In social science, there can be different understandings of a concept; many concepts are contested and some words/concepts can be used both as a scientific concept and as an everyday term. In this chapter, we briefly present how we understand and use key concepts (some of them referred to in Annex 1, part A, page 14-15) in the compilation and analyse of data of this study.

Ambition

Ambition is an everyday word and one of the categories we use in the compiling of the non-research-based data delivered from the hubs. Ambitions in this study are not the same as plans, but rather visions, aims or ideas of future state or actions.

Biodiversity

We follow the Oxford Languages dictionary definition of biodiversity as the variety of plant and animal life in the world or in a particular habitat, a high level of which is usually considered to be important and desirable.[4]

Change

Change is an everyday word which is used as a verb - *to change* – that is to make a difference, or as noun – *a change* - a shift form one state to another. Much of the compiled data describes change from one environmental state to another.

DPSIR

DPSIR is an analytical framework focusing on Driver-Pressure-State-Impact-Response elements. According to FAO/UN[5], “the Driver-Pressure-State-Impact-Response (DPSIR) Framework provides a structure within which to present the indicators needed to enable feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future. The DPSIR framework assumes a chain of causal links starting with ‘driving forces’ (economic sectors, human activities) through ‘pressures’ (emissions, waste) to ‘states’ (physical, chemical and biological) and ‘impacts’ on ecosystems, human health and functions, eventually leading to political

[4] https://languages.oup.com/google-dictionary-en/

[5] https://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1026561/

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‘responses’ (prioritisation, target setting, indicators). Establishing a DPSIR framework for a particular setting is a complex task as all the various cause-effect relationships must be carefully described and environmental changes can rarely be attributed to a single cause”. The DPSIR framework is used in D2.3 especially to fit into the DPSIR analysis in Task D2.5, reported in D2.5 report.

Ecosystem services

Ecosystem services are outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare.[6] Ecosystem services can be regarded as an attempt to calculate benefits provided by nature and ecosystem services analyses promote policy decisions that recognize the full range of benefits and costs associated with actions that affect those services. Two criteria distinguish ecosystem services from other ecosystem conditions or processes. First, an ecosystem service must be linked to an identifiable set of human beneficiaries. The service can be an aspect or consequence of an ecological condition and can directly or indirectly benefit or profit the beneficiaries. Second, physical and institutional access constraints must not prevent people from realizing those benefits.[7]

Environment

Environment in this study context refers to “the complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.[8]

Impact

Impact is an everyday word, used as verb – *to impact* – to create an effect, and as noun – *an impact* - an effect. Here, the word Impact is mostly used to describe the effects an industry has forced on nature.

Hub

Hub is an everyday word with several meanings. One of them is “a center of activity”.[9] This fits well into the concept Arctic Hub. Each hub is a centre for one or more industrial activities that affects the nature of its vicinity.

Habitat fragmentation

[6] https://www.britannica.com/science/ecosystem-services
[7] https://www.britannica.com/science/ecosystem-services
[8] https://www.merriam-webster.com/dictionary/environment
[9] https://www.merriam-webster.com/dictionary/hub

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Habitat fragmentation describes the emergence of discontinuities (fragmentation) in an organism's preferred environment (habitat), causing population fragmentation and ecosystem decay. Causes of habitat fragmentation include geological processes that slowly alter the layout of the physical environment (suspected of being one of the major causes of speciation) and human activity such as land conversion, which can alter the environment much faster and causes the extinction of many species. More specifically, habitat fragmentation is a process by which large and contiguous habitats get divided into smaller, isolated patches of habitats.[10] Fragmentation of habitat is relevant for understanding one of the challenges the reindeer industry face when other industries expand geographically.

Perceptions

Perceptions concept is here used as an everyday word, meaning how something is regarded, understood, or interpreted.

Pollution

Pollution is an everyday word meaning 'matter out of place'. According to Oxford Languages dictionary, it is the presence in or introduction into the environment of a substance which has harmful or poisonous effects.[11] Here, pollution is used mainly about harmful substances for mining and aquaculture industries.

[10] https://en.wikipedia.org/wiki/Habitat_fragmentation

[11] https://www.google.com/search?q=what+means+pollution&rlz=1C1GCEB_enNO953NO954&oq=what+means+pollution&aqs=chrome..69i57j0i22i30l5j0i15i22i30l2j0i22i30j0i15i22i30.7376j1j1&sourceid=chrome&ie=UTF-8

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5. ArcticHubs and specific industries: an overview

In this chapter, an overview of the specific sectors most relevant to the ArcticHubs project is being presented. As described in the ArcticHubs Annex 1 Project Document (Part A summary & Part B 1.3 Concept & Methodology), the ArcticHubs project will develop sustainable solutions for reconciliation of competing livelihoods and land-use modes in key Arctic 'hubs'—important socioeconomic nodes in a geographical network—and their surroundings, considering in particular the needs and cultures of local communities (incl. indigenous people). This will be achieved by applying multi- and interdisciplinary, multi-actor participatory approaches to systematically map, identify and analyse global drivers and pressures with high environmental, societal and economic impacts affecting 33 key hubs examining sustainability of **fish farming, multiple use of forests, tourism, mining and indigenous cultures** (map of hubs, see Annex (table 2) in the end of this chapter).

The Hubs are places or areas that act as socio-cultural, economic and industrial nodes that are interconnected via a geographical, infrastructural and economic network. They are typically focussed in historically important areas that have formed organically or were strategically planned, according to flows of people, goods, capital, information, organisational activities and power relations. As well as being a relatively densely populated area, each hub also lies at the heart of vast tracts of sparsely populated land with different land-use modes.

The project will analyse important Arctic hubs that have grown or are currently growing around specific industries, such as forestry, tourism, mining or fish farming, and their relationships to the surrounding regions. The hubs included here have been carefully selected by project partners as focal places for the industries and activities where global and local dimensions meet, and in many cases cause conflicts. In many of these hubs partners have also previous experience and research results that can be used also in ArcticHubs. Some of the selected hubs host one key industry, whereas others have increased complexity due to a combination of industries (e.g. mining and tourism in close proximity), whilst all have relationships with more traditional livelihoods (e.g. reindeer herding) and other land-use modes (e.g. nature conservation). Furthermore, indigenous territories are cultural hubs, in which it is important that the identity, culture and sense of belonging of native communities are strengthened and maintained whilst the area adapts to new economic activities.

In this chapter, we introduce the key specific industries for the ArcticHubs: Forestry, aquaculture, tourism, mining. In addition, we provide an introduction to Indigenous territories from the viewpoint of ArcticHubs approach. The key industries and hubs are presented in table 1. The chapter acts as an orientation to the following chapter describing in more detail the compilation and analysis of data related to the selected Arctic hubs and the industries.

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Table 1. Respective hubs and associated industries

Hub/ Industry	Forestry	Aquaculture/ Fish farming	Tourism	Mining	Indigenous
Kemi (FI)	x				
Kemijärvi (FI)	x				
Inari (FI)			x		x
Kittilä (FI)			x	x	
Jokkmokk (SE)	x				x
Malå (SE)	x			x	x
Gällivare (SE)	x			x	x
Varangerfjord (NO)		x	x	x	
Egersund (NO)		x	x	x	
Svalbard (NO)			x	x	
Kautokeino (NO)				x	x
Westfjords (ISL)		x	x		
Suðuroy (FAROE)		x	x		
Nuuk (Greenland)			x		x
Mariensee (Austria)	x				
Alagna Valsesia (ITA)			x		
Germanasca (ITA)				x	

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5.1. Forestry

Forestry in Arctic Hubs

Forestry hubs in Arctic Hubs:

Finland: - Kemi

- Kemijärvi

Sweden: - Jokkmokk

- Malå

- Gällivare

Austria: - Mariensee

General overview:

ArcticHubs includes forestry hubs in Finland, Sweden, and two learning hubs in Austria. The forestry hubs in Sweden are co-located with indigenous and mining hubs, but for the forestry hubs in Finland,and Austria, forestry and related industries (pulpmill) are the main activities that will be studied in these locations. In Sweden, the main focus is on the impact of forestry on reindeer husbandry and the indigenous culture as forestry activities over the last 70 years have changed the original open pine forests with abundant lichens to dense managed monoculture forests that favor mosses. This has consequences for reindeer food supplies and migration. In Finland, the main focus is on the planning of new large pulp mills and the forestry activities needed to supply these. Discharges to water and air from the pulp mills have a negative environmental impact, but the produced bioenergy, on the other hand, reduces greenhouse gas emissions. In Austria, the main focus is on the interaction between forestry and tourism and reducing damage to forest stands. General for all locations is the need for sustainable forestry practices to protect biodiversity and improve conditions for other users, for example in Sweden and Finland by implementing reindeer adjusted forestry methods.

Main environmental impacts of forestry:

- Forestry encompasses the science, business, and art of nurturing, managing, and conserving forests and their resources in sustainable manner to achieve specific goals, fulfil needs, and uphold values (IUFRO, 2000)[12]. In simple terms, it involves taking care of forests in a way that ensures they thrive while meeting human needs and preserving their ecological balance.

[12] IUFRO 2000. Terminology of forest management. IUFRO World Series, volume 9, ed. M. Nieuwenhuis. Vienna: IUFRO Secretariat.

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Sustainable forestry, as emphasized by Oliver (2003) [13], seeks to ensure that every ecosystem contributes its fair share of benefits without exploiting itself or compromising the ability to other ecosystems to provide value. Further, Helms (2002) [14],specify that there are multiple and diverse meanings of forestry, and thar forestry is intertwined with both societal and professional practices. Forestry is not a straightforward concept, as it is related to sometimes contested practices. In this report, forestry refers to forest management practices and the conflicts and possibilities associated with them.

- Risk for unsustainable forestry as the demand for wood resources increases
- Impact on habitat of protected species
- Loss of lichen pasture in winter grazing areas for reindeer
- Loss of old growth forests which provided lichen resources and shade for the reindeer during hot summers
- Habitat destruction, loss and fragmentation. Habitat destruction, as concluded by Tilman et al. (1994) [15],refers to the irreversible loss of competitive species due to prolonged or delayed effects of following habitat destruction, potentially leading to extinction. The European Environment Agency (EEA) underlies that habitat destruction results from increased land pressure due to rapid human population growth, pollution, and over-exploitation (2004)[16]. It manifests in various forms, including the loss of wild species' habitats, degradation through vegetation removal and erosion, and fragmentation, which confines native species to small patches of undisturbed land surrounded by which confines native species to small patches of undisturbed land surrounded by cleared areas for agriculture and other purposes. Human advance on natural habitats, especially in forested environments, disrupts original communities of flora and fauna, contributing significantly to biodiversity loss (Ceballos et al., 2015[17]; Vergara-Tabares, 2020)[18].Given the high dependence of many species to forests, the connection between forestry and habitat loss is particularly pronounced.

Main environmental impacts of pulp mills:

- Increase in water temperature in sea/rivers due to discharge of cooling water

[13] Oliver, C. D. (2003). Sustainable forestry: What is it? How do we achieve it?. *Journal of Forestry*, *101*(5), 8-14.
[14] Helms, J. A. (2002). Forest, forestry, forester: What do these terms mean?. *Journal of Forestry*, *100*(8), 15-19.
[15] Tilman, D. 1994. Competition and biodiversity in spatially structured habitats. Ecology 75:2-16.
[16] **EEA(2004)** **https://www.eea.europa.eu/help/glossary/eea-glossary/habitat-destruction**

[17] Ceballos, G., Ehrlich, P. R., Barnosky, A. D., García, A., Pringle, R. M., & Palmer, T. M. (2015). Accelerated modern human-induced species losses: Entering the sixth mass extinction. Science Advances, 1(5), e1400253. https://doi.org/10.1126/sciadv.1400253
[18] Vergara-Tabares, D. L., Cordier, J. M., Landi, M. A., Olah, G., & Nori, J. (2020). Global trends of habitat destruction and consequences for parrot conservation. *Global Change Biology*, *26*(8), 4251-4262.

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- Eutrophication and water pollution due to discharge of wastewater containing P, N, AOX and metals
- Emissions to atmosphere (SO_2, NO_x, TRS and particles)
- Reduction of greenhouse gas emissions (bioenergy will replace use of fossil fuels)
- New infrastructure development and increase in traffic
- Habitat destruction due to infrastructure development. Infrastructural development involves the planning, constructions, and maintenance of physical structures and systems to support societal functions and economic growth. In the context of provided, it encompassed the establishment of roads, buildings, and other facilities, which often result habitat fragmentation, impacting local and landscapes. Infrastructural development can pose challenges to biodiversity and traditional migration routes. Infrastructure related to forestry, mining, tourism, and aquaculture activity can disturb local wildlife with new railroads, buildings, setting ponds ect.).
- Impact on fish from cooling/waste waters from pulp mill
- Local impact on landscape by clearing river banks and shore lines
- Increase in noise levels, particularly during construction

Interaction/conflicts/possible conflicts with other activities:

- Increase in water temperature due to discharge from pulp mills affects local commercial and recreational winter fishing and recreational activities due to deterioration of ice conditions
- Conflicts with reindeer husbandry, mainly due to loss of food supplies (lichen) for reindeer which affects animal health and migration behaviour
- Impacts of tourism on forestry: damage to forest stands by cross country skiers, litter, disturbance of wildlife, habitat destruction for trails and ski lifts.

Environmental impact assessments and monitoring programs:

Environmental impact assessments are required for wood pulp mills.

5.2. Aquaculture /Fish farming

Aquaculture Hubs

Norway: - Varangerfjord

- Egersund

Iceland: - Westfjords

Faroe Islands: - Suðuroy

General summary:

ArcticHubs includes fish farming hubs in three northern European countries, Norway, Iceland and Faroe Islands. The European fish farming hubs are all co-located with tourism hubs, and both Varangerfjord and Egersund also with mining hubs. A major part of the focus of environmental impact is therefore on the consequences of the environmental impact of one activity on other activities in the area.

Fish farming is well established in Norway and the Faroe Islands, while in Iceland, salmon farming has been rapidly increasing since 2010 (Young et al., 2019). The Faroe Islands has the largest production of farmed fish per capita in the world and all of the suitable habitats are occupied by fish farms (Young et al., 2019). The Varangerfjord, Egersund, Westfjords and Suðuroy hubs are comparable in size: they produce a similar quantity of biomass salmon in sea cages, 10-25 k tons; the production of freshwater smolt (land-based production) varies between 3-8 million (the operation of smolt production on Suðuroy is expected to start in 2023). Egersund also has 2 lake-based trout production facilities producing 1000-1500 ton trout per year.

Environmental conditions that can affect the production in the Westfjords include: presence of land and sea ice can damage sea cages; local strong ocean currents help degradation of organic waste and oxygen flow, winter weather can cause road closures, problems with feeding and escapees. In Norway, extreme weather events are a major cause for escapees.

Other activities include commercial fishing, recreational fishing and tourism in Varangerfjord, Egersund, Suðuroy and Westfjords, while wild salmon river fishing is an important activity in Varangerfjord and Westfjords. Seabed mining in Westfjords does not cause any conflict with fish farming, but fjord deposits from iron mining activities in Kirkenes has affected the water quality to some extent and affected commercial and recreational fishing.

The main environmental impacts of fish farming are similar in all locations and are summarised below. The impact on wild salmon (genetic mixing, diseases etc.) is mainly an issue in the hubs with wild salmon rivers, Varangerfjord and Westfjords.

Main environmental impacts:

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- Transfer of diseases and pathogens to wild fish populations
- Impact of biological and chemical waste on benthic fauna
- Escapes: genetic mixing with wild fish populations
- Transfer of diseases and pathogens to other marine species (lobster, shrimp, whelk)
- Impact of excess feed, nutrients on wild fish behaviour
- Plastic waste
- Heavy metal pollution (Cu)
- Habitat use

Other environmental impacts include:

- Sound pollution from boats and trucks
- Air pollution by boats (oil) and trucks (diesel)
- Visual impacts related to aquaculture as well as mining and tourism alter the aesthetics of natural landscapes and habitats. These changes can evoke emotional responses from both local communities and visitors (Maehr et al. 2015)[19].Changes due to intensified hub activities can sometimes lead to the transformation of pristine environments. Like fish farming activities often involve the installation of aquaculture cages, pens, and processing facilities in costal waters which can visually intrude upon the marine landscape.

Interaction/conflicts/possible conflicts with other activities:

- *Commercial fisheries*: cod, haddock, lobster, whelk, shrimp. Impact on shrimp stocks and cod spawning areas. Possible negative impact on lobster, whelk and fish quality. Spatial separation between fish farming and commercial fisheries to limit conflicts.
- *Indigenous fishing:* Coastal indigenous fishing has close economic, social, and cultural linkages with marine ecosystems that are vital for their cultural heritage. Like other small-scale fisheries, they are vulnerable to environmental changes (ISSF)[20]. Indigenous fishing together with recreational and traditional fishing, often intersect with burgeoning industry, like fish farming, but also mining and tourism development, leading to potential conflicts over resource allocation, environmental impacts, and cultural heritage.
- *Recreational fishing*: impact on wild salmon river fishing from parasite infection and genetic mixing with escapees.
- *Tourism*: minor impact, mainly visual and sound.

[19] Maehr, A. M., Watts, G. R., Hanratty, J., & Talmi, D. (2015). Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape. Landscape and urban Planning, 142, 71-79.
[20] http://toobigtoignore.net/research-cluster/indigenous-marine-fisheries/

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- *Sea bed mining*: sea bed mining of calcareous algae sediments in Westfjords creates no conflicts with fish farming
- *Mining*: Impact of suspended sediments from fjord deposits from iron mining (Kirkenes)

5.3. Tourism

Tourism hubs

Finland:	- Inari
	- Kittilä
Norway:	- Varangerfjord
	- Egersund
	- Svalbard
Iceland:	- Westfjords
Faroe Islands:	- Suðuroy
Greenland:	- Nuuk
Italy:	- Alagna Valsesia

General summary:

ArcticHubs includes tourism hubs in northern European countries, and a learning hub in Italy. Several of the tourism hubs are co-located with fish farming activities, mining, and indigenous activities. Tourism is well established in the Finnish hubs and in Svalbard, but is still being developed in Egersund, Nuuk, Suðuroy and the Westfjords.

Tourism has an impact on the environment and can affect other natural resource users in the same area; however, tourism is also affected by the environmental impact of other activities in the area, particularly mining and fish farming. General environmental impacts caused by tourism that occur in all locations include the general carbon footprint of travel (greenhouse gas emissions) as tourists tend to travel far to visit these Arctic locations. Also, the disturbance of Arctic wildlife, trampling of vegetation, the impact of waste and litter, and the consequences of infrastructure development are

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common to all tourism hubs. On the other hand, the interactions and conflicts with other activities and natural resource users (e.g. mining) are more specific for each hub.

Main environmental impacts:

- Waste production, litter, from transport, cruise ships and accommodation
- Plastic waste
- Oil spills from cruise ships
- Trampling of natural vegetation, erosion: Increased tourism activities can lead to trampling and erosion, particularly in fragile ecosystems and popular natural attractions (Aall, 2014[21]; Gossling, 2002[22]). The influx of visitors, coupled with the construction of infrastructure like trails and viewing platforms, can put immense pressure on the land, leading to soil compaction, vegetation damage, and loss of biodiversity. Trampling not only degrade the aesthetic value of the landscape but also disrupt vital ecological processes.
- Animal disturbance (reindeer herding, arctic wildlife): Tourism activities can disturb wildlife by encroaching on their habitats, causing disruptions to feeding breeding, and migration patterns. Noise pollution, habitat fragmentation, and direct interactions with tourists can stress animals and affect their behaviour, potentially leading to reduced reproductive success and population declines.
- Infrastructure development, roads, buildings, skilifts – habitat fractionation/destruction, landscape changes
- Carbon footprint travel to/from tourist destinations
- Introduction of invasive species (particularly Svalbard)
- Water and energy consumption

Other environmental impacts include:

- Sound pollution from boats (jet skis) and snow scooters
- Air pollution by transport (boats, vehicles, snow scooters)
- Visual impact infrastructure in pristine nature

Interaction/conflicts/possible conflicts with other activities:

[21] Aall, C. (2014). Sustainable tourism in practice: Promoting or perverting the quest for a sustainable development? *Sustainability*, *6*(5), 2562-2583.

[22] Gössling, S. (2002). Global environmental consequences of tourism. *Global environmental change*, *12*(4), 283-302.

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- Conflicts with agricultural sector (extensive sheep farming on Suðuroy) and nature conservationists regarding access to nature
- Possible conflicts with other users of natural resources e.g. mining
- Conflicts with reindeer herders, particularly from dogsledding tourism (Inari)
- Conflicts between tourism operators and local hunters in Nuuk regarding humpback whales
- Nature conservation: nature reserves/protected areas attract tourists causing trampling, erosion, littering (Vestfjords)

5.4. Mining

Mining Hubs

Finland:	- Kittilä
Norway:	- Kautokeino-Kvalsund
	- Varanger
	- Svalbard
	- Egersund
Sweden:	- Malå/ Kristineberg
	- Gällivare
Italy:	- Germanasca

General summary:

ArcticHubs includes mining hubs in Finland, Sweden, Norway, and 1 learning hub in Italy. Varangerfjord and Egersund in Norway are co-located with both fish farming and tourism hubs. Kittilä and Svalbard are all co-located with tourism hubs, and Kautokeino-Kvalsund, Kristineberg/Malå and Gällivare in Norway and Sweden are co-located with indigenous hubs. Both Swedish mining hubs are also co-located with forestry hubs. Large amounts of data are available in most of the mining hubs: planning documents and environmental impact assessments both done by the mining companies as well as by other stakeholders in the area highlight the differences in viewpoints on environmental impact by the different stakeholders that can and do create conflicts. The quality of environmental impact assessments carried out by the mining industry itself is questioned more and more. In addition,

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there is a large number of scientific research papers investigating different types of environmental impact of mining activities and related infrastructure and the consequences on indigenous lifestyle and other activities, such as fishing or tourism. Other data includes national databases which contain a wealth of historical and current information on landcover/land use and changes in the past decades, statistical information of various activities, and many newspaper articles.

Main environmental impacts:

- Waste production: land deposits
    - Acid mine drainage (iron/copper sulfide mines) – pollution of water ways and soils: acidification and heavy metal pollution
    - Habitat destruction and fragmentation
- Waste production: sea/fjord deposit (specific for mines in Norway)
    - Habitat destruction
    - Spreading of submarine tailings
    - Impact on water quality, suspended sediments, heavy metal contamination
    - Impact on marine fish populations and spawning areas
    - Plastic waste
    - Impact on salmon populations in National Salmon fjord and river
- Waste: discharge of flocculation chemicals to sea/fjord
    - Toxicity: Impact on marine fish, bottom fauna: Mining activities can introduce toxic substaances into the environment, posing significant risks to ecosystem, wildlife, and human health. The extraction, processing, and disposal of minerales can release pollutants such as heavy metals, acids, and chemicals into soil, water, and air.
    - Long distance transport of heavy metals by aerosols
    - Accumulation of heavy metals with increasing trophic level
    - Hunting: reindeer and ptarmigan were hunted for food by early mining communities on Svalbard, and polar bears were shot for safety
    - Traffic: wildlife disturbance
    - Traffic: disturbance reindeer herding
    - Infrastructure development, roads, buildings – habitat fractionation/destruction, landscape changes.
    - Impact on vegetation: several plant species are threatened by mining related infrastructure, particularly in the high Arctic tundra environment of Svalbard
    - Impact on biodiversity, e.g. marine, bird populations
    - Carbon footprint transport and contribution to global warming by selling coal internationally

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- Water use: change in water table
- Air pollution: dust, particularly from landfill sites causes health issues and affects local agriculture

Other environmental impacts include:

- Noise pollution
- Visual impact infrastructure

Interaction/conflicts/possible conflicts with other activities:

- Impact on tourism and recreational activities (infrastructure, landscape changes, noise)
- Conflicts with reindeer herders, impact on migration route and calving/grazing areas
- Conflicts with recreational and commercial fishing due to sea/fjord deposit and possible effect on water quality and fish populations and behaviour (specific for Norway)
- Impact on National Salmon Fjord/River status

5.5. Indigenous hubs

Finland: - Inari

Norway: - Kvalsund-Kautokeino

Greenland: - Nuuk

Sweden: - Gran Sameby (Gällivare, Jokkmokk, Malå)

General summary:

ArcticHubs includes indigenous hubs in Finland, Sweden, Norway and Greenland. The indigenous hubs in Sweden and Norway are co-located with mining hubs, and in Sweden also with forestry hubs, while the indigenous hubs in Finland and Greenland are co-located with tourism hubs. The data collected for the indigenous hubs consists dominantly of scientific research papers investigating different types of environmental impact from local industrial activities and transport infrastructure on the indigenous lifestyle, what measures can be taken to reduce these impacts and improve co-existence of industrial activities and indigenous lifestyle, and the environmental impact of indigenous activities. Other data includes national databases which contain a wealth of historical and current information on landcover/land use and changes in the past decades, reindeer husbandry and statistical information of various activities, newspaper articles and an application for whale protection.

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The indigenous hubs in Finland, Sweden and Norway are all characterized by traditional Sami reindeer husbandry. Reindeer husbandry is affected by the environmental impacts of industrial activities in the area as these activities impact the grazing lands and migration routes for the reindeer. Areas that were traditionally used become more fractionated by transport infrastructure (roads, railways, powerlines), habitats are lost as result of mining activities (e.g. large open pit mines and land deposits in Sweden), food supplies are diminished as result of forestry practices (old growth forests with lichens are replaced by more dense managed forests with mosses), and reindeer are disturbed by tourist activities (e.g. snow scooters) and windmill parks. The combined effect of these environmental impacts from nearby industrial activities also limits the reindeers' ability to adapt to the effects of climate change. On the other hand, reindeer husbandry has an impact on the environment itself as well: overgrazing has had an impact on the Arctic vegetation, predator control affects predator populations, and there is an increase in off road motorized traffic and vehicle tracks in wilderness areas. The indigenous hub in Greenland is characterized by Inuit hunting and fishing. Here, tourism activities can disturb Arctic wildlife and traditional whale hunting, and proposed mining activities are expected to disturb reindeer and Inuit hunting.

Different mitigation efforts are in place or are being investigated to reduce environmental impact and conflicts with indigenous hubs, such as the development of more sustainable forestry management practices (lean forestry, promoting lichen growth), rehabilitation of abandoned mining and forestry areas and a reduction of mining activities at certain seasons to reduce disturbance of reindeer.

Main environmental impacts affecting indigenous lifestyle/activities:

- Disturbance of reindeer by tourism activities, e.g. snow scooter tracks
- Disturbance by mining activities:
  - Industrial noise and rock blasting
  - Spreading of dust reduces reindeer's ability to find lichen
  - Runoff from mining areas impacts water quality
  - Habitat loss and habitat fractionation
- Habitat fractionation/loss by infrastructure development
  - Roads, railway lines
  - Mining activities
  - Wind power
- Impact of forestry activities on reindeer husbandry:
  - pasture degradation, loss of lichen pasture
  - need for supplemental feeding
  - loss of cool shade forests for cooling and insect avoidance

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- Impact of tourism on indigenous whale hunting in Greenland
- Impact of proposed mining activities on indigenous hunting in Greenland
- Climate change

Main environmental impacts by indigenous activities:

- Impact of grazing on Arctic vegetation, e.g. overgrazing
- Increase in off road motorised traffic – vehicle tracks
- Predator control

Interaction/ conflicts/possible between indigenous hubs and nearby industrial activities

- Mining activities, existing and planned/proposed
- Some tourism activities (snow scooters, cruise boats)
- Wind power
- Forestry
- Infrastructure development (e.g. roads, railways, power lines)

Mitigation and collaboration

- Reduced mining activities during calving and migration
- Restoring lichen growth (improving pasture quality) in forestry and mining areas
- Forest management practices adapted to reindeer husbandry
- Consultation procedures between state forestry and reindeer husbandry (Inari, Finland)
- Renoducts over highways and railways

Annex *to Chapter 4 on ArcticHubs and specific industries: an overview*:

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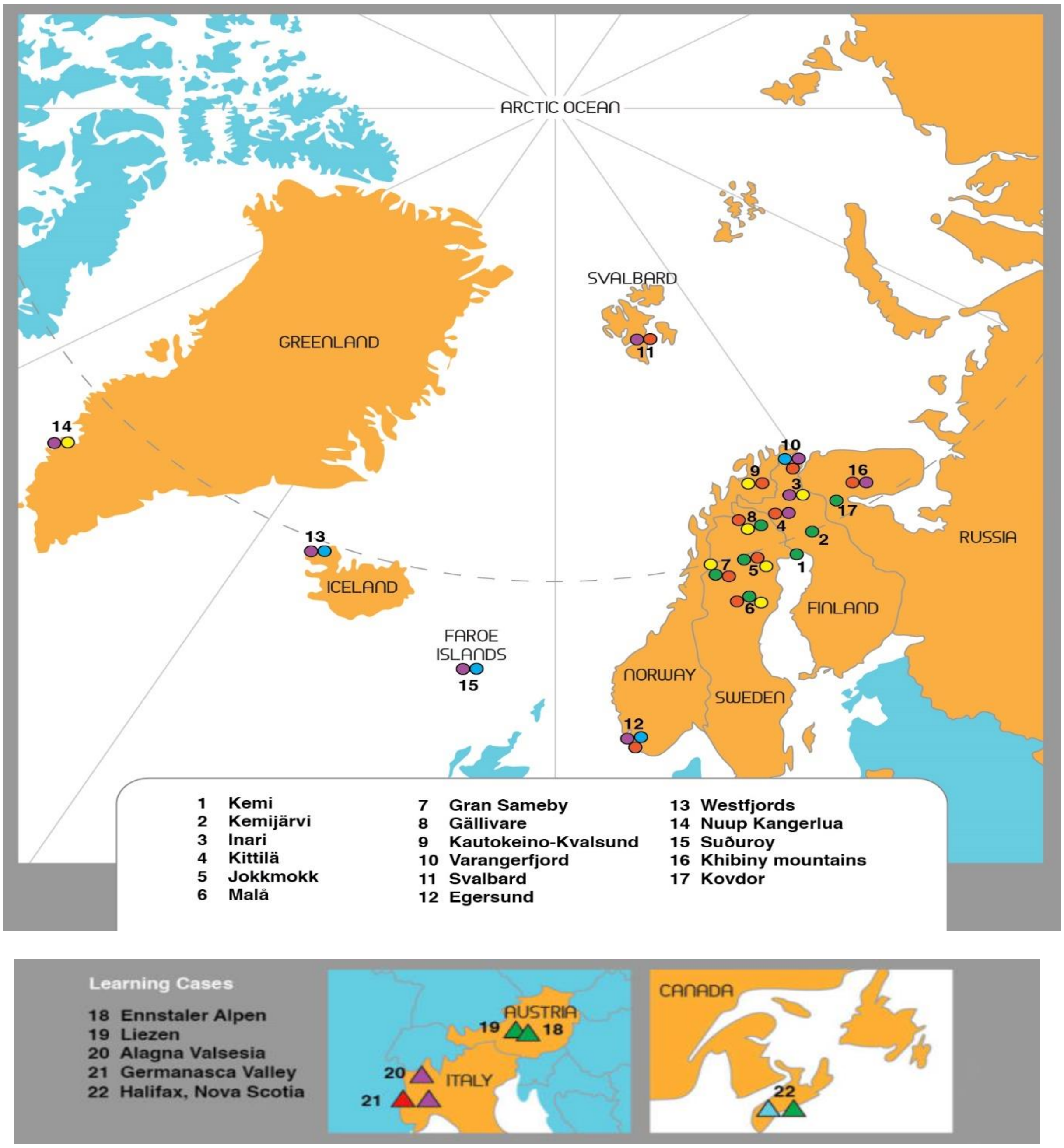

Figure 1. Arctic hub locations

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6. Compilation

This chapter includes a compilation of environmental assessments for all hubs included in this study to identify impacts of industry-specific economic activities. Each hub description contains: a general hub introduction including an industrial factsheet about hub-specific industrial players or activities, an overview about the environmental state of the art and background, a compilation of environmental impacts (in terms of habitat and landscape, changes in biodiversity and pollution), notes on industry conflicts with other activities, notes on mitigation processes linked to environmental impacts as well as some information on perceptions and ambitions.

6.1. Forestry

ArcticHubs includes six forestry hubs in Finland, Sweden and two learning hubs in Austria. While the forestry hubs in Sweden share their location with indigenous and mining hubs, the forestry hubs in Finland and Austria represent forestry and related industries (pulp and paper) as main activities that will be studied in these locations. In both Finland and Sweden, a significant focus has been directed towards the impact of forestry on reindeer husbandry and consequently the indigenous culture: Over the last 70 years, forestry activities have changed the original open pine forests with abundant lichen vegetation to densely managed monoculture forests with accumulated mosses. This is associated with consequences for reindeer food supplies and migration. Moreover, from a Finnish perspective, a signature development is the planning of large new pulp mills which are dependent on the supply of material produced by forestry. While discharges to water and air from the pulp mills have negative environmental impacts, produced bioenergy, on the other hand, reduces greenhouse gas emissions. In Austria, a characteristic feature of the industry is the interaction between forestry and tourism and reducing damage to forest stands.

6.1.1. Kemi

Kemi is situated on the Bothnian Bay, at the mouth of the river Kemijoki, and it is part of the Lapland region in Finland. The town has a population of 20,331 (2021) and covers an area of 747.28 square km. The paper and wood pulp industry has been the main economic activity in Kemi for a long time. Due to declines in paper demand in Europe for over a decade, a significant overcapacity in the paper market has challenged the cost-competitiveness of many paper mills. As a result, Stora Enso made a decision to permanently close down pulp and paper production in the Veitsiluoto Mill in 2021 with 670 people losing their job. Metsä Fibre, part of Metsä Group, informed in 2021 about a new investment to build a new bioproduct mill in Kemi. The new Metsa Fibre bioproduct mill acts as a great compensation for the Kemi region for the loosses of Storenso jobs in terms of industrial jobs in the region. The investment is the largest (EUR 1.6 billion) that has ever been made by the Finnish forest industry in Finland. The new bioproduct mill will not use fossil fuels, and renewable energy in the form of electricity, but wood-based fuels and district heat will be sold from the mill to external customers. Despite the clearly increased production compared with the current Kemi pulp mill, the new bioproduct mill is expected to move below the emission limits of the current environmental permit of the existing mill. The new bioproduct mill will utilize the Best Available Technology (BAT) and an associated Environmental Impact Assessment (EIA) was ready in 2019. The Regional State Administrative Agency for Northern Finland granted the environmental and water supply permits to the Kemi bioproduct mill in 2020.

Figure 2. Industrial factsheet Kemi

6.1.1.1. State of the art / environmental background

The surrounding landcover of the Kemi centre is partly sea (Bothnian bay) and partly old industrial environment. The new bioproduction plant of Metsæ Group will be located at the mouth of the river

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Kemijoki, west from Kemi, at the Bothnian Bay. The region is a built environment, strongly modified by industrial operations and characterized by industrial buildings, containers, wastewater treatment plants, wood storage areas and waste management areas. In this area, also the old Metsägroup pulp mill is located which will be pulled down as soon as the new bioproduct mill will start operating. Pulp and paper manufacturing in Finland is regarded as largest industry segment in terms of water- and energy use, but also in terms of chemicals and combustion products that are released to the environment (Corcelli et al, 2018) (however, situated in an industrial area, the Metsä group bioproduct mill is estimated to not cause major impacts on soil or bedrocks, geologically important locations, or groundwater). The closest residential buildings are located at 300-500m distance from the border of the industrial estate. Wood that is used for raw material will be harvested mostly from Lapland, North Ostrobothnia and Kainuu. One of the closest nature protection areas is the Bothnian Bay National Park, in the outer archipelago of Kemi and Tornio (established in 1991, with 157 km2 of size). The islands in the area have been formed by post-glacial rebound, and the scenery is still in a constant state of change. Here, also numerous traditional fishing bases can be found. Currently, the pulp and paper industry can be characterised by a transitional phase towards increasing material efficiency and recycling processes (Corcelli et al, 2018).

An important feature of the industrial profile of Kemi is the close interaction of the paper and wood pulp industry and the forestry sector due to the continuous need of bio-based fuels originating from primary production. When it comes to forestry activities, the national forest volume in Finland remained the same between 1920 and 1980, but since then it has been growing continuously as a result of a stronger utilization of silvicultural activities as well as the effects of climate change (**Article 1**[23]). The Finish state forestry is mostly led by Metsähallitus and guided by regulative legislation such as the Forest Act and the Conservation Act. However, the new national investments into the Finnish bioeconomy have increasingly changed forest use and associated methods. Accordingly, the logging possibilities in Finnish forests are expected to double in 2050 and the intensity of tree harvesting will also shift more and more from southern to northern Finland (Article 1).

6.1.1.2. Environmental impacts

The following environmental impacts are based on the main industrial activities in and around Kemi that have been determined as economically trendsetting. In this regard, special focus has been on forestry and the pulp and paper sector in the Kemi region. The following paragraphs on environmental impacts will respectively introduce first the forestry perspective followed by the paper pulp industry perspective.

[23] "Article 1" refers to https://www.luke.fi/en/natural-resources/forest/multiple-use-of-forests/theimpact-of-forestry-reindeer-husbandr (link is currently unavailable and will be updated in the final version)

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A. Habitat and landscape

The increased need of wood for the new bio pulp mill (7,6 mill m3 per year) is expected to increase forest cuttings in Lapland, North Ostrobothnia and Kainuu (EIA, 2019). In general, different forestry methods are associated with divergent impacts on natural habitats when it comes to vegetation formation (Article 1). These changes are regarded as positive and negative for different forest users, nevertheless they can be understood as impacting the ecological conditions of forests. Accordingly, clear-cutting activities increase sunlight radiation favouring the drying of mosses, wavy hair grasses and lichen growth (Article 1; Akujärvi et al, 2014). Lichen growth is furthermore linked to the natural habitat of reindeer herds as they provide an essential food source (Miina et al, 2020). On the other hand, spruce-forest logging and controlled burning are associated with losses of lichen types and hindrances within animal territories. The operating of forestry machines, the logging of residues and processes of soil preparation is associated with soil surface erosions, soil temperature changes, changes in radiation and the changing of moisture- and nutrient conditions. More specifically, soil preparation methods such as screefing (sculping) and harrowing can impact the composition of forage plants in moist forests (Article 1). Besides, the thinning of trees increases radiation but decreases moisture conditions which favour forage plant growth. In addition, the extraction of logging residues has shown to decline soil nutrients posing risks for biomass production in general (Article 1). Altogether, different specific forestry methods can be linked to various developments in biomass and vegetation species abundance. In this regard, within the compiled literature for this report, a special focus was often on lichen coverage in forests due to the plant species' important role in the ecosystem (see next chapter). From this perspective, forestry methods in their abundance have shown to come with individual consequences for ecology and biodiversity leading to an increased fragmentation of habitats. This is linked to the next subchapter on biodiversity changes.

The pulp and paper industry in Kemi is not necessarily associated with strong visible impacts on the surrounding landscape as the new mill is mostly located in the existing industrial estate. However, the clearing of riverbanks and parts of the shore may cause negative impacts on the local landscape in Kemi (EIA, 2019). Moreover, a weakening of ice conditions of sea- and river water is observed due to increasing water temperatures because of cooling- and wastewater discharges. Consequently, yearly ice cover durations have become shorter with up to one month (EIA, 2019). Eventually, the impacts of increasing forestry activities can be seen as a contributing consequence from introducing biorefinery solutions as they are currently an important driver of wood production.

B. Changes in biodiversity

As discussed in the previous section, different forestry methods can be linked to different developments in vegetation abundance and that a special focus has often been on lichen growth in

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Finnish forests within the scientific literature. In general, lichens contribute to several ecosystem functions. Accordingly, they support biogeochemical nutrient cycles and nutrient webs in northern forests, and they provide insulation as well as moisture retention of forest soil. Lichens are regarded as ecological indicators for forest biodiversity and old-growth forests and besides, they provide critical winter forage for reindeer. Therefore, lichens are a crucial factor for multifunctional forest use and represent an indicator for effects of forest management strategies on ecosystem services (Miina et al, 2020). The mechanical disturbance of forest management is regarded as negatively impacting lichens (Miina et al, 2020). In addition, the scientific literature discusses the role of leaving retention trees during final harvesting processes. Hence, several species responses are dependent on the maintenance of retention vegetation which has become a global approach to reconcile often conflicting goals of timber production and safeguarding biodiversity as well as the delivery of several ecosystem services (Kuuluvainen et al, 2019). However, current low amounts of retention do not provide habitat quality and continuity which comes with a decline of red-listed species which are dependent on old living trees and coarse woody debris (Kuuluvainen et al, 2019). As a result, current retention strategies are considered as poor in terms of ecological benefits, also because they are associated with external costs that are aimed to be minimized (Kuuluvainen et al, 2019). Such discussions are not only related to Kemi and address a national perspective.

The pulp and paper industry in Kemi, with special focus on the new pulp mill, is associated with impacts on habitats with noteworthy flora. For example, the extremely threatened *Artemisia Campestris*, a nature directive species will be destroyed (EIA, 2019). Moreover, the impact area of the new mill is expected to extent its range to the Bothnian Bay National Park which is a Natura 2000 protected area. Here, the eutrophication of the waters is expected to increase as a result of the pulp and paper industrial activities (EIA, 2019).

C. <u>Pollution</u>

The trendsetting role of bio-based pulp and paper mills and refineries continuously increases the need of wood. For example, the consumption of forest chips for heating and power creation totalled 7.3 mill m3 (Anttila et al, 2018). However, there is a remarkable deficit of relevant small trees in southern Finland and there is an increasing tendency to import pulp-wood sized material from northern regions and transboundary. Hence, increasing long-distance transport of energy wood is associated with slightly higher CO2 outputs from traffic and associated noise pollution (Anttila et al, 2018; EIA, 2019). Furthermore, the ongoing construction of the new pulp and paper mill in Kemi is considered as noise-intensive, also during the operational phase. The noise levels are caused by heavy traffic which is expected to be 10 times stronger during the construction phase compared to the operational phase

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(EIA, 2019). But also, the operational phase is associated with increasing infrastructure development and accumulating traffic in terms of roads, railways, and sea traffic. Accordingly, wood is e.g., transported mainly by trains while pulp wood material is delivered to the mill via trucks (EIA, 2019).

More environmental impacts in terms of pollution are observed in the context of the increasing discharges of effluent-, waste- and cooling water to the surrounding ecosystems from the pulp and paper industrial complexes in Kemi. More detailed values are presented in table 2 and 3.

Table 2. Emissions to sea/water from present pulp mill (shut down) (EIA, 2019)

EMISSIONS TO SEA/WATER	AMOUNT
WASTEWATER	61400m3/d
CHEMICAL OXYGEN DEMAND (CODCR)	650mg/l
SOLID WASTE	50mg/l
NITROGEN (N)	11mg/l
PHOSPHOR (P)	0.73mg/l
ADSORBABLE ORGANIC HALIDES (AOX)	6mg/l

Table 3. Emissions to sea/water from new bioproduct mill (EIA, 2019)

EMISSIONS TO SEA/WATER	AMOUNT (PRELIMIARY VALUES)
WASTEWATER	88200m3/d
CHEMICAL OXYGEN DEMAND (CODCR)	450mg/l
SOLID WASTE	60mg/l

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NITROGEN (N)	8mg/l
PHOSPHOR (P)	0.5mg/l
ADSORBABLE ORGANIC HALIDES (AOX)	8mg/l

Here, the scientific literature and impact assessments highlight different components as environmentally threatful. According to Pöykiö et al. (2004), organochloride compounds from effluent waters have impacted the surrounding terrestrial and marine ecosystems around the Stora Enso and Metsahallitus complexes nearby the Bothnia region by entering associated flora and fauna organisms. However, modernisations of wastewater treatments and reduced chlorinated substance discharges from the mills have been linked to decreasing halogenated compounds in sediments as a result of long-term data observations of Extractable Organc Halogens (EOX) (Pöykiö et al, 2004). At that time, also trichloroguaiacol concentrations in biles of perches were analysed which have shown to be low. Besides, gonodal disorders were found in burbot roach and perch, however the level of bioaccumulation was unclear in this regard (Pöykiö et al, 2004). According to the EIA (2019) of the Metsæ fibre bioproduct mill, eutrophication and increased algal production with moderate environmental risks have been particularly observed close to the wastewater discharge points. This is associated with minor impacts on salmon, trout and whitefish which are the most-farmed species in the surrounding region (EIA, 2019).

Additionally, according to a Life Cycle Analysis (LCA) with focus on certain impact categories linked to different production phases (forestry, pulp production, paper production, energy production and material distribution) of the Kemi pulp and paper in industry, pulp production is mostly linked to the industry's negative environmental impacts. In this regard, pulp production processes were responsible for 55% of the industry's Freshwater Eutrophication Potential (FEP), 46% of the industry's Human Toxicity Potential (HTP) and 42% of the industry's Metal Depletion Potential (MDP) (Corcelli et al, 2018). On top of that, some other significant environmental impacts can be linked to paper production. Accordingly, paper production processes have proven to be responsible for 38% of the pulp and paper industry's Terrestrial Acidification Potential (TAP), 28% of the industry's Photochemical Oxidation Formation Potential (POFP) as well as 50% of the industry's Terrestrial Ecotoxicity Potential (TEP). Environmental consequences of forestry processes were rather negligible in terms of the analysed impact categories (Corcelli et al, 2018).

Furthermore, the LCA showed environmental impacts in terms of atmospheric and greenhouse gas emissions. Also, those were mostly linked to pulp production processes which contributed with 46%

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to the industry's Global Warming Potential, with 39% to the industry's Ozone Depletion Potential as well as with 46% to the industry's Fossil Depletion Potential (Corcelli et al, 2018). Altogether, the pulp production processes account for 90% of the industry's GWP, ODP, TEP and FDP as well as for 80% of the industry's TAP and HTP. The most influential pulp production processes in this context are digesting, chemical recovery and bleaching processes; Mechanical pulping was regarded as most impactful in comparison with chemical pulping (Corcelli et al, 2018).

Compared to the present situation, the new bio-based pulp and paper mill in Kemi is also associated with local improvements of air quality and decreasing amounts of greenhouse gas emissions due to the independence on fossil fuels and the consumption of bioenergy (EIA, 2019).

In this context, biorefineries in Kemi are expected to have a much higher potential to notably reduce CO2 emissions by replacing fossil fuel mixes (e.g., peat, coal, oil, gas) used for power boilers and lime kilns with renewable alternatives. This could drop national emissions to 2-4% (Lipiäinen & Vakkilainen, 2021). On top of that, biorefineries in Kemi are also expected to increase efficiency in energy use while the production of energy will increase. The overproduction of energy can consequently also be used elsewhere (Lipiäinen & Vakkilainen, 2021). The displacement of fossil fuels, the more efficient use of wood raw material and minimizations of process waste has been developed further in Kemi's bio-based production centres such as Stora Enso and Metsahallitus by e.g., dissolving pulp for textile fibres, cleaner production technologies, biogas production from waste streams or chemical recovery processes that reduce necessary chemical inputs (Temmes & Peck, 2020). From such perspectives, mobilizing bio-based solutions within the pulp and paper industry is associated with positive impacts in terms of GWP, FEP, HTP and TEP due to recycling, increased material efficiency and sustainable energy production (Corcelli et al, 2018).

6.1.1.3. Conflicts with other activities

There are some emissions to water from the pulp and paper industry such as discharges of cooling water and organic halogens, phosphor, or nitrogen. Although these emissions are not associated with high deteriorations of ecological systems, cooling water can have impacts on recreational activities such as winter fishing (EIA, 2019).

Moreover, forest cuttings are associated with positive and negative impacts on different forestry user groups. The loss of lichen vegetation through different forestry methods is a controversial development for reindeer herders. For reindeer herding, lichens are an important part of the diet and are dependent on them, also during winter.

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6.1.1.4. Mitigation

Although, the pulp and paper industry is associated with decreasing greenhouse gas emissions, especially the construction of the new pulp mill, the industry itself is dependent on wood. This is associated with a further need for sustainable forest methods and uses of wood to preserve forests in their role of essential carbon sinks. Possible mitigation methods are e.g., making more use of thinning methods.

When it comes to industry impacts on flora and fauna, transplantations of plants and creating an important balance between different habitats will be important. Furthermore, the establishment of green zones surrounding pulp and paper factories can have positive impacts on the landscape.

The increasing traffic as a result of transport of new products will come with a further need for new alternatives for traffic arrangements. A restructuring of infrastructure has been planned to secure the fluency of traffic. Especially the construction phase of new factory buildings is associated with noise pollution, also because of increasing traffic. Here, possible mitigation concerns noise banks and more inclusion of electric vehicles.

6.1.1.5. Ambitions

There are several scientific publications about Finnish forestry, but limited material related to perception and ambitions.

Company information can provide information about ambitions and the company self-perception. The Metsä Fibre company homepage informs that the company utilises green technology and renewable energy and is one of the greenest and most sustainable companies in the industry

- Metsä Fibre – Kemi bioproduct mill project (metsafibre.com)
- Stora Enso initiates a plan to permanently close down pulp and paper production at Kvarnsveden and Veitsiluoto mills (Unfortunately, there is no access to the information via the www link announced)

Furthermore, a blog post asserts the sustainability of Finnish forestry.

- Sikanen, L., 2017. Finland – probably the most sustainable forest bioeconomy in the world. https://www.luke.fi/en/blog/finland-probably-the-most-sustainable-forest-bioeconomy-in-the-world-2/, accessed 30th July 2021 (Unfortunately, there is no access to the information via the www link announced)

6.1.1.6. Perceptions

According to K. Raition, do Finland's forestry myth undermines its radical climate ambition. Finland's self-image that its forest sector is leading the world in addressing the biodiversity crisis – which forestry

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is actually driving – withstand scrutiny. Forestry remains the most important cause of biodiversity loss in Finland both in terms of species and their habitats. The notion that logging forests is good for the climate is similarly flawed.

- Raition, K., 2019. In: Climate Home News (https://www.climatechangenews.com/2019/07/09/finlands-forestry-myth-undermines-radical-climate-ambition/)

In addition, National Park information describes the region where the forestry hubs are located. The presentation seems to be targeting tourists.

- Bothnian Bay National Park - Nationalparks.fi

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Kemin MetsäFibren biotuotehtaan YVAn yleisötilaisuuden kalvot 29.12.2020.(In Finnish)

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Metsä Fibre – Kemi bioproduct mill project (metsafibre.com)

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6.1.2.Kemijärvi

Kemijärvi is situated in the South-eastern part of Lapland, and it is part of the Lapland region in Finland. The town has a population of 7 167 and the area is 3 931,14 km², of what 426,78 km² waters. Population density is 2,05 inhabitants/km². About 5300 people live in the central area of Kemijärvi. The wood pulp industry was one of the main economic activities in Kemijärvi from 1965 to 2008 until Stora Enso shut down its pulp mill. The Stora Enso mill produced about 250000 tons of pulp per year in the beginning of the millennium and the number of personnel in the mill was about 220. A new development within the wood-based industry in Kemijärvi is associated with the construction of the Keitele Group owned sawmill. After the Stora Enso pulp mill shut down, local actors started to plan this new pulp mill in the area. The company Boreal Bioref was established to promote the associated planning and construction process. In 2021, a new company, Vataset, took over the planning of the complex. According to an EIA report from year 2017 the mill is expected to produce 500000 tons of different types of pulp. The annual wood consumption is estimated to be 2,8 million m3 per year and comprises mostly Scots pine. In addition to traditional pulp production, the planned mill can also produce dissolving pulp, which can be used for new bio-based products.

Industrial factsheet **Kemijaervi**– *Vataset* bioproduct mill

Company:	Vataset
Ownership:	Vataset
Location:	Kemijärvi, Lapland region, Finland
Activity:	Planned bioproduct mill.
Spatial extent:	Mill area 100-150 ha.
Resource need:	2.9 m3 wood annually. Raw material areas: Lapland and other parts of northern Finland. Wood procurement area in Lapland and northern Finland (Kainuu, Ostrobothnia) about 150 km radius from refinery.
Production:	250000 tons of annual softwood, bioproducts including e.g., biomaterials, bioenergy, biochemicals. 370-400 GWh of renewable electricity per year.
Impact on CO2 emissions:	Production 12 556 t/a, car transportation 21 748 t/a, train transportation 4 286 t/a. As a total, avoided CO2 emissions 106437 -115410 t/a.
Employment expected:	2700 in construction phase (about 2 years), in production phase mill 185, other indirect employment effects about 800.
Impact to regional economy:	The volume of primary production increases with 6.5% and the volume of industry with 4.5 % in Lapland.
Impact traffic:	About 195 trucks per day, one train. Day time heavy traffic about 10 vehicles/h, nighttime traffic 4 vehicles/h. Total effect in EIA big negative (---).

Figure 3. Industrial factsheet Kemijarvi

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6.1.2.1. State of the art / environmental background

Vataset's developing mill complex is planned to be located in the Kemijärvi biopark, close to the centre of Kemijärvi. The main business idea of the Biopark is to serve as a platform to produce biomaterials, energy, synergies with the circular economy and new bio-generation opportunities. Accordingly, Vataset's new mill will be established on already existing industrial estates. In cooperation with the Lapland ELY centre, an 8–10-year development program has been planned for the Eastern Lapland Road network which is associated with new infrastructural and logistical opportunities for the Kemijärvi business side (Kemijärvibiopark, 2022)[24] [25]. As of early 2024, the funding for the planned mill has not yet been confirmed.

Located in north-east Lapland, Kemijärvi is the most northern municipality with town status in Finland. The land area of the municipality covers 3,900 km2 and is characterised by forests, hills, swamps, lakes, ridges, and rivers (Aho, 2008 [26]). Moreover, Kemijarvi is located closely to lake Kemijärvi which is the largest natural lake in the basin of the Kemijoki River. It covers an area of 230 km2 and has a shoreline of 572 kilometres (visitkemijärvi, 2022)[27]. Surrounded by water bodies and natural landscape, Kemijärvi is an attractive tourism destination, important sights are e.g., the Pyhä National Park and the Suomu fells which are both a 40-minute drive away. The Kemijarvi municipality inhabits 9 Natura 2000 sites of which the closest is Tynnyriaapa with 8,5km distance.

Similarly to Kemi, an important feature of the industrial profile of Kemijärvi is the close interaction of the paper and wood pulp industry and the forestry sector due to the continuous need of bio-based fuels originating from primary production. Regarding forestry activities, the national forest volume in Finland remained the same between 1920 and 1980, but since then it has been growing continuously as a result of stronger utilization of silvicultural activities as well as the effects of climate change (Article 1). However, the new national investments into the Finnish bioeconomy have increasingly changed forest use and associated methods. Accordingly, the logging possibilities in Finnish forests are expected to double in 2050 and the intensity of tree harvesting will also shift more and more from southern to northern Finland (Article 1). More concretely, figure 4 presents the extent of the essential wood procurement area that Kemijärvi's industry makes use of.

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[24] In English | Kemijärven biopuisto (kemijarvibiopark.fi)

[25] Change agency and path development in peripheral regions: from pulp production towards eco-industry (tandfonline.com)

[26] Aho, S. Control over resources in place reinvention: Kemijärvi in far-away Lapland. *Place Reinvention in the North*, 101.

[27] Nature Attractions | Natural Attractions | Visit Kemijärvi (visitkemijarvi.fi)

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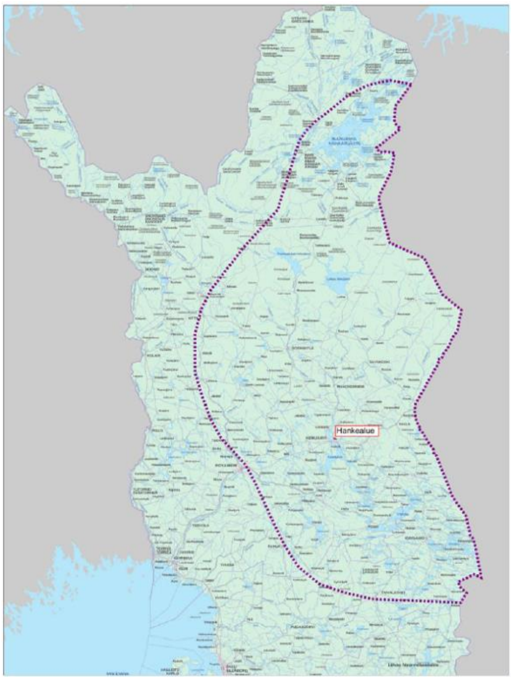

Figure 4. Wood procurement area for Kemijarvi

6.1.2.2. Environmental impacts

The following environmental impacts are based on the main industrial activities in and around Kemijarvi that have been determined as economically trendsetting. In this regard, special focus has been on forestry and the pulp and paper sector in the Kemi region.

A. Habitat and landscape

The increased need of wood (2,9 mill m3 per year) for the new bio product mill in Kemijaervi is expected to increase forest cuttings in Lapland as well as parts of North Ostrobothnia and Kainuu (EIA, 2019). Raw wood material comes mainly from thinning phase forests, impacts of cuttings on the carbon balance are not evaluated in EIA (2017) and needs more analysis.

In general, as in Kemi, different forestry methods are associated with divergent impacts on natural habitats when it comes to vegetation formation (Article 1). These changes are regarded as positive and negative for different forest users, nevertheless they can be understood as impacting the ecological conditions of forests. Accordingly, clear-cutting activities increase sunlight radiation favouring the drying of mosses, wavy hair grasses and lichen growth (Article 1; Akujärvi et al, 2014). Lichen growth is furthermore linked to the natural habitat of reindeer herds as they provide an essential food source (Miina et al, 2020). On the other hand, spruce-forest logging and controlled burning are associated with losses of lichen types and hindrances within animal territories. The operating of forestry

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machines, the logging of residues and processes of soil preparation is associated with soil surface erosions, soil temperature changes, changes in radiation and the changing of moisture- and nutrient conditions. More specifically, soil preparation methods such as screefing (sculping) and harrowing can impact the composition of forage plants in moist forests (Article 1). Besides, the thinning of trees increases radiation but decreases moisture conditions which favour forage plant growth. In addition, the extraction of logging residues has shown to decline soil nutrients posing risks for biomass production in general (Article 1). Altogether, different specific forestry methods can be linked to various developments in biomass and vegetation species abundance. In this regard, within the compiled literature for this report a special focus was often on lichen coverage in forests due to the plant species' important role in the ecosystem. From this perspective, forestry methods in their abundance have shown to come with individual consequences for ecology and biodiversity leading to an increased fragmentation of habitats, also for reindeer populations. This is linked to the next subchapter on biodiversity changes.

Moreover, the discharge of cooling water is associated with weakening ice conditions of sea- and river water due to increasing water temperatures. Consequently, yearly ice cover durations have become shorter (EIA, 2017). Besides, the discharge of emissions such as chemical oxygen, phosphor nitrate, adsorbable halides and metals are associated with a small increase of nutrients with minor effects on water vegetation and consequently, lighter effects on fish spawning in autumn (EIA 2017).

B. Changes in biodiversity

As discussed in the previous section, different forestry methods can be linked to different developments in vegetation abundance and that a special focus has often been on lichen growth in Finnish forests within the scientific literature. In general, lichens contribute to several ecosystem functions: They support biogeochemical nutrient cycles and nutrient webs in northern forests, and they provide insulation as well as moisture retention of forest soil. Lichens are regarded as ecological indicators for forest biodiversity and old-growth forests and besides, they provide critical winter forage for reindeer. Therefore, lichens are a crucial factor for multifunctional forest use and represent an indicator for effects of forest management strategies on ecosystem services (Miina et al, 2020). The mechanical disturbance of forest management is regarded as negatively impacting lichens (Miina et al, 2020). In addition, the scientific literature discusses the role of leaving retention trees during final harvesting processes. Hence, several species responses are dependent on the maintenance of retention vegetation which has become a global approach to reconcile often conflicting goals of timber production and safeguarding biodiversity as well as the delivery of several ecosystem services (Kuuluvainen et al, 2019). However, current low amounts of retention do not provide habitat quality and continuity which comes with a decline of red-listed species which are dependent on old living trees and coarse woody debris (Kuuluvainen et al, 2019). As a result, current retention strategies are

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considered as poor in terms of ecological benefits, also because they are associated with external costs that are aimed to be minimized (Kuuluvainen et al, 2019). Such discussions are not only related to Kemijarvi or Kemi and address a national perspective.

Moreover, the Kemijarvi area around the mill is home to the directive species Ranunuculus lapponicus which must be conserved according to the Nature Conservation Act. Besides, additional Red List species have been observed in the surrounding milieu, however these yet must be recorded (EIA, 2017)[28]. In such contexts, especially the construction phase of the bioproduct mill received negative feedback from the 2017 EIA. Next to the endangering of mentioned protected plant species and related habitats, the construction phase is also associated with the risk of disturbing nesting birds.

In the case of Kemi, an important takeaway was that different forestry methods have proven to have different impacts on forest habitats and associated biodiversity (see above). In the case of Kemijarvi, the wood procurement in mostly the northern Finnish region including Lapland and Ostrobothnia is characterised by forest thinning methods. However, to actively conserve the forest habitats and to create important biodiversity features, thinning processes are PEFC[29] certified and promote the maintenance of e.g., decaying wood as well as deciduous- and old trees. This increases the preservation of biodiversity and comes with positive effects.

Besides, according to the 2017 EIA, the closest Natura 2000 area (Tynnyriaapa in 8,5km distance) has not shown major negative effects associated with mill operations.

C. Pollution

In general, the trendsetting role of bio-based pulp and paper mills and refineries continuously increases the need of wood. For example, the consumption of forest chips for heating and power creation totalled 7.3 million m3 of wood (Anttila et al, 2018). However, there is a remarkable deficit of relevant small trees in southern Finland and there is an increasing tendency to import pulp-wood sized material from northern regions and transboundary. Hence, increasing long-distance transport of energy wood is associated with slightly higher CO2 outputs from traffic and associated noise pollution (Anttila et al, 2018; EIA, 2019). Furthermore, the ongoing construction of the new pulp and paper mill in Kemijarvi is considered as noise-intense, also during the operational phase. Traffic will increase during the construction phase of the new mill, compared to the operational phase. During the operational phase, also the amount of road railway will increase considerably. For example, wood will be transported to the mill by trucks while pulp will be transported from the mill to the Kemi harbour by train (EIA, 2017). In such contexts, the impact assessment has defined associated impacts as high.

[28] This reference is linked to Vatasets EIA during construction phase. The exact reference must be added from colleagues!
[29] PEFC Finland - PEFC - Programme for the Endorsement of Forest Certification

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More concretely, approximately 195 trucks and one train per day are linked to transport associated with the mill operation. During daytime, heavier traffic with about 10 vehicles per hour are expected while 4 vehicles per hour are expected during night-time.

When it comes to noise pollution, there is an increase especially during the construction phase of the new mill, but also during the operation. Here, noise levels caused by industrial operations and heavy traffic at the closest residential buildings will increase and exceed recommended limits. The impact according to the EIA is defined as highly negative (EIA, 2017).

More environmental impacts in terms of pollution are observed in the context of the increasing discharges of effluent-, waste- and cooling water to the surrounding ecosystems from the pulp and paper industrial complexes in Kemijarvi and Kemi. According to Pöykiö et al (2004), the scientific literature and impact assessments highlight different associated components as environmentally threatful (see more detailed information in chapter 5.1.1.2.C, paragraph under table 2 and 3). For processing, around 27000 m3 of water are needed per day while around 2.3-2.5 m3/s are needed for cooling. Moreover, compared to the former Stora Enso mill, wastewater loads will be the same or lower. Impacts of wastewater reach only to the Kemijärvi lake but not downstream of the Kemijoki River.

On the other hand, Kemijaervi's new bioproduct mill will eventually decrease greenhouse gas emissions. Discharged emissions from fossil fuels will be compensated through bioenergy, and the bioenergy produced in the mill will replace a considerable amount of electricity produced elsewhere by using fossil fuels. The contrasting increase in greenhouse gases caused by transportation is minor when taking emission reductions in consideration.

More specifically, table 4 shows a short overview about emissions to the atmosphere. While these emissions come with a short-term smell effect, all are clearly under allowed highest limit values (EIA, 2017).

Table 4. Emissions to atmosphere

EMISSIONS TO ATMOSPHERE	AMOUNT
SULFUR DIOXIDE (SO2)	120-129
NITROGEN (NOX)	1106-1195
TOTAL REDUCED SULFUR (TRS)	25-28
PARTICLES	119-129

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6.1.2.3. Conflicts

Same conflicts as in Kemi: See chapter 5.1.1.

6.1.2.4. Mitigation

The pulp and paper industry is associated with a reduction of greenhouse gas emissions because fossil fuels are continuously replaced with bio energy. However, this process comes with higher wood demands which is associated with a further need for sustainable forest methods and uses of wood to preserve forests in their role as essential carbon sinks. Possible mitigation methods are e.g., making more use of thinning methods.

Moreover, a more efficient and continuous use of sustainable forestry practices and active conservation is essential to preserve important biodiversity features such as red listed species and associated important habitats. To avoid conflicts with reindeer herders due to increasing losses of lichens, discussions between foresters and reindeer herders must be prioritized in the future.

I response to the increasing traffic and consequent infrastructure, new alternatives for traffic arrangements have been planned to mitigate the effects of traffic and associated safety conditions. In addition, to reduce noise pollution, noise levels can be reduced by constructing alternative road connections, noise barriers, alternative selections of building materials and new technology.

6.1.2.5. Ambitions

There are several scientific publications about Finnish forestry, but less other material related to perception and ambitions.

Company information can provide information about ambitions and the company self-perception. The Metsä Fibre company homepage informs that the company utilises green technology and renewable energy and is one of the greenest and most sustainable companies in the industry

- Metsä Fibre – Kemi bioproduct mill project (metsafibre.com)
- Stora Enso has permanently closed down pulp and paper production at Veitsiluoto mills in Kemi

Furthermore, a blog post asserts the sustainability of Finnish forestry.

- Sikanen, L., 2017. Finland – probably the most sustainable forest bioeconomy in the world. https://www.luke.fi/en/blog/finland-probably-the-most-sustainable-forest-bioeconomy-in-the-world-2/, accessed 30th July 2021 (Unfortunately, there is no access to the information via the www link announced)

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6.1.2.6. Perceptions

According to K. Raition, do Finland's forestry myth undermines its radical climate ambition. Finland's self-image that its forest sector is leading the world in addressing the biodiversity crisis – which forestry is actually driving – withstand scrutiny. Forestry remains the most important cause of biodiversity loss in Finland both in terms of species and their habitats. The notion that logging forests is good for the climate is similarly flawed.

- Raition, K., 2019. In: Climate Home News (https://www.climatechangenews.com/2019/07/09/finlands-forestry-myth-undermines-radical-climate-ambition/)

In addition, National Park information describes the region where the forestry hubs are located. The presentation seems to be targeting tourists.

- Bothnian Bay National Park - Nationalparks.fi

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(please, find scientific article references in reference list of chapter 5.1.1. which were both listed for hub Kemi and hub Kemijaervi.)

Bothnian Bay National Park - Nationalparks.fi

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Kemin MetsäFibren biotuotehtaan YVAn yleisötilaisuuden kalvot 29.12.2020. In Finnish

Metsä Fibre – Kemi bioproduct mill project (metsafibre.com) Stora Enso initiates a plan to permanently close down pulp and paper production at Kvarnsveden and Veitsiluoto mills

6.1.3. Gällivare

The Gällivare hub is the same as the municipality and covers 1,68 Million hectares of land and inland water. With a population of 17000 inhabitants, it is one of the larger inland municipalities in region. Although dominated by the mining industry, Gällivare municipality is also part of the traditional lands

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of Sami people in the greater Sapmi land area, and town of Gällivare is located in Swedish central Norrbotten at the knot point of the three Sami reindeer herding villages (Samebyer) Gällivare, Baste Cearru and Unna Tjerusj. (Figure 6)

Figure 5. The Gällivare forest hub area with forest land in dark green, nature reserves light green, national parks light blue and biotope protection yellow. Municipality border in red.

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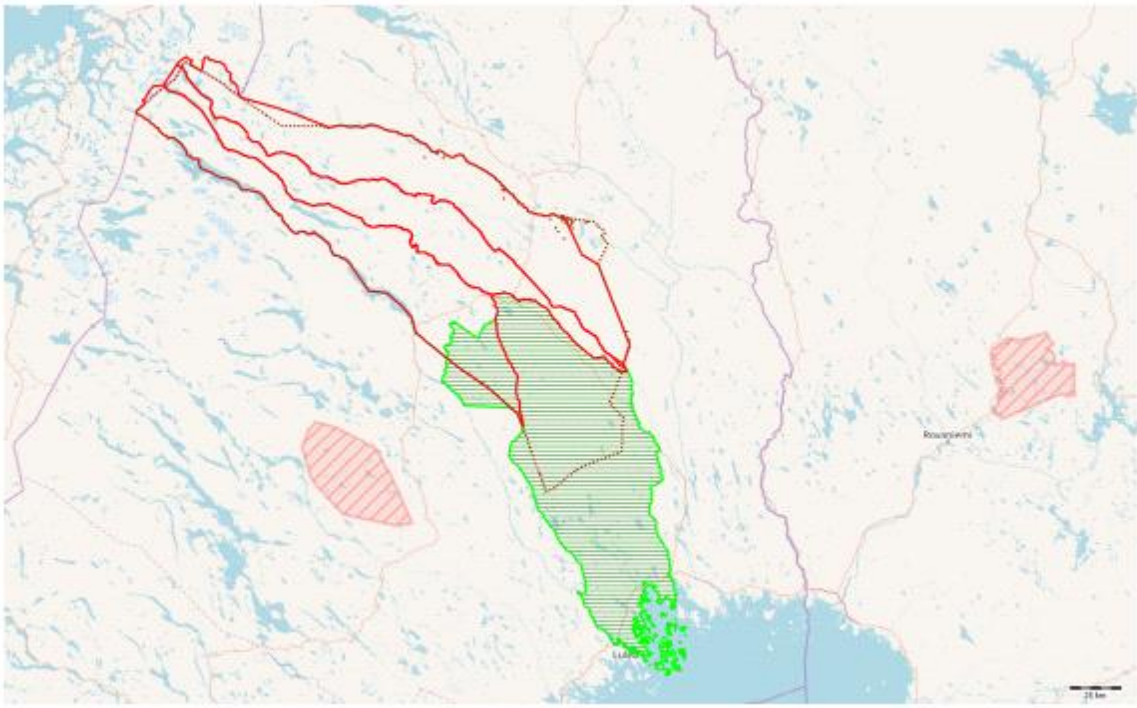

Figure 6. The reindeer herding communities residing/operating in Gällivare hub, Girjas, Baste Cearru and Unna Tjerusj.

With regards to forestry 736,000 hectare are classified as productive forest land outside formally protected forest land forest and in addition another 5% are voluntary set asides. Thus, approximately 700,000 hectars (or 42% of the total hub area) are available for commercial forestry and thereby an important timber resource for sawmills and pulp mills in the region.

6.1.3.1. State of the art / environmental background

Forestry in Gällivare is basically part of the timber balance area covering Norrbotten and Västerbotten, which in total amounts to 7.1 Millio hectares of which of 6.4 mill hectares is available for timber harvesting. Gällivare then makes up 11% of the timber balance area in the region while the contribution to the timber supply is less due to poorer site productivity. However, as there is no local wood processing industry, most of the harvested timber is transported out of the municipality to supply sawmills and pulp mills in other parts of the region. In the region there are 15 sawmills, 1 pole factory and 3 pulp (paper) mills, demanding 11.9 mill m3fub (14.3 m3sk) of timber.

Based on final felling assessment data from the Swedish Forestry Agency, the total area of final felling has been assessed to 0.67% of the total area available for timber harvesting) during 2021 and the volume has been estimated to 402,000 m3sk in final felling. In addition, it may be assumed that

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another 80,000 m3sk is harvested in thinning and other cuttings. The annual harvesting on any forest land in Gällivare then sum up to some 480,000 m3sk. In Sweden, about 6% of the harvested volume is used for fuelwood (Skogstyrelsen, 2001)[30] and we may then assume that 29,000 m3sk are used locally for this purpose, while 451,000 m3sk (376,000 m3fub) is transported out of the hub. The harvesting in Gällivare then contributes to 3% of the timber supply in the region.

6.1.3.2. Environmental impacts

Almost all forest land in the region is environmentally impacted by human activities, and with the introduction of commercial forestry, the impact has increased both in space and consequences. In Gällivare, where 700,000 hectares are available for commercial forestry, at least 42% of the total hub area exhibits many features corresponding to "Today's forestry landscape" in contrast to the Pristine forest's features (table 5).

Table 5. Differences between pristine forest and today's forest landscape regarding processes and dynamics. (Reproduced after Bleckert and Pettersson 1997)

PRISTINE FOREST	TODAY'S FOREST LANDSCAPE
WILDFIRES EVERY CENTURY IN MANY SITES	Wildfires every 10.000 year
WILDFIRES IN DIVERSE PRIMEVAL FOREST	Wildfires in sites with few tree spices
POWERFUL SPRING FLOOD WITH FLOODED FORESTS	Forests without natural water impact
NATURAL RELATIONSHIP BETWEEN PIONEER TREE/SECONDARY TREE	Unnatural order of succession
NATURAL GRAZERS AFFECT THE FOREST	Few natural grazers

[30] Reference leads to error (http://pxweb.skogsstyrelsen.se/pxweb/sv/Skogsstyrelsens%20statistikdatabas/Skogsstyrelsens%20statistikdatabas__Bruttoavverkning/JO0312_01.px/table/tableViewLayout2/?rxid=03eb67a3-87d7-486d-acce-92fc8082735d)

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CONTINUITY OF BIOLOGICAL QUALITIES	Temporary biological qualities
30-40% OF THE VOLUME CONSISTS OF DEAD WOOD	About 6% of the volume consists of dead wood
PLENTY OF OLD GIANT TREES	Giant trees are missing
30% OLD GROWTH FOREST (>200 YEARS)	The really old growth forest is missing
LARGE CONTIGUOUS NATURE TYPES	Small, isolated nature types
MULTI-LAYERED FORESTS	Single layered forest
NATURAL TREE SPECIES MIX	Monocultures
OLD DECIDUOUS FORESTS ON RICH SOILS	Farmland without forest

A. Habitat and landscape

Forestry activities are closely associated with habitat loss and habitat fragmentation not least regarding those that are important to reindeer populations. Here, the focus on lichen abundance is discussed in particular because it is an important reindeer feed. Several different forestry methods have changed the ecological state and abundance of different tree species in forests which has affected the availability of feeding grounds for reindeer. Forestry methods such as largescale logging, intensive reforestation efforts and fire suppression have resulted in a decline in old, open pine-dominated, post-fire successional stands on low productive sites which are important habitats for ground lichens. Such stands have instead been replaced by dense, managed forests that favour especially mosses at the expense of lichens. The introduction of lodgepole pine and fertilization processes have also proven to have negative effects on ground lichen abundance. Furthermore, damage caused by soil scarification causes substantially decreases both in terms of cover and biomass of ground lichens. In addition, clear-cut forestry has shown to increase negative consequences for arboreal lichen which are especially important for reindeer populations during winters with harsh snow conditions. In such contexts, forest reindeer herding communities are similarly affected by forestry taking place on summer grazing lands. Here, the loss of shady old spruce forests is a major concern. These stands are becoming increasingly important during hot summer days and at the same time, they are becoming increasing rare.

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Construction of forest roads, which is needed to access the timber resource, affects the environment, both from the perspective of a landscape and in each individual site. Also, studies show that road drums on the forest road network directly, or over time, risks becoming a tress-passing obstacle for aquatic life, and due to ditches along the roads, each new forest road also contributes to a changed hydrology (Skogsstyrelsen 2001).

B. Changes in biodiversity

The previous sub-chapter has already highlighted the impacts of forestry activities on the abundance of ground lichens. As it has been described in previous forestry hub chapters, lichens are not only essential feed for reindeer, but they are also an important biodiversity indicator for forest biodiversity in general. Moreover, lichens are regarded as ecological indicators for old-growth forests and thus are an important factor for multifunctional forests. This makes them also an indicator for the effects of forest management strategies on several ecosystem services (Miina et al, 2020).

C. Pollution

The combustion of fuel is the main source of pollution in forestry operations (i.e. felling and off-road transport) and onward transport from depots to processing industries. Based on key figures of the fuel consumption in Swedish forestry in 2014, reported by Skogforsk (2019), the fuel consumption for silviculture, harvesting and onwards transport of the in Gällivare may be estimated to 1.77 M litre (4.71 litre/m3 * 376,000 m3fub).

6.1.3.3. Conflicts with other activities

The most conflicts between forestry and other activities are associated with reindeer husbandry. Different forestry methods are associated with an increasing loss of food supplies for reindeer. This concerns especially several types of lichen vegetation. Such developments have been causing negative effects on animal health and migration behaviour. Since 1950 has lichen rich forest declined with 78% in the inland of Norrbotten where the Gällivara and Jokkmokk hubs are located (Sandström et al 2016).

6.1.3.4. Mitigation

Mitigation measures that respond to conflicts with reindeer herders because of e.g., losses of lichen vegetation, comes with a demand for the Implementation of reindeer adjusted forestry methods. This includes more smart and gentle soil scarification methods (lean forestry), more inclusion of thinning techniques and clearings, as well as continuous cover forestry. Eventually, restauration processes of lichen areas in the forests are important to find compromises between both operating industries.

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6.1.3.5. Ambitions

There is no relevant input data from hubs related to ambitions.

6.1.3.6. Perceptions

There is no relevant input data from hubs related to perceptions.

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6.1.4. Jokkmokk

The Jokkmokk hub is the same as the municipality and covers 1,98 mill hectares of land and inland water. The small town of Jokkmokk, and the entire municipality with some 5000 inhabitants, is one of the most prominent places for Sámi culture. Thus, the hub is foremost defined by the indigenous traditional land use, that includes reindeer husbandry, hunting and fishing, which largely take place in the forested landscape of 765,000 hectares. Young Sámi from the whole of Sápmi go to Jokkmokk for education, and here is also the principal museum of Sami culture Ájtte, that is an information centre for mountain tourism. Jokkmokk is also the meeting place for several samebyar (Sámi reindeer herding communities) and located in the heart of their wintering areas.

Forestry has a long history in the area, and today some 600 000 hectares are considered productive and available for harvesting. Thus, 30% of the total hub area is currently affected by forestry in one way or another. Yet, forestry is by most reindeer herding communities considered as the most impending threat to reindeer husbandry.

Figure 7. The Jokkmokk hub area with forest land in dark green, nature reserves light green, national parks light blue and biotope protection yellow. Municipality border in red.

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Figure 8. The reindeer herding communities residing/operating in Jokkmokk hub; Sirges, Jåhkågaska

6.1.4.1. State of the art / environmental background

Similar to Gällivare, forestry in the Jokkmokk hub is is included in the timber balance area of Norrbotten and Västerbotten, which in total amounts to 7.1 Millio hectars whereof 6.4 Million hectars is available for timber harvesting. The 600 thousand hectares in Jokkmokk then constitute 9 % of the timber balance area in the region while the contribution to the timber supply is less due to poorer site productivity. However, as there is no local wood processing industry, most of the harvested timber is transported out of the municipality to supply sawmills and pulp mills in other parts of the region.

Based on final felling assessment data from the Swedish Forestry Agency, the total area of final felling has been assessed to 4722 hectars (0.79% of the area for timber harvesting) during 2021 and the volume has been estimated to 587,000 m3sk in final felling. In addition, it may be assumed that another 113,000 m3sk is harvested in thinning and other cuttings. The annual harvesting on any forest land in Jokkmokk then sum up to some 700,000 m3sk. In Sweden, about 6% of the harvested volume is used for fuelwood (Skogstyrelsen, 2001) and we may then assume that 42,000 m3sk are used locally for this purpose, while 658,000 m3sk (548,000 m3fub) is transported out of the hub. The forestry in Jokkmokk contributes to approximately 5% of the industrial demand in the region.

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6.1.4.2. Environmental impacts

The completely dominant forestry management practice in the region since the 1950s is a stand-wise rotation forestry resulting in even aged stands of either pine or spruce, but sometimes in a mix. Birch was until 1990s considered as of low industrial value, but has since then become a sought-after raw material for the pulp industry. Thus, the previous practice of clear away all young birch trees in the ticket stage or first thinning is modified, and old growth birch trees is considered as very valuable for the biodiversity. To meet the growing demand of long fibre pulp wood, the exotic species *Pinus contorta* was introduced as a monoculture on company owned forest land, and from 2010 and onwards also some minor volumes of sawlogs of contorta could potentially be harvests.

A. Habitat and landscape

Forestry activities are closely associated with habitat loss and habitat fragmentation not least regarding those that are important to reindeer populations. Here, the focus on lichen abundance is discussed in particular because it is an important reindeer feed. Several different forestry methods have changed the ecological state and abundance of different tree species in forests which has affected the availability of feeding grounds for reindeer. Forestry methods such as largescale logging, intensive reforestation efforts and fire suppression have resulted in a decline in old, open pine-dominated, post-fire successional stands on low productive sites which are important habitats for ground lichens. Such stands have instead been replaced by dense, managed forests that favour especially mosses at the expense of lichens. The introduction of lodgepole pine and fertilization processes have also proven to have negative effects on ground lichen abundance. Furthermore, damage caused by soil scarification causes substantially decreases both in terms of cover and biomass of ground lichens. In addition, clear-cut forestry has shown to increase negative consequences for arboreal lichen which are especially important for reindeer populations during winters with harsh snow conditions. In such contexts, forest reindeer herding communities are similarly affected by forestry taking place on summer grazing lands. Here, the loss of shady old spruce forests is a major concern. These stands are becoming increasingly important during hot summer days and at the same time, they are becoming increasing rare.

Construction of forest roads, which is needed to access the timber resource, affects the environment, both from the perspective of a landscape and in each individual site. Also, studies show that road drums on the forest road network directly, or over time, risks becoming a tress-passing obstacle for aquatic life, and due to ditches along the roads, each new forest road also contributes to a changed hydrology. (Skogsstyrelsen 2001).

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B. Changes in biodiversity

The previous sub-chapter has already highlighted the impacts of forestry activities on the abundance of ground lichens. As it has been described in previous forestry hub chapters, lichens are not only essential feed for reindeer, but they are also an important biodiversity indicator for forest biodiversity in general. Moreover, lichens are regarded as ecological indicators for old-growth forests and thus are an important factor for multifunctional forests. This makes them also an indicator for the effects of forest management strategies on several ecosystem services (Miina et al, 2020).

C. Pollution

The combustion of fuel is the main source of pollution in forestry operations (i.e. felling and off-road transport) and onward transport from depots to processing industries. Based on key figures of the fuel consumption in Swedish forestry in 2014, reported by Skogforsk (2019), the fuel consumption for silviculture, harvesting and onwards transport of the in Jokkmokk may be estimated to 1.77 M litre (4.71 litre/m3 * 376,000 m3fub).

6.1.4.3. Conflicts with other activities

The most conflicts between forestry and other activities are associated with reindeer husbandry. Different forestry methods are associated with an increasing loss of food supplies for reindeer. This concerns especially several types of lichen vegetation. Such developments have been causing negative effects on animal health and migration behaviour. Since 1950 has lichen rich forest declined with 78% in the inland of Norrbotten where the Gällivara and Jokkmokk hubs are located (Sandström et al 2016).

6.1.4.4. Mitigation

Improved and innovative forest activities to reduce loss of landscape connectivity as well as ground and pendulous lichen rich forests is much needed. Such goals can be achieved through improved participatory dialogue between reindeer husbandry and forestry. Today there are no active mines in the Jokkmokk area. There is however, a long-time, ongoing dialogue and conflict around the establishment of the Kallak mine.

- Planting pinus contorta
- Samrad consultations
- Isolation areas with no forest operations
- More pre-commercial thinnings
- Use of remote sensing technology

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6.1.4.5. Ambitions

There is no relevant input data from hubs related to ambitions.

6.1.4.6. Perceptions

There is no relevant input data from hubs related to perceptions.

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6.1.5.Malå

The Malå forestry hub is defined by the sawmill situated in the town of Malå, and its timber procurement area, which can currently be described as a circle with a radius of 100 km (figure 9 & 10). Malå municipality has 3,000 inhabitants, which is just about 10% of the population in the entire circle (Statistikmyndigheten, 2022). However, similar to most areas in the province of Västerbotten and Norrbotten, it contains a complex land-use situation where forestry mining, wind power developments, and infrastructure projects overlap with the land use needs of Sami reindeer husbandry. Out of the total hubarea of 3,14 million hectars, 2,18 million hectares are forest land whereof approximately 76% is classified as productive forest land outside formally protected areas. In addition, another 5% are voluntary set asides. In sum, 1.6 million hectares are currently available for forestry, meaning that about 50% of the total hub area is affected by forestry in one way or another.

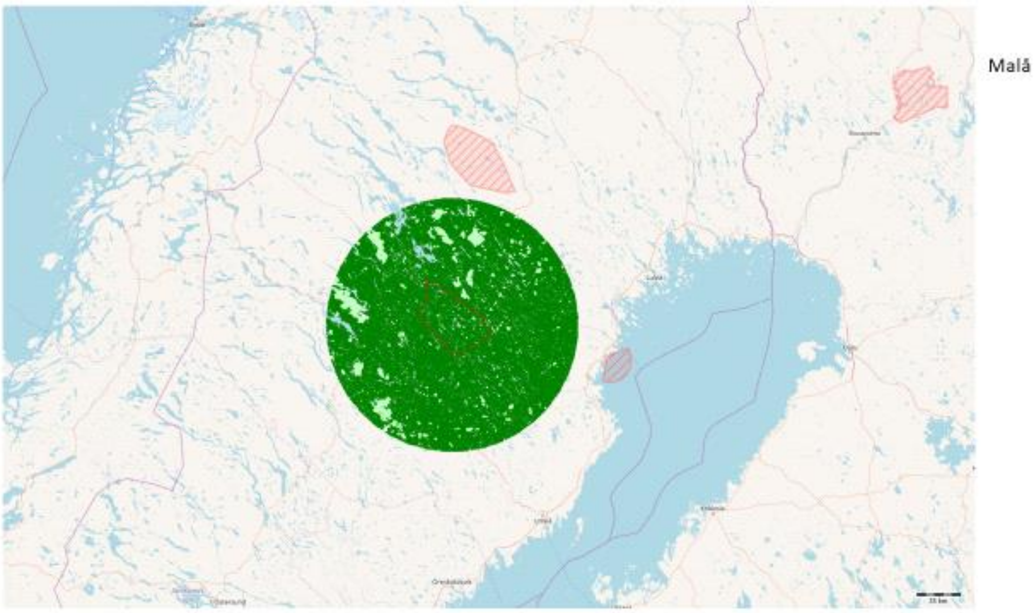

Figure 9. The Malå hub area with forest land in dark green, nature reservs light green, national parks light blue and biotope protection yellow. Malå municipality borders indicate with red line.

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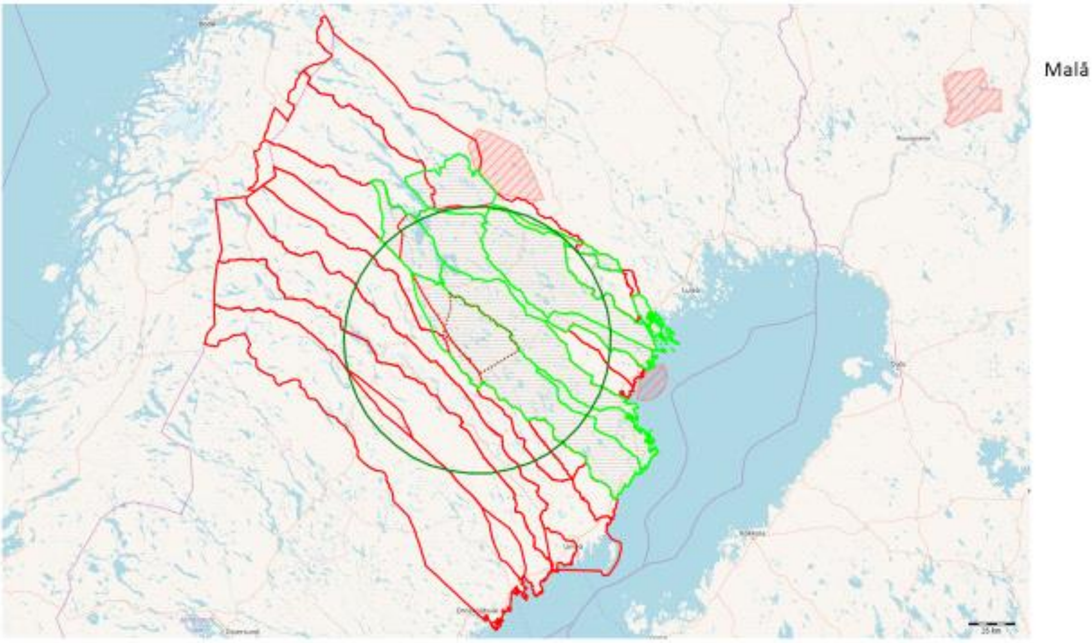

Figure 10. The reindeer herding communities residing/operating in Malå hub; Ståkke, Östra Kikkejaure, Västra Kikkejaure, Mausjaur, Maskaure, Malå (skogssamebyar) and Luokta-Mavas, Semisjaur-Njarg, Svaipa, Gran, Ran, Ubmeje tjeälddie, Vapsten, Vilhelmina norra (fjaellsamebyar)

6.1.5.1. State of the art/ environmental background

Forestry and the further processing of timber in sawmills has a long tradition in the hub. While the number of sawmills has declined, the production intensity both in the forest and at the processing plants has increased. At present there are only two sawmills operating in the hub, Setra in Malå and GlommersTimber in Glommersträsk. However, the hub is at same time also a timber harvesting or purchasing district for other sawmills and pulp mills in the region meaning that only about one fifth of the timber harvested in hub area is processed in Malå (Wahlberg Roslund 2021). Similar to Gällivare, and Jokkmokk, the forestry in Malå hub is part of the timber balance area of Norrbotten and Västerbotten, contributing to about 25% of the total.

The actual final fellings in the hub area has been assessed with support from the Swedish Forest Agency, showing that the amount of final felling during 2021 was 12,300 hectars with an estimated volume of 1.950.000 m3sk or 1.619.000 m3fub. In relation to the total area available for harvesting, the final felling area amounts to 0.77%, indicting a rotation period that exceeds 100 year. The volumes generated from thinning's, which depending on the quality of the site are done 1-3 times during the rotation period, and other cuttings is harder to assess. However, based on general statistics for northern Sweden (Skogsdata 2019 table 4.6) we may assume that another 400.000 m3sk (330,000

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m3fub) to the harvested volume. The harvested volumes in the Malå hub area then support the region (timber balance area of Västerbotten and Norrbotten) with 2 350 000 m3sk representing about 17% of the industrial demand in the region.

The timber supply to Setra Malå sawmill involves 350.000 m3fub (410.000 m3sk) pinewood logs that are harvested and transported to the sawmill, while a similar amount of pulpwood logs from pine-trees are sold and transported to the pulp mills along the coast. Other assortments (spruce logs and broadleaf logs that harvested in the same operations as the pine logs are delivered to other industries in the region. (Wahlberg Roslund, 2021)

At Setra Malå sawmill the logs are processed to 170,000 m3 planks and boards whereof 20-25% is planed. 32.200 m3 planks and boards, and 9 200 m3 becomes further refined products delivered to Swedish costomers, whereof 21.000 m3 respectively 9.200 m3 to customers in Västerbotten. Some 91.000 m3 pulpwood chips, are sold to the mill in Piteå, while 70.000 m3 sawdust and 8.000m3 bark are sold to the nearby heat and powerplant owned by Skellefte kraft. This plant produces 72 000 MWh, wherof 75% delivered to Malå sawmill and 25% to the district heating grid (32.2 km) with 239 connections.

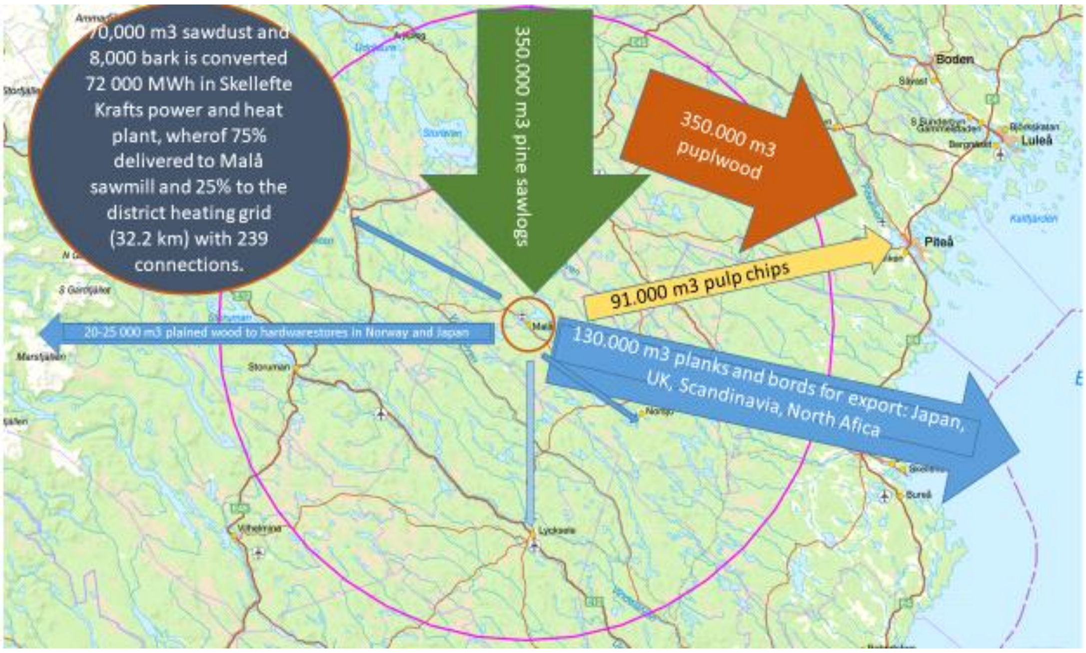

Figure 11. Comprehensive description of the current flow of timber resource flow in the Malå hub (May 2022)

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The owners of the sawmill Setra AB, are planning for major investments in this industrial unit, which will imply that the production will double from 170,000 m3 sawn goods 340,000 m3, which requires that the volume saw logs increases from about 340,000 m3fub (about 410,000 m3sk) to 680,000 m3fub saw logs (820, 000 m3sk). Setra is also investigating increasing the processing operations of wood products and further developing biofuel fractions. All in all, this means that the energy supply and storage possibilities also need to be reviewed.

6.1.5.2. Environmental Impacts

The completely dominant forestry management practice in the region since the 1950s is a stand-wise rotation forestry resulting in even aged stands of either pine or spruce, but in sometimes in a mix. Birch was until 1990s considered as of low industrial value, but has since then become a sought-after raw material for the pulp industry. Thus, the previous practice of clear away all young birch trees in the ticket stage or first thinning is modified, and old growth birch trees is considered as very valuable for the biodiversity. To meet the growing demand of long fibre pulp wood, the exotic species *Pinus contorta* was introduced as a monoculture on company owned forest land, and from 2010 and onwards also some minor volumes of sawlogs of contorta could potentially be harvests. The distribution of pine, spruce, contorta and broadleave (mainly birch) for industrial purpose according to a Business As Usual (BAU) scenario is presented in table 6. As the typical rotation period of forest stands in the hub are 80-100 years, the harvest potential by tree species and assortments reflects the regeneration and management of young stands that was done 4-5 decades ago or more. Similarly, the current forest conditions together with a BAU practice

Table 6. The potential timber harvest by assortments for the Malå hub area, 1000 m3fub/year based on data from the Forest Impact Assessment 2015 (SKA2015) scenario Business As Usual forecast that

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by the turn of the century the total harvest potential has increased with 41% and that pine trees have become an even more dominant species.

		2010-	2020-	2030-	2040-	2050-	2060-	2070-	2080-	2090-	2100-2110
Pine	Sawlogs	1185	1399	1495	1957	1972	2093	2014	1973	2004	2196
Pine	Pulpwood	810	1098	1154	1310	1314	1403	1532	1902	2056	1872
Spruce	Sawlogs	793	704	573	482	499	453	400	333	330	359
Spruce	Pulpwood	953	811	619	537	497	458	624	770	991	1068
Contorta	Sawlogs	2	16	135	158	239	301	221	126	52	82
Contorta	Pulpwood	10	52	152	117	133	148	94	98	42	60
Broadleav	Pulpwood	656	590	606	546	735	817	971	905	1002	949
TOTAL		4410	4670	4734	5108	5390	5673	5855	6106	6476	6585

A. Habitat and landscape

Forestry activities are closely associated with habitat loss and habitat fragmentation not least regarding those that are important to reindeer populations. Here, the focus on lichen abundance is discussed in particular because it is an important reindeer feed. Several different forestry methods have changed the ecological state and abundance of different tree species in forests which has affected the availability of feeding grounds for reindeer. Forestry methods such as largescale logging, intensive reforestation efforts and fire suppression have resulted in a decline in old, open pine-dominated, post-fire successional stands on low productive sites which are important habitats for ground lichens. Such stands have instead been replaced by dense, managed forests that favour especially mosses at the expense of lichens. The introduction of lodgepole pine and fertilization processes have also proven to have negative effects on ground lichen abundance. Furthermore, damage caused by soil scarification causes substantially decreases both in terms of cover and biomass of ground lichens. In addition, clear-cut forestry has shown to increase negative consequences for arboreal lichen which are especially important for reindeer populations during winters with harsh snow conditions. In such contexts, forest reindeer herding communities are similarly affected by forestry taking place on summer grazing lands. Here, the loss of shady old spruce forests is a major concern. These stands are becoming increasingly important during hot summer days and at the same time, they are becoming increasing rare.

Construction of forest roads, which is needed to access the timber resource, affects the environment, both from the perspective of a landscape and in each individual site. Also, studies show that road drums on the forest road network directly, or over time, risks becoming a tress-passing obstacle for aquatic life, and due to ditches along the roads, each new forest road also contributes to a changed hydrology. (Skogsstyrelsen 2001)

B. Changes in biodiversity

The previous sub-chapter has already highlighted the impacts of forestry activities on the abundance of ground lichens. As it has been described in previous forestry hub chapters, lichens are not only

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essential feed for reindeer, but they are also an important biodiversity indicator for forest biodiversity in general. Moreover, lichens are regarded as ecological indicators for old-growth forests and thus are an important factor for multifunctional forests. This makes them also an indicator for the effects of forest management strategies on several ecosystem services (Miina et al, 2020).

C. Pollution

The combustion of fuel is the main source of pollution in forestry operations (i.e. felling and off-road transport) and onward transport from depots to processing industries. Based on key figures of the fuel consumption in Swedish forestry in 2014, reported by Skogforsk (2019), the fuel consumption for silviculture, harvesting and onwards transport of the in Gällivare may be estimated to 7.63 M litre (4.71 litre/m3 * 1,619,000 m3fub).

6.1.5.3. Conflicts with other activities

The most conflicts between forestry and other activities are associated with reindeer husbandry. Different forestry methods are associated with an increasing loss of food supplies for reindeer. This concerns especially several types of lichen vegetation. Such developments have been causing negative effects on animal health and migration behaviour. Since 1950 has lichen rich forest declined with 78% in Västerbotten where the Malå hub is located (Sandström et al 2016).

6.1.5.4. Mitigation

Mitigation measures that respond to conflicts with reindeer herders because of e.g., losses of lichen vegetation, comes with a demand for the Implementation of reindeer adjusted forestry methods. This includes more smart and gentle soil scarification methods (lean forestry), more inclusion of thinning techniques and clearings, as well as continuous cover forestry. Eventually, restauration processes of lichen areas in the forests are important to find compromises between both operating industries.

6.1.5.5. Ambitions

There is no relevant input data from hubs related to ambitions.

6.1.5.6. Perceptions

There is no relevant input data from hubs related to perceptions.

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6.1.6. Mariensee

The private forest enterprise “Mariensee” is located in the Wechsel region, in the eastern foothills of the Central Alps situated at the highest elevations at the border between Lower Austria and Styria at 1743 m. The forest enterprise “Mariensee” originated from the estate of the Lordship of Aspang. Ludwig Haber-Linsberg acquired the properties on the northern slope of the Wechsel in 1865 and bequeathed them to his stepson Hermann Schenker. After several acquisitions, especially in the second half of the 19th century, the family business has reached a total size of about 2000 hectares. Of this, 1700 hectares are managed as forest, 50 hectares are used as grassland and 170 hectares are used as alpine pastures by a farming community. In 1971, Dr Ulrich Schenker handed over the forestry operation in Mariensee and the estate operation in Linsberg to his son Stefan Schenker.

The forests and the composition of tree species were intensively shaped by the hammer mills (until 1865), which required the timber (as fuel wood and charcoal) to operate the plants. The management was characterized at that time by huge clear-cuts and reforestations with 100 % of Norway Spruce. As a result of this clear cuts, large stands of the same age class are still a reminder of this time. Today, in addition to spruce, also larch, fir and, in the water-draining ditches, sycamore maple, ash and beech are planted. Instead of large clear-cuts, natural regeneration is favoured, and small ponds are also deliberately created to increase the evaporation area.

As a private forest enterprise, the owner is aiming to broaden the economic base beyond forestry operations. They currently manage and operate two other private forest enterprises and cooperate in the "ARGE Wechselforst". The task of this community is the joint sale of timber and the joint use of machinery and personnel resources as well as the use of the existing expert knowledge from the individual operations on the overall area. Besides timber production, there is a strong interest in offering recreation facilities.

Many kilometres of the Wechsel-Semmering, panoramic trails are located on the forest roads. For cross-country skiers and hikers, a popular place to stop is the Marienseer Schwaig. Originally, the Marienseer Schwaig was a shelter for cattle farmers, now investments were made for sanitary facilities and a solar system to rent the huts to tourists. At the end of the valley, the "Wildwasser" theme trail leads along the Pöstlingbach stream to the Marienseer Schwaig. The Mönichkirchen Mariensee ski area is located nearby, and some areas are leased for ski runs. Since 2018 the enterprise is offering a mountain bike trail network in cooperation with the Wexltrails as part of the ARGE Wechselforst.

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Industrial factsheet **Liezen**– *Schenker-Mariensee* forestry

Company:	Mariensee
Ownership:	private
Location:	Mariensee
Activity:	Multiple -purpose forestry
Spatial extent:	total 2000 ha
Natural resources:	The area is dominated by montane to subalpine mixed forests of Norway Spruce, Beech, Silver Fir and Larch. Forests are in mosaic with agricultural land in lower parts, mixed and pure spruce mountain forests and alpine meadows on the upper limit.
Production:	Timber production is the main service provided, but increasing interest is in the utilization of non -timber forest products embedded in recreation services to diversify the income portfolio of landowners.
Employment:	4-man years internally, 4-man year externally
Ecosystem services:	timber production and several other services (hunting, retail services, renewable energy, pedagogics, skiing mountain biking)

Figure 12. Industrial factsheet Mariensee

6.1.6.1. State of the Art/ environmental background

Forests are an important element of the rural landscape. The landscape is dominated by vegetative cover and is protected and managed by agriculture or forestry. These landscapes can provide diverse FES and associated benefits to humans. The management of forest landscapes has therefore a crucial impact on their ability to fulfil multiple functions and to provide a sustainable income to forest landowners.

From the 2000 ha of landcover in the Mariensee area, 1700 hectares are managed as forest, 50 hectares are used as grassland and 170 hectares are used as alpine pastures by a farming community.

When it comes to nature protected landscapes, there is a natural reserve and financial compensations are provided by contracts.

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6.1.6.2. Environmental impacts

The following environmental impacts are based on the main industrial activities in Austrian Mariensee with a special focus on the forestry sector.

A. <u>Habitat and landscape</u>

Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
Land use 1. more cross-country skiing and mountain bike trails	a. Damage forest stands by tourism (cross-country skiing) b. Off-track skiing is disturbing wildlife c. More garbage	Low (most infrastructure already existing) No parking spaces for downhill skiing guests	During winter time (10-20 years)	(60.000 sold cross-country skiing sets per year in Austria and 500.000 active cc-skier Danger for humans – accidents with slope preparation	skilift company Mönichkirchen-Mariensee is allowing but charging cross-country skiers a small fee to use the skislope for walking up. Therefore the company has a small profit and the people are nudged out of the forest onto the slope.	
2. more traffic by tourists	a. wildlife disturbance b. Habitat fractionation	Seasonally high	15-30 years			
3. land deposits	Local habitat destruction for trails, skiing slopes	medium	5-10 years			

There are some concerns about how Mountainbiking affects the environment, for example, that it can increase erosion depending on different factors like slope and soil conditions. Also, wild game is believed to be disturbed more by mountainbikers than by hikers. However, these negative effects can be reduced by correct management and visitor guidance: with good planning, soils that are prone to erosion or wildlife habitats can be avoided. This is a better option than trying to prohibit mountain biking, which might just lead to the creating of “illegal” routes. [3]

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B. Changes in biodiversity

Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
4. Forest management	Change of tree species composition	medium				

C. Pollution

Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
Air Dust	1. bikers on the trails 2. vehicles in the valley	Low				
Sound noise pollution by visitors	3. bikers, hikers in the forest 4. vehicles in the valley	Low				

March 2022, Forst Schenker also started operating a new photovoltaic roof system on the roofs of the former sawmill in Mariensee. With an expected yearly revenue of 110 000 kWh, this would generate enough electricity to supply about 25 households with electricity – avoiding about 7 940 kg CO emissions. [4] Even though they do provide a source of sustainable, emission-free energy, there are also negative environmental impacts of photovoltaic systems: the necessary fabrication of steel and aluminum, and silicon needed for their construction before they are taken into operation causes considerable amounts of CO_2-emissions – Cucchiella and Dadamo (2012) calculated more than 2000 kg CO_2-eq/kWp being generated during the manufacturing phase. [10] More environmental pollution is caused after the life cycle of a photovoltaic system: taking into account not only the production, but also recycling and disposal, photovoltaic systems generate 43-63 g CO2-eq/kWh according to a calculation by the German Federal Environmental Agency. However, during a 30-year life cycle they avoid the generation of 694 g CO2-eq/kWh, so their balance is quite positive: avoiding about 627 g CO2-eq/kWh.[11]

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6.1.6.3. Conflicts with other activities

See table in chapter 5.1.6.2.A

6.1.6.4. Mitigation

In case of conflicting FES, trade-offs are inevitable and must be considered in forest resource planning. Trade-offs occur when the provision of one ES is reduced because of the increased use of another FES or if external drivers such as management or climate change push the ecosystem into a state where one service is favored at the cost of another. The potential for trade-offs between objectives increases as the number and variety of management objectives grows. Increasing interest is identified in the utilisation of NTFP and in offering recreation services by the land owners in order to diversify the income portfolio of services and products. New business options for gaining income from forest management (selling licenses for collecting NTFPs, using trails and roads, gaining funds for nature conservation activities ecetera) are explored in order to provide recommendations to managers.

In the case of bark beetle infestations, pesticides and biocides may be one solution to avoid heavy damages to forest stands. In Austria, harvested wood stacks which are still in bark can be treated with cypermethrin, which is rather toxic not only for bark beetle, but also for other insects and water dwelling organisms; therefore there are strict rules on how to use it - the use close to bodies of water is forbidden. [5] [6] In the Mariensee hub, pesticides are not used at all – instead, preventative measures are used, and bark beetle infested trees are searched for and harvested before the beetle can spread.

Another option of avoiding bark beetle problems and increasing harvesting income can be whole-tree-harvesting: not only the timber, but also the other biomass (branches, bark) is harvested. While this can reduce material available to bark beetles, it also can lead to critical nutrient removal compared to a normal harvest. While the mass extraction rises from 40% to 70% with whole-tree-harvesting, the nutrient removal of the main nutrient's nitrogen, phosphorus, calcium, magnesium, and potassium rises somewhere between 300% up to 1000%. This can make whole-tree-harvesting rather unsustainable – it should be done only on nutrient-rich sites and only with careful planning. The Austrian Forest Inventory classified 49% of the tested soils as possible sites for whole-tree-harvests, on 27% of the sites it would be problematic, and the other 24% were classified as unsuitable for whole-tree-harvesting. [7] To avoid nutrient extraction, there is no whole-tree harvesting in Mariensee.

Fertilization and liming could be possible solutions for a lack of soil nutrients; however, they affect the environment in other ways, too – mostly positively: living biomass and soil life can increase, biodiversity can rise, the water regime can improve, and degraded soils can be restored. Sometimes, liming can also have negative impacts: humus mobilization can happen too fast, nitrate leaching can

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occur, and the strong and sudden changes can affect the soil life and roots negatively. [8] In the Mariensee hub, fertilization is not necessary.

To create climate-stable, bark-beetle resilient forests, a change of the tree species composition is necessary – but often, this change is hindered by too high wild game populations, with browsing by ungulates impeding the growth of young trees. As the Austrian game impact monitoring has shown, this issue is also a problem in the district Neunkirchen, to which the hub Mariensee belongs. While in the period of 2016-2018 only 30% of young trees in the sample areas were affected strongly by ungulates, in the period of 2019-2021 this number had risen to a value of 67,5%. [12] However, the hunting concept of Mariensee is adapted to decrease the pressure by ungulate browsing and mitigate the negative effects: hunting is increased in key areas, and in other areas, chemical and mechanical protection of young trees is used to avoid damages.

6.1.6.5. Ambitions

No relevant input data in English related to ambitions.

6.1.6.6. Perceptions

No relevant input data in English related to perceptions.

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6.2. Aquaculture

ArcticHubs includes four fish farming hubs in three northern European countries, Norway, Iceland and Faroe Islands, and one learning hub in Canada. The four European fish farming hubs are all co-located with tourism hubs, and both Varangerfjord and Egersund also with mining hubs. A major part of the focus of environmental impact is therefore on the consequences of the environmental impact of one activity on other activities in the area. Fish farming is well established in Norway and the Faroe Islands, while in Iceland, salmon farming has been rapidly increasing since 2010 (Young et al., 2019). The Faroe Islands has the largest production of farmed fish per capita in the world and all of the suitable habitats are occupied by fish farms (Young et al., 2019). The Varangerfjord, Egersund, Westfjords and Suðuroy hubs are comparable in size: they produce a similar quantity of biomass salmon in sea cages, 10-25 k tons; the production of freshwater smolt (land-based production) varies between 3-8 million (the operation of smolt production on Suðuroy is expected to start in 2023). Egersund also has 2 lake-based trout production facilities producing 1000-1500 tons trout per year. The main environmental impacts of fish farming are comparable in all locations and are summarised below.

6.2.1. Suðuroy

Suðuroy is the southernmost island in the Faroe Islands (see figure 13). Total area is 165 km2 or 11.8 % of the total area of the Faroe Islands, and the population is 4660. Suðuroy is today considered a periphery of the Faroe Islands without migration, limited skilled employment opportunities, and other general issues characterizing also the Arctic periphery and associated hubs. Historically, Suðuroy was a centre for the Faroese transition from an agricultural subsistence economy to an industrial fisheries economy. Since the 1990s the local fisheries sector has declined in the sense that fewer fishing vessels are in operation, and ownership of the operating businesses is increasingly non-local. As the traditional composition of the marine industries is changing, becoming part of the aquaculture and tourism industries is increasingly seen as a viable solution to secure income and local livelihoods in the future. At the same time, both aquaculture and tourism may come into conflict with other land use activities, both at sea and on land.

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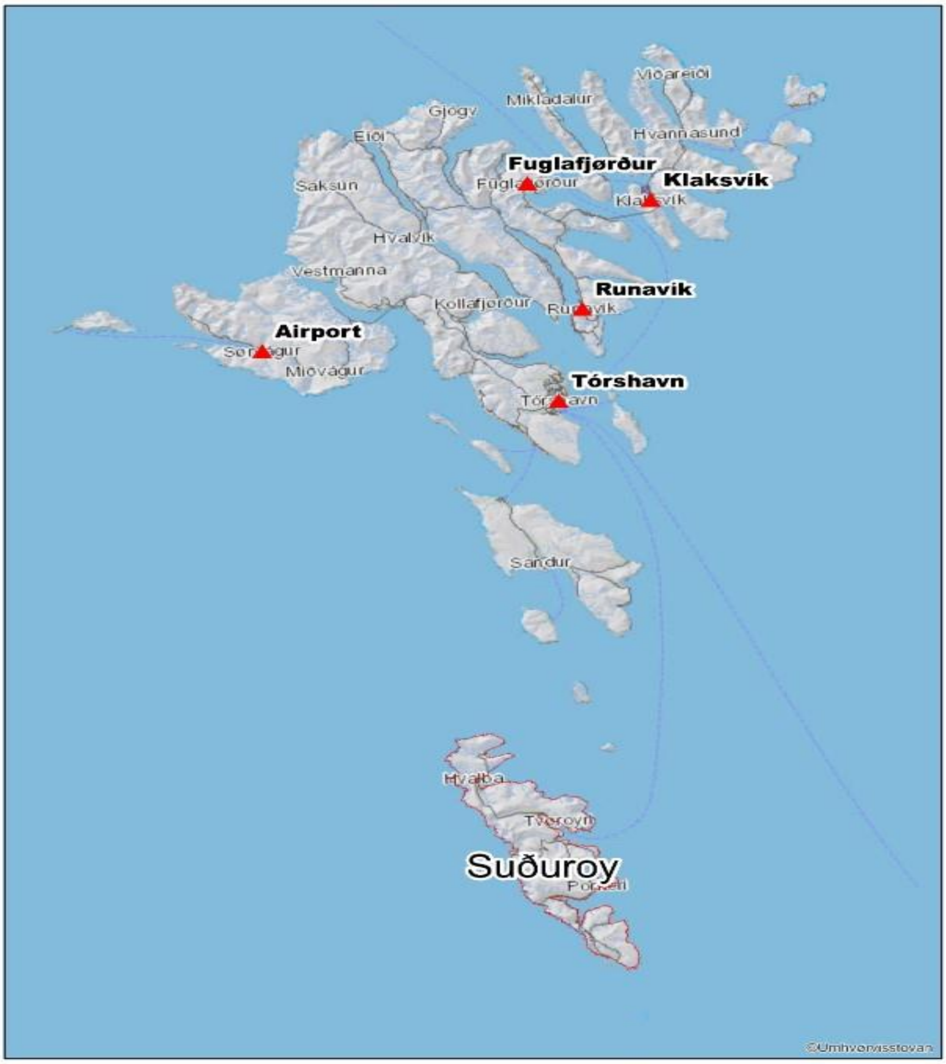

Figure 13. Faroe Islands: Suðuroy, and other larger populated areas in the Faroes including airport and ferry connections (Føroyakort, (2022))

In terms of aquaculture, the Faroe Islands are reported to have the largest production per capita of farmed fish in the world. All fjords and sounds in the Faroe Islands are exploited to their full extent when it comes to current production methods in open salmon cages (see figure 14). Since 2016, the production of salmon in the Faroes has ranged between 1.3 and 1.5 tons per capita. The most active aquaculture company holding permits in the Suðuroy area is Bakkafrost (see industrial factsheet in

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figure 15) which is characterised by open cage fish farming, fish processing and smolt development. The company's goal is to produce 15.000 tons of salmon within a few years, this equals more than 3 tons per Suðuroy inhabitant on an annual basis. Currently, Bakkafrost is constructing a new smolt plant which is expected to produce 3 million smolt annually with a size of 500g when released to the fjords. The plant will start operating in 2023.

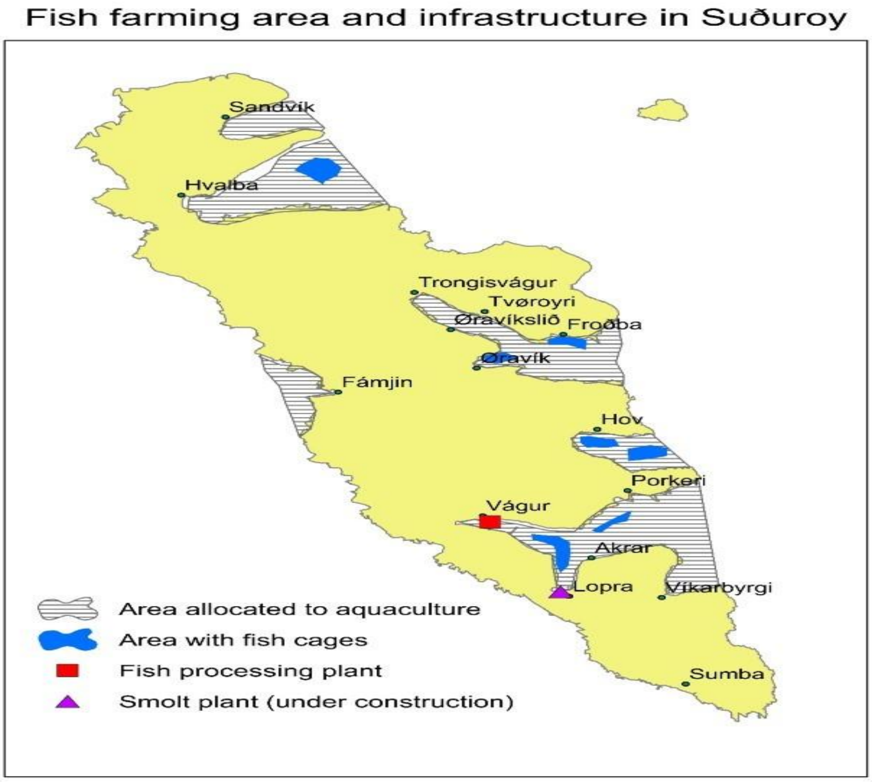
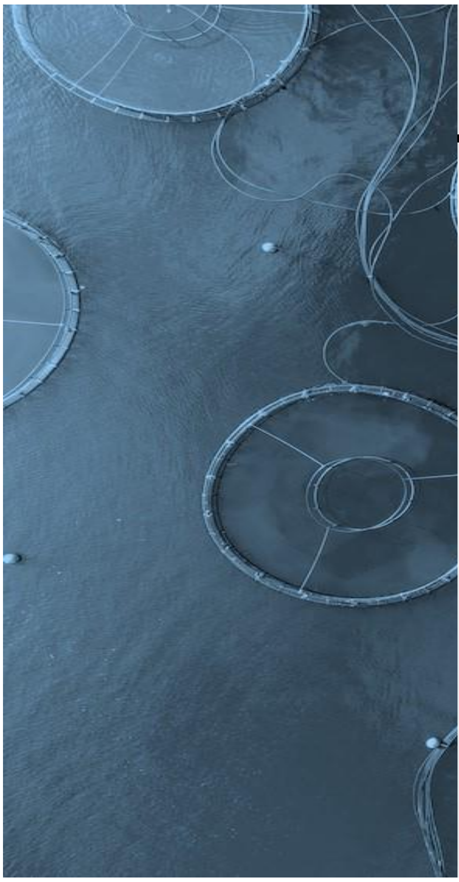


Figure 14. Fish farming area and infrastructure in Suðuroy (Source data: the Environment Agency; Føroyakort (2022))



Industrial factsheet **Suðuroy**– *Bakkafrost* aquaculture

Company:	Bakkafrost
Ownership:	Faroese owners with registration at Oslo stock exchange
Location:	All fjords on west-part of Suðuroy island
Activity:	Open cage farming in the fjords; planned smolt plant on land in Ónavík (Lopra) (under construction); Fish-processing plant (Vágur)
Spatial extent:	Smolt production in Ónavík (Lopra) is expected to require 12.000 cubic meters of production space, covering 10.000 square meters (Bakkafrost, 2020)
Natural resources:	Fresh water (land-based farming facilities). In 2020 the plan was to release 2.1 mill smolt in the fjords of Hov and Vágu.
Production:	The prospected smolt plant in Ónavík (Lopra) is expected to begin operation in 2023 and to produce 3 mill smolt (weighing 500 g when released to the fjords) annually. The expected production will be 15.000 tons of farmed salmon in Suðuroy annually (Bakkafrost, 2019)
Activity:	100 in total in Suðuroy (10 at the Ónavík (Lopra) facility)
Employment:	100 in total in Suðuroy (10 at the Ónavík (Lopra)) facility (Hansen, 2019)

Figure 15. Industrial factsheet Suðuroy

6.2.1.1. State of the Art / Environmental background

Most of the landscape in Suðuroy is dominated by grassland. Figure 16 is a map layer of Suðuroy showing a more detailed classification of the area. Hence, the landscape is characterised by infield (Bøur) surfaces surrounding the inland fjords, smaller rock exposures distributed over the central island landscape (Hellusvað), heather that can only be rarely detected (Lyngur), smaller amounts of bogs (Mýra), additional land that is not covered by vegetation (Svarðloysi), and water (Vatn), eventually. (Føroyakort, 2022). Aquaculture in terms of fish cage farming, is exclusively located in the inland fjords located along the western coastline of Suðuroy island (Føroyakort, 2022). In this regard, aquaculture much outsources the geographical opportunities given for the industry. In addition, figure 8 shows the allocation of areas that are used by fish farming including fish cages as well as the fish processing plant and planned smolt plant located in the southern part of the island. It is expected that the smolt production in Ónavík (Lopra) will require 12.000 cubic meters of production space covering an area of 10.000 square meters. Besides, there are also few seaweed farms at the island coasts.

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With focus on the Inland areas, most of the Suðuroy landscape is used for traditional agricultural subsistence activities of which sheep rearing is the most prominent. At the same time, small-scale fisheries and household fisheries at the coastlines have been specifically important for the local economy as well.

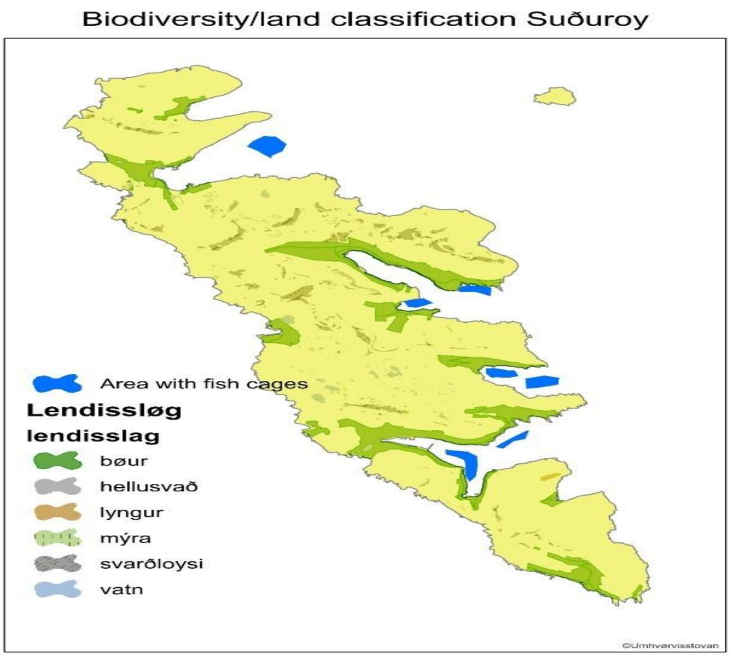

Figure 16. Biodiversity/land classification of Suðuroy with Bøur (infield), Hellusvað (rock exposure), Lyngur (heather), Mýra (bog), Svarðloysi (land not covered with vegetation), Vatn (water) (Source data: the Environment Agency; Føroyakort, 2022))

6.2.1.2. Environmental impacts

The following environmental impacts are based on the main industrial activities in Suðuroy with a special focus on the aquaculture sector of Suðuroy island.

A. Habitat and landscape

In the Faroes, environmental impact assessments are specifically required for the development of projects in the marine or coastal areas and for the development of energy infrastructure. When it comes to aquaculture, most recent Environmental Impact Assessments (EIAs) for operation in the

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inland fjords have been carried out in 2019 and granted permits mostly last until around the end of this decade. Only in the fjord area close to the city Hov, the latest EIA was undertaken in 2011 (Faroese Food and Veterinary Authority, 2022). In such contexts, the environmental assessment of aquaculture was according to recommended values

However, since 1998, a regular testing of the environment around the salmon cages in the fjords have been carried out in the Faroe Islands. In 2020, Fiskaaling and the Environment Agency of the Faroe Islands analysed some of the benthic data which was published in the report *Botndjórasamfeløg – eitt føroyskt sammetingargrundarlag (2020)*. According to the document, the local impact in the proximity of the salmon cages have been documented, but the wider environmental impacts are not known in detail.

Moreover, members of the local population frequently reported on negative environmental impacts of aquaculture on the coastal environment. Here, the decreasing quality of fish was mentioned more specifically, but these reports have so far not been scientifically investigated. Lobster fishers have likewise observed negative impacts from the chemicals used in fish farming (Bogadóttir 2020)

B. <u>Changes in biodiversity</u>

According to reports from fishermen that catch particularly whelk and lobster, negative impacts on these species were associated with continuous salmon farming. However, more detailed scientific knowledge is lacking in this regard. This complements also aforementioned reports on weaker fish quality.

Furthermore, and very recently, a rapid decline in demersal catches of coalfish (Pollachius virens), has been linked to fish farming. Here, the suspected reason for the decline of the coalfish stock is that the young fish get caught in the salmon cages. This development has been observed and discussed by the fisheries and aquaculture industry, politicians (e.g., the Minister of Fisheries) and marine scientists in local newspapers (Dimmalætting 28. May 2021 and Dimmalætting 5. June 2021).

Moreover, salmon aquaculture has nearly always been afflicted by sea lice. Currently, this represents a main bottleneck for the further expansion of the industry. Sea lice, a common name for a range of marine ectoparasitic copepods within the Caligidae family, feed on the fish's skin and mucus. Here, Lepeophtheirus salmonis (salmon louse) is particularly harmful to salmonid species in the northern hemisphere (Kragesteen et al, 2019). There are three main issues with elevated levels of sea lice in salmon farms. One issue is impaired salmon growth where in the worst case, salmon can die of infection either directly or indirectly by secondary infections. Another issue is the treatment itself, which is both costly and can have a negative effect on the local environment. The third issue is the artificially increased infection pressure on wild fish which has been shown to pose a serious risk to wild salmonid stocks (Kragesteen et al, 2019). Apart from a small, introduced stock maintained since the

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1940's in four rivers, salmon are non-native in Faroese rivers. However, to reduce spreads of sea lice and its impact on farmed and wild salmons, a monitoring system was introduced in 2009 with a limit of 2 gravid lice salmon−1, which was lowered to 1.5 gravid lice salmon−1 in a revision of the regulations in 2017 (Kragesteen et al, 2019).

C. Pollution

Aquaculture activities in the Faroese inland fjords come with waste production. This includes biological waste from the open salmon cages in the fjords, chemical waste that is used in production (this could also be linked to fish treatments such as against sea lice), and biological waste from the smolt plant. More concrete data on potential impacts of those have not been analysed further in the frame of this project report.

6.2.1.3. Conflicts with other activities

As mentioned in chapter 5.2.1.2.B, in the Faroe Islands, commercial fishermen have reported negative impacts associated with salmon cage farming on fisheries, especially in terms of lobster and whelk. Here, a decreasing fish quality has been reported.

6.2.1.4. Mitigation

When it comes to conflicts with fishermen as mentioned in the previous paragraph, the promotion of a stronger spatial separation between fish farming and commercial fisheries in Faroe Islands (Suðuroy) is associated with the potential to limit conflicts

Besides, Suduroy has introduced a biogas plant on the island Streymoy. It has been newly constructed by a subsidiary of the constructing company operating on Suðuroy.

6.2.1.5. Ambitions

Company information can provide information about ambitions and the company's self-perception. According to their website, Bakkafrost is the largest salmon farmer in the Faroe Islands, and we have a duty to ensure we also do this responsibly. This means thinking long-term on economic, social, and environmental issues. Our mission is to produce healthy world-class salmon.

- Company website: https://www.bakkafrost.com/en/sustainability

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6.2.1.6. Perceptions

- Annual sustainability reports and annual reports: https://www.bakkafrost.com/media/2356/bf_annualreport_web_2019.pdf

Consultancy report, in Faroese

- Report on analyses of benthic fauna: Fiskaaling 2020. Botndjórasamfeløg – eitt føroyskt sammetingargrundarlag. Frágreiðing Heidi S. Mortensen, Gunnvør á Norði, Birgitta Andreasen og Tróndur T. Johannesen (Unfortunately, there is no access to the information, no web link)

Potential interesting views on conflicts between local fishermen and fish farming industry, but the information is only in Faroese.

- Employment: http://kvf.fo/netvarp/sv/2019/01/14/20190114bakkafrost
- Discussions in local newspapers by fisheries, aquaculture industry, politicians and marine scientists on the recent rapid decline of the coal fish stocks: Dimmalætting 28. May 2021 and Dimmalætting 5. June 2021 (Unfortunately, there is no web link access to the information).

- Reports from fishermen on the negative impact on lobster and whelk and on fish quality, catching data, regular testing of the environment around the sea cages since 1998. (Unfortunately, there is no access to the information, no web link, or other identifiable sources)

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6.2.2. Varangerfjord

The Varangerfjord (Northern Sami: Várjavuonna, Kven: Varenkinvuono, Finnish: Varanginvuono) is the easternmost fjord in Norway. The fjord is located in Troms and Finnmark county between the Varanger Peninsula and the mainland of Norway. The fjord flows through the municipalities of Vardø, Vadsø, Nesseby, and Sør-Varanger. The fjord is approximately 95 kilometer's long, emptying into the Barents Sea. Its mouth is about 70 kilometers wide, located between the town of Vardø in the northwest and the village of Grense Jakobselv in the southeast (figure 17).

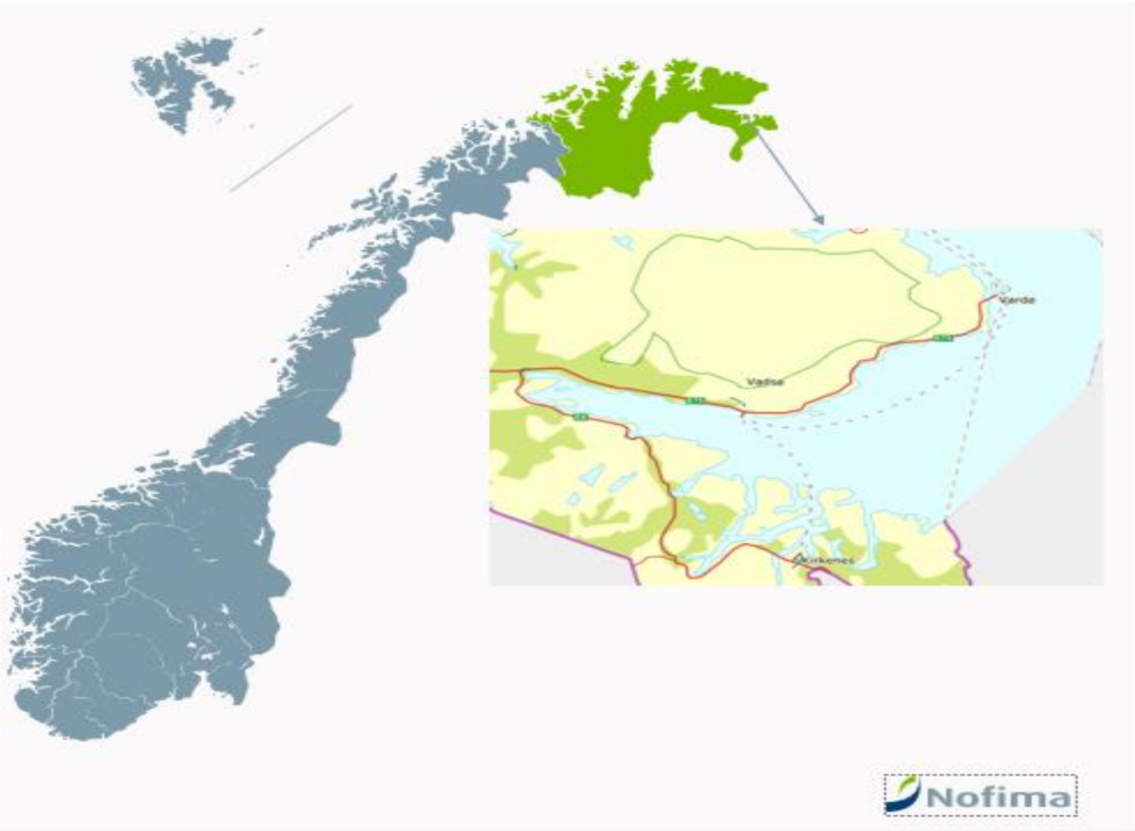

Figure 17. The location of the Varangerfjord Hub

When it comes to the blue economy, Varangerfjord is characterised by extensive aquaculture and fishery activities. On the one hand, Varangerfjord is a traditional sea Sámi community with traditional fisheries. On the other hand, Lerøy has started salmon farming in Varangerfjord and other multinational aquaculture companies are planning to establish new aquaculture farms in the fjord. A global driver affecting Varangerfjord is the potential of developing ten times more salmon production to meet the demands of salmon products in the world. Also, fishing tourism has increased next to the international players, this has greatly influenced the traditional fisheries as well. Aquaculture licenses

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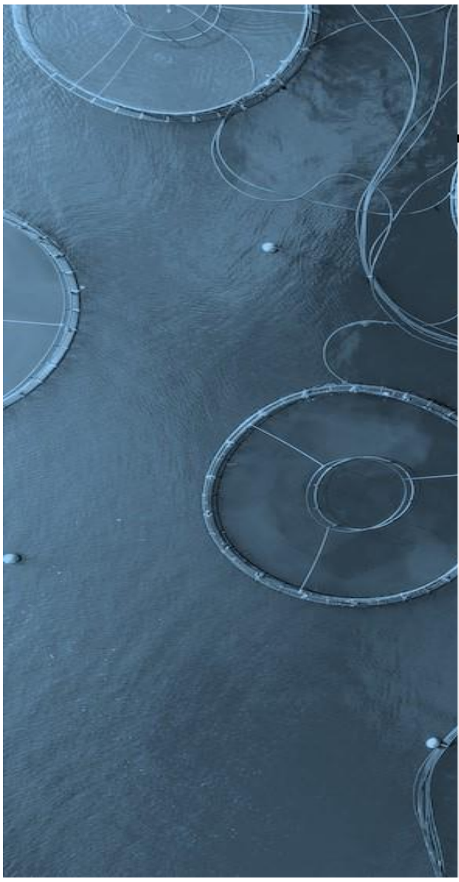
for within the Varangerfjord area are owned by the company Lerøy Aurora AS which specializes in seafood production in Troms and Finnmark (see figure 18: Industrial factsheet Varangerfjord).



Industrial factsheet **Varangerfjord** – *Lerøy Aurora* aquaculture

Company: Lerøy Aurora AS

Ownership: Lerøy Seafood Group

Location: Troms and Finnmark (with license for salmon cage farming in Varangerfjord)

Activity: Lerøy Seafood Group is Norway's largest exporter of seafood, and one of the largest producer of Atlantic Salmon in the world. Today the company has a global presence stretching from China to the USA

Spatial extent: 9 aquaculture farms in Troms and Finnmark (4 in Finnmark, of which one in Varangerfjord)

Production: 4,887 GWT harvest volume in 1st quarter of 2022 for Troms and Finnmark

(Lerøy, 2022; Lerøy, 2021)

Figure 18. Industrial factsheet Varangerfjord: Lerøy Aurora

Although a major focus will be on the aquaculture industry in terms of environmental performance (as this is the centre of attention of ArcticHubs), some of the next paragraphs will also introduce relevant information about the fisheries industry as it shares significant space with aquaculture.

Aquaculture

Atlantic salmon (Salmo salar) is ranked in the top 10 of the most produced and most valuable marine fish species in the world's aquaculture (FAO, 2020). Although global production volume has been relatively stable at around 2 million metric tons (MMT), the salmon price has displayed some volatility over the past 10 years, mostly due to reduced short-run elasticity of supply (Asche et al., 2019). Salmon cage farming has traditionally been located at higher latitude regions, such as Norway, Faroe Islands, Iceland, Scotland, Canada, and Chile. In Norway 600 salmon/trout farming location was active in 2020

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distributed along the Norwegian coastline (figure 19). Approximant 5 % was used for rainbow trout and 95 % was used for salmon production. North Norway accounting for 25 % of this production. The production has increased from 1 million metric tons in 2009 to 1,4 million metric tons in 2019 (SSB).

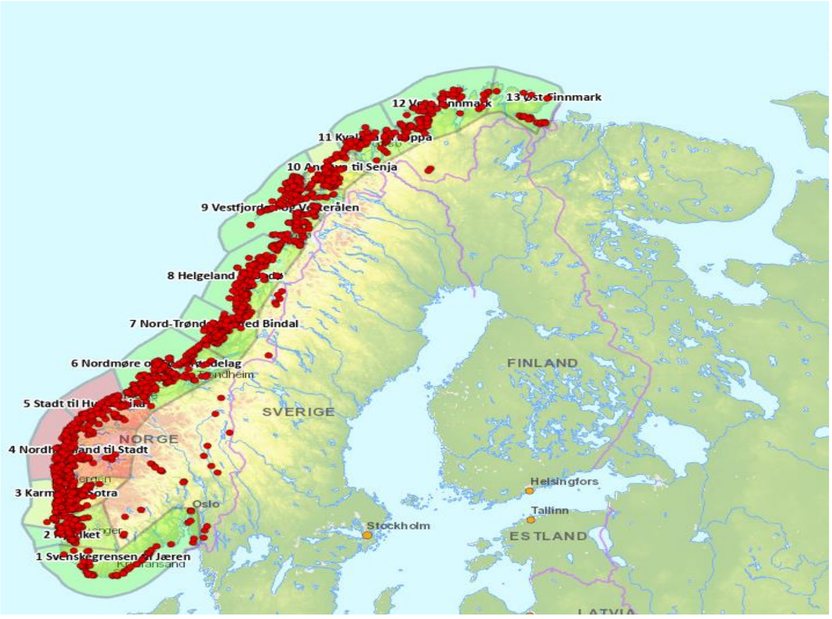

Figure 19. Active farming locations in 2020, distributed along the Norwegian coastline.

The production of salmon in Northern Norway has been steady increasing for the past 25 years and is currently at about 600 metric tons, where Nordland County still has the largest production after Troms and Finnmark county (figure 20).

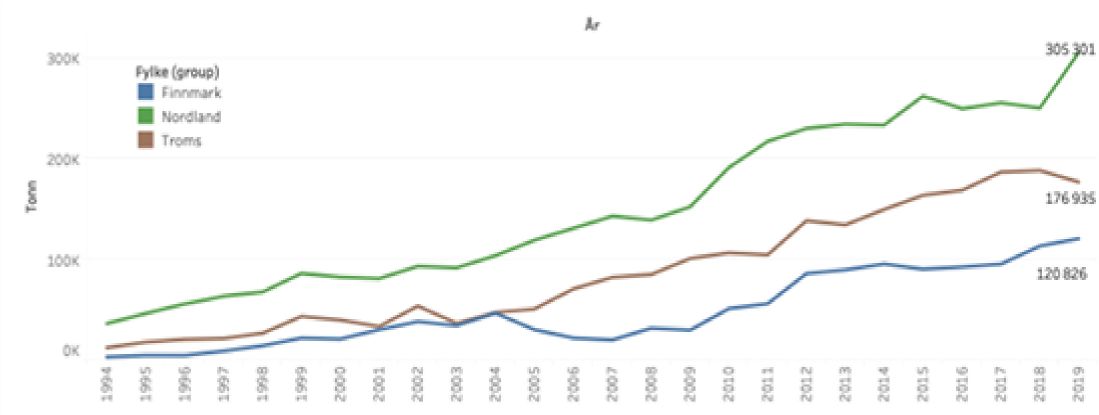

Figure 20. Production of salmon (metric tons) in Northern Norway in the period 1994 to 2019 (source: FDR)

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Fisheries

A total of 11048 fishermen were registered in 2019, with a total catch of 248,352 tones (SSB). The fisheries in Norway had in 2019 a first-hand value of 21637 mill. NOK, where cod fisheries is the most important fisheries followed by mackerel, herring and saith (Table 7).

Table 7. Catch (in tons) delivered from Norwegian fisherman and first-hand value of the catch in 2019 (source: Statistisk Sentralbyrå (SSB))

	Catch (ton)	First-hand value (mill. NOK)
Total	2483523	21637
Cod	329897	7486
Mackerel	159085	2509
Herring	561535	2574
Saith	194980	1668
Shrimps	27758	946
King crab	1726	303
Other species	1208542	6151

The traditional fisheries in Varagnerfjord hub are whitefish (cod, saith and haddock), halibut, shrimps, and red king crab, where approximately 140 small fishing boats (size under 11 m) are fishing and delivering their catch in the Varangerfjord (table 8). The most important fisheries in Varangerfjord are cod fisheries. The first-hand price of cod has been affected by the Covid 19 pandemic, with a drop from 25 NOK /kg in 2019 to 15 NOK /kg in 2021 (NRF).

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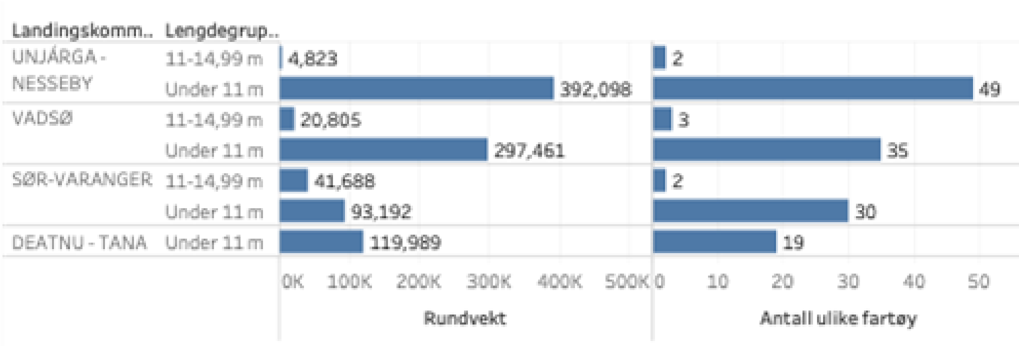
Table 8. Catch (in tons) and number of fishing boats fishing cod and saith in Varangerfjord in 2020 (source: Norges Råfisklag (NRL))



Next to the traditional fisheries in the Varangerfjord, the king crab is currently the most valuable species exported from Norway. Since 2000, a total of 38 539 tons of RCK have been caught, 89 % of the catch has been registered in the quota area while the remaining catch has been taken in unregulated sea areas. In 2020, Norway king crab exported MNOK 668, equivalent to a volume of 2017 tons (Seafood.no). A total of 772 vessels with king crab concessions have been registered in 2020: 665 vessels in open group and 107 in closed group. Of this 106 king crab vessels are related to Varangerfjord. In total 37 companies have license to by king crab in Troms and Finnmark county. Table 9 (see below) give an overview of the company's and the quantity in tons of king crab they have bought in 2020.

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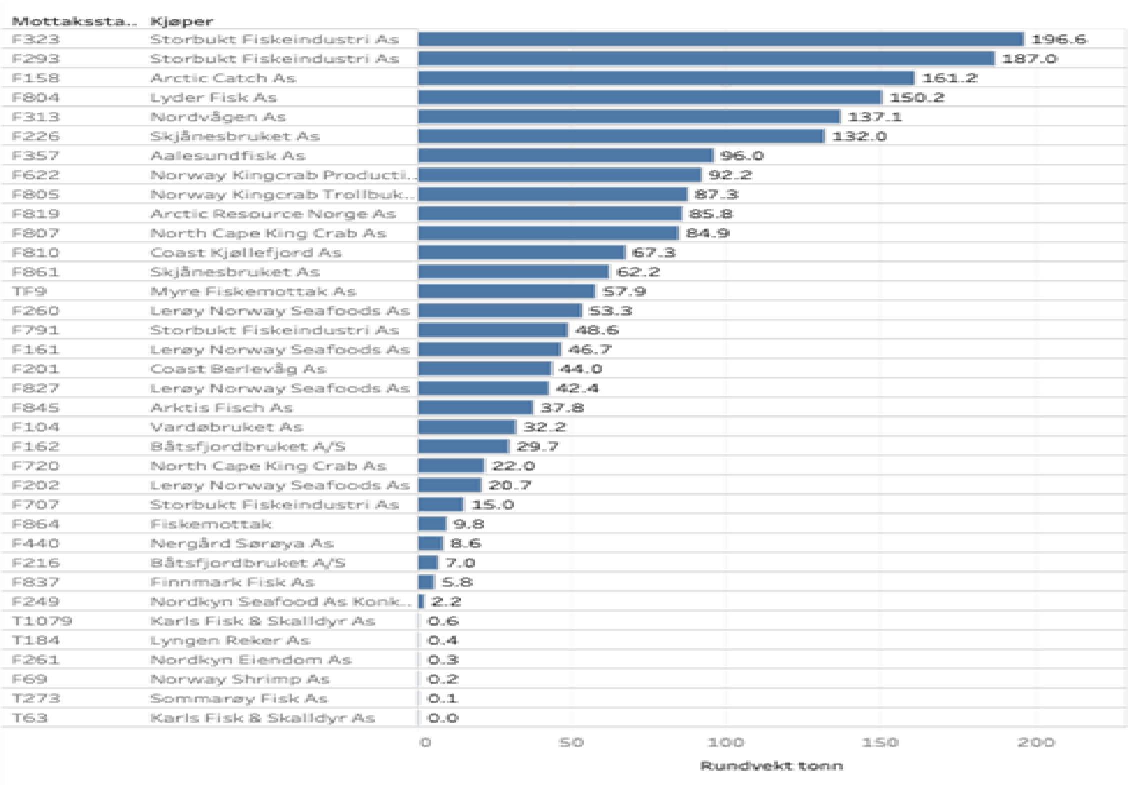
Table 9. Overview of companies in Troms and Finnmark county and the quantity (in tons) of king crab they have bought in 2020



6.2.2.1. State of the art / environmental background

The coastal zone in northern Norway is distinctive with large fish and shellfish resources and a great potential for value creation for several marine industries like aquaculture, tourism, but also offshore windmill plants and mining. The precondition for sustainable business development in the north is therefore that different industries can operate well side by side in the coastal zone. In this context, there are often conflicts about the use between existing and new industries and the level of conflict between various players in the coastal zone can be high at times.

The Varangerfjord is the only fjord that runs on an East-West axis. Accordingly, the surrounding vegetation zones run parallelly with this orientation, so that the northern shoreline is mainly characterised by tundra, whereas the southern shoreline has a richer vegetation with easy access to pine woodland located close to the major river systems that drain from the interior to Varanger's southern shoreline (Damm et al, 2020). In general, while western Finnmark is somewhat warmer, eastern Finnmark is drier and colder, though warm continental winds in the summer can raise temperatures above 30 °C. Because of limited precipitation, the landscape is rather barren in

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vegetation, giving it a more ‘Arctic’ character; stretches of the outer coastlands exhibit ‘true' Arctic vegetation in the strict bioclimatic sense (Damm et al, 2020). Moreover, the Varangerhalvøya National Park is located close to the northern shoreline of the Varangerfjord where subarctic and low Arctic mainland meet each other. The national park is surrounded by several protected areas with landscapes characterized by rugged and discarded layered rocks on the coast, unique dune systems, pebble beaches with clear traces from the uplift and the rough Arctic business coast with drift timber and the absence of vegetation on the outermost coast (Varangerhalvøya, 2022).

In the Varangerfjord itself, industrial activities linked to the blue economy extent over the largest part of the water area and can be characterised by higher ship traffic. Fishing boats under 11 m in length are not equipped with automatic identification systems (AIS), but an automatic tracking system that uses transceivers on ships is used by vessel traffic services (VTS). Boats over 11 m are obligated to use AIS and figure 21 maps the tracking information from fishing boats over 11 m. Accordingly, this group of boats fish only in the outer part of the Varangerfjord, according to applicable regulations.

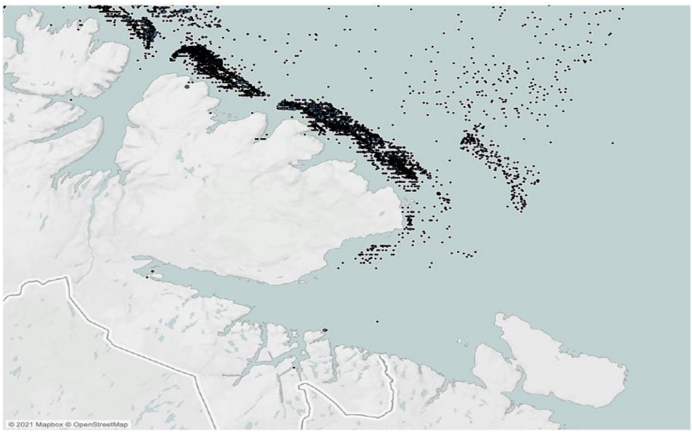

Figure 21. Fishing boats over 11 m in length (black points) with AIS fishing in the Varangerfjord area in 2021 (source FDR)

In addition, Figure 22 illustrates the fishing area and the catch (in tons) of the biggest 6 shrimp boats that trawl shrimp in the Varangerfjord. The AIS data from FDR has been used to determine the fishing area. In addition, 106 king crab fishing boats are fishing exclusively in the Varangerfjord (Seafood.no, 2020).

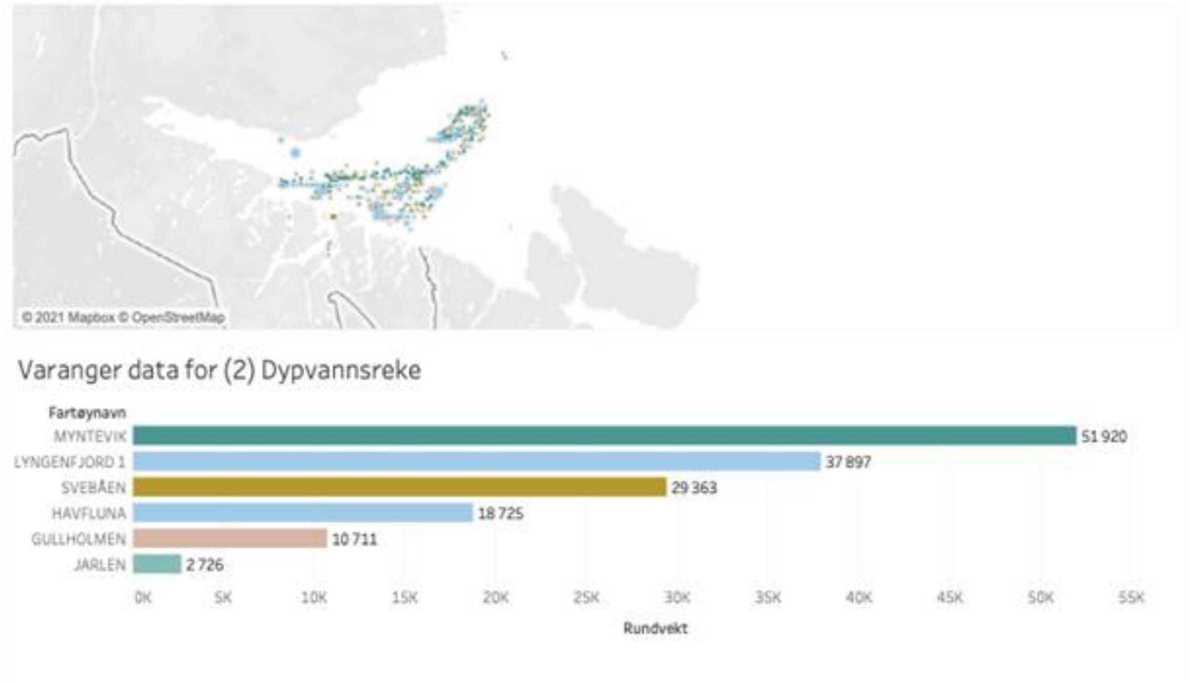

Figure 22. Fishing area (AIS data) and catch (in tons) of the 6 shrimp boats that trawl shrimp in the Varangerfjord (FDR)

Over time, the red king crab has significantly impacted the area in and around the Varangerfjord. The species was introduced to the southern Barents Sea in the 1960's with the aim to develop a new, commercially attractive stock. However, in the subsequent decades, the stock has indeed become abundant and widespread, but the species' presence also implies intense predation on benthic biota and thereby severe degradation of benthic ecosystems.

6.2.2.2. Environmental impacts

To abate the environmental impact and risk associated with Atlantic salmon farming, the government of Norway has imposed restrictions on awarding production licenses as well as regulations limiting the allowed biomass, stocking numbers, and production densities in cages. These have mostly been motivated by concerns regarding the impact of salmon farms on surrounding wildlife, especially the spread of the salmon louse (Lepeophtheirus salmonis L.) and escapes of salmon from farms to wild populations (Hersoug et al., 2019; Iversen et al., 2020; Larsen and Vormedal., 2021). Fish farming is today in Norway the largest source of anthropogenic supply of phosphorus to coastal areas, as well as a major source of nitrogen emissions, and this has also been considered to have negative environmental effects. There are also other aspects like impact on the environment like discharges of

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plastic, feed human activities and chemicals to sea. In the following capture some of the most environmental impact and risk associated with Atlantic salmon farming are listed.

The following environmental impacts are based on the aquaculture industry operating in the Varangerfjord in terms of salmon farming.

A. Habitat and landscape

In the Varangerfjord area four production licenses have been granted including two sea-based facilities and two land-based facilities with salmon smolt and arctic charr production. Besides, there is also one license granted for shellfish and macroalgae production (figure 23). The sea cage farming license for salmon is owned by the company Lerøy Aurora.

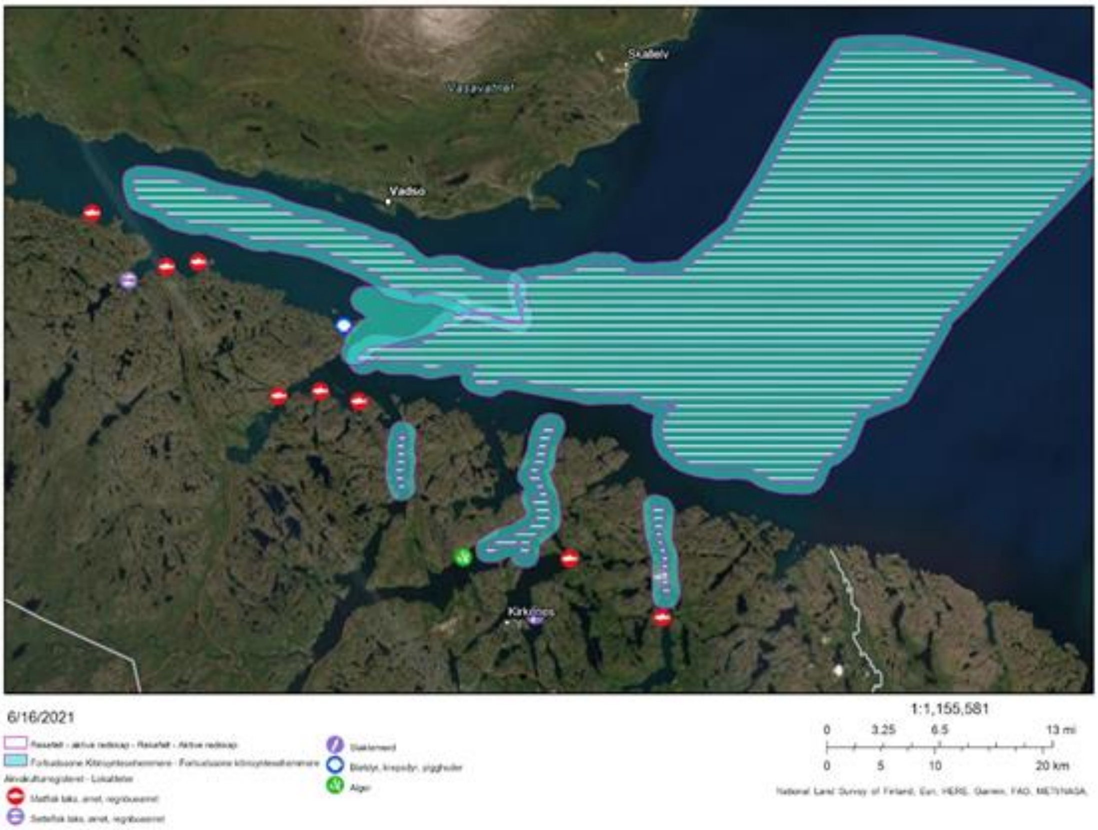

Figure 23. Aquaculture license, shrimp area and restricted area for use of chitin inhibitory lice chemicals in Varangerfjord (source: FDR)

Nevertheless, the aquaculture industry in terms of salmon farming can be characterised by several environmental impacts and the threat to ecological systems posed by aquaculture activity is

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significant. The risk of pathogen transmission from farmed to wild salmon has been demonstrated and open-net sea-pen salmon culture is recognized as a coastal ecosystem modifier across trophic levels, epidemiologically linking vastly separated wild salmonid populations (Morton and Routledge, 2016).

One of the major challenges in Norwegian aquaculture industry is the infestation of salmon by the salmon louse (Lepeophtheirus salmonis) (Torrisen et al. 2013). Salmon lice are small marine ectoparasites feeding on mucus, blood, and skin of salmonids and if present in sufficient numbers they can cause significant damages to the farmed fish and the wild Salmon population. To combat salmon lice, the industry is using several techniques, including different mechanical (e.g., hot water, pressure) biological (e.g., cleaner fish) and chemical treatments. In recent years, mechanical and biological treatment have increased, but still many farms use chemotherapeutic treatments (e.g. organophosphates, pyrethroids, and hydrogen peroxide (H2O2)) or in-feed treatments (e.g. emamectin benzoate) to keep the sea lice numbers below the allowed levels (Remen & Sæther 2018). Disease outbreaks and parasites still pose a significant threat to the sustainability of salmon farming and profitability of sea cage farm operations (Overton et al., 2019). The threat posed by sea lice (Lepeophtheirus salmonis and Caligus elongatus) has long been recognized and continues to be of particular concern, as these parasitic copepods continue to induce high levels of mortality in the salmon farming and have negative environmental impact (Larsen & Vormedal, 2021). Chemotherapeutants used to control sea lice infestations in salmonid aquaculture are a growing environmental concern. Hydrogen peroxide (H2O2), a common bath treatment used around the world, is released directly into the environment where nontarget organisms are at risk of exposure and can potentially affect the ecosystem (Fang et al. 2018).

B. <u>Changes in Biodiversity</u>

A negative impact linked to Varangerfjord aquaculture are farmed salmon escapes. Escaped farmed salmon make their way up the river systems and mixes with the wild population can lead to a change in the characteristics of wild salmon. Offspring of wild salmon and farmed salmon shows poorer survival and adaptability than pure wild salmon (Araki et al., 2017). Large amounts of escapes can also affect the ecosystems in the rivers, like the introduced of pink salmon into the Barents Sea. The recapture of escaped farmed salmon varies from year to year. The level was at its lowest in 2017 with about 17 000 individuals. In contrast, the number was up to 290 000 in 2019 (Barentswatch, 2021). There are several factors that can cause the salmon to escape from the cages: The fish can escape in connection with withdrawal or other operation and handling, such as the removal of sea lice. There may be wear and tear-on nets that causes the salmon to get through, or cases that are a result of boat hit-and-run accidents. However, extreme weather is the cause of most escape incidents. Inter-breeding and competitive interactions of escapees with wild salmon within rivers may have detrimental effects on wild populations.

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Another significant impact on wild fish is associated with the aquaculture fish feed that is released into the natural environment. With an annual feed consumption of one million tonnes in Norway, the annual spill is calculated to be 70,000 tonnes of feed. The consumption of food pellets by aggregated fish causes changes in their biological condition due to the different availability of food and its composition compared to natural resources. Aquafeeds are composed of fish meal and fish oil, as well as vegetable-based ingredients. They contain a high protein content (40%–70%), are highly digestible and have low amounts of ash, salts, total volatile nitrogen, and dimethyl nitrosamine. The introduction of this source of food to the marine environment modifies the fatty acid (FA) composition and fat content levels of tissues of wild fish that feed on the lost pellets may also be elevated. This has been demonstrated for saithe (Pollachius virens) (Skog et al., 2003; Fernandez-Jover et al., 2011) and Gadus morhua (Fernandez-Jover et al., 2011) living close to salmon farms along the Norwegian coastline. This enhanced biological condition is a typical marker of higher spawning success. Fat content and fatty acid composition of commercial aquafeeds may differ so greatly from typical natural fish diets that negative effects may occur (Tayler and Dampster 2016). There is some indication that on average more than 10 tonnes of wild fish of 15 species forage near fish farms. In saithe an average of 33 grams of pellets were found (Ryen 2009). New results indicate that pellets from the aquaculture industry affect the quality of the saithe (Humborstad et al., 2021) Abundance and assemblage composition of wild fish around farms vary significantly across geographical areas. Aggregations are temporally stable over the scale of several weeks to months, both in relative size and species composition, indicating some degree of residency of wild fish at farms. However, large seasonal differences in the species composition and biomass of wild fish assemblages have been noted around farms in Norway (Uglem et al., 2009; Demster et al 2009; Humborstad et al. 2021) Around salmon farms in the Norwegian coastal ecosystem, the bentho-pelagic Gadus morhua were significantly more abundant on rocky bottoms than on plain sand or mud bottoms beneath salmon farms (Dempster et al. 2009). Similarly, cod abundance was negatively correlated with water depth, indicating that farms in shallower areas aggregated more of this species. Several other species that were abundant around salmon farms were unaffected by any of the farm attributes tested (benthic habitat type, depth, farm size) (Dempster et al. 2009). Taken together, the results suggest that fish farms are most attractive to wild fishes when they are large, located in shallow waters, are close to the coast, and are placed over a rocky substrate, although there are certain species that will likely be attracted regardless of these features (Dempster et al. 2009). Strong attraction to fish farms may interfere with spawning migrations or other behaviours. Otterå and Skilbrei (2014) tracked saithe in western Norway and compared their findings to similar studies conducted prior to the expansion of salmon farming there. They found that distribution of saithe is strongly influenced by salmon farms, and that saithe are now less likely to undertake offshore spawning migration than before, especially smaller individuals.

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Finally, little is known about the influence of salmon farms on the wildlife, but noise, light and land seizures can affect seabirds, whales, seal, and other marine wildlife.

C. Pollution

Ever since fish farming has existed along the coast of Norway it has contributed to the release of nutrients. Fish farming is today the largest source of anthropogenic supply of phosphorus to coastal areas, as well as a major source of nitrogen emissions. Emissions of nutrients such as phosphorus and nitrogen normally occur via the metabolic processes when the fish digest the dry feed (Norwegian Environment Agency, 2019). In case of large discharges of nutrients, one can experience a resurgence of algae. When the algae die, they sink to the seabed and the degradation, which requires oxygen, affect the seabed ecosystem by making it oxygen poor. In general, The Norwegian Environment Agency reports that Norwegian fjords generally have good water replacement that prevents the accumulation of nutrients and organic matter. However, the lack of figures makes it difficult to establish which amounts of nutrients make different fjords achieve a saturation rate. Important habitat areas for different fish and shellfish species and vulnerable areas such as coral reefs, sponge areas, calcareous algae, macro algae, deposits and eel grass meadows may be at risk from large discharges of nutrients.

Furthermore, fish farms use impregnation agents on the net to prevent grow, normally agents based on copper, and it is estimated that 80-90 percent of the copper leaks out during a net's lifetime (180 days at sea). Copper is also included in the feed as an essential metal for the fish. High concentrations of copper are toxic for aquatic organisms and copper is listed as a water region-specific substance in the water regulations. Discharges may affect the classification of the ecological condition of the water body. In general, little is known about the influence of salmon farms on the distribution of different metals and elements, including potentially toxic metals, such as Hg, Cd, Pb and Zn in wild fish. A study from Pacific Canada suggested that salmon farms may act as a source of Hg at a local scale (Tayler and Dempster 2016). A study documented the concentrations of 30 elements in the livers of demersal Atlantic cod (Gadus morhua) and pelagic saithe (Pollachius virens) caught in association with salmon farms or at reference locations in three regions throughout the latitudinal extent of Norway. The authors concluded that salmon farms do not lead to a general increase in the concentrations of potentially harmful elements in wild fish and suggested that the distribution of Hg and other elements in wild fish in Norwegian coastal waters may be more influenced by habitat use, diet, geochemical conditions, and water chemistry (Bustnes et al. 2011).

In addition, modern aquaculture makes use of plastic-based lines, cages or nets suspended from buoyant or submergible structures as well as nanotech plastic-based anti-biofouling agents and paints (Lusher et al., 2017). Tanks, pens, nets, floats, pontoons as well as the pipes of the fish feed suppling systems are made of plastic material. Plastic materials within aquaculture sites are maintained and

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controlled for chemical degradation, biofouling and corrosion, with regular inspections to ensure strength and stability (Gomier et al. 2020). Pellets that pass-through feed pipes under pressure cause abrasion in the pipes and wear the plastic from the inside, causing the formation of an unknown number of plastic fragments. Plastic from the feed pipes enters the salmon pens together with the pellets, and is spread into the sea, where it may be taken up by biota. Microplastic particles of various polymers from the salmon industry has been observed and quantified in fish feed, sea water, suspended matter, sediments and on fish gills. The long-term effects of microplastic ingestion are unknown (Gomier et a., 2020).

In the Table 10 (see next page) some of the most environmental impact and risk associated with Atlantic salmon farming are listed and evaluated from high to low impact based on the evaluation of the status of the knowledge at this stage.

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Table 10. Fish farming and the environmental effects (dark blue= high impact; light blue = medium impact: white= low impact)

Impact	Negative enviromantal impact						
	Low trophic species e.g. algae, benthos	Wild fish population	Fisheries	Habitat destruction	Turism industry	Impact on animal populatltion , e.g. birds , seals, otter, whale	
Breeding and Hatchery (FW)							
Disease							
Pollution							
Juvenile (FW)							
Disease							
Pollution							
Growout (Marine)							
Viral disease							
Bacterial disease							
Parasitic infection: Sea Lice							
Parasitic infection: Ameobic Gill Disease (AGD)							
Cleanerfish							
Parasitc treatment (e.g. Sea lice)							
Plastic pollution							
Heavy metal							
Area use (for salmon farming)							
Feed loss							
Nutrients							
Sound pollution							
Light pollution							
Human activities							
Slaughter							
Human activities							
Transport							
Road							
Air							
Train							
Wellboat							
Feed							
Marine ingredients							
Terrestrial ingredients							

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6.2.2.3. Conflicts

Critical impacts of salmon aquaculture in the Varangerfjord are associated with parasite infection and the genetic mixing of wild fish and fish farm escapees. This is mostly a concern of recreational fishing activities which are an important part of the tourism industry but can also concern indigenous fishing activities taking place in the Varangerfjord area (is that right?).

6.2.2.4. Mitigation

A mentionable mitigation practise has for longer been the combating salmon lice. As described in the previous chapter 3.2.2.2.1, the industry is using several techniques in this regard including mechanical (e.g., hot water, pressure) biological (e.g., cleaner fish) and chemical treatments. In recent years, the application of mechanical and biological treatments has increased, but still many farms use chemotherapeutic treatments (e.g. organophosphates, pyrethroids, and hydrogen peroxide (H_2O_2)) or in-feed treatments (e.g. emamectin benzoate) to keep the sea lice numbers below the allowed levels (Remen & Sæther 2018).

6.2.2.5. Ambitions

Lerøy seafood is the main seafood company in Varangerfjord. They are trading on a global market and the homepage includes information about sustainability policy and environmental measurements. According to their homepage, Lerøy is both producing in and harvesting from the sea, and it is an absolutely imperative for the Group to keep the oceans clean and healthy. The company strive to reduce the environmental footprint and minimise their influence on wild habitats including wild salmon stocks.

- https://www.leroyseafood.com/en/sustainability/

6.2.2.6. Perceptions

Company information can provide information about ambitions and the company's self-perception.

- Company website: https://www.leroyseafood.com/en/

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6.2.3. Vestfjords

The Westfjords region (Figure 24) in the northwest part of Iceland comprises, approximately 9.400 km² of Iceland´s land area (NLSI, n.d. 1). Glaciers from the last ice-age have formed the landscape, with steep mountains and deep and narrow fjords. Agricultural land is limited but rich fishing grounds and sheltered fjords have been the foundation for settlements and sometimes more prosperity than in other parts of Iceland. The Westfjords area, with around seven thousand inhabitants, can be divided into three economic areas, the North part, the South part and 'Strandir', where small fishing villages are the basis for the economy (Edvardsdótttir, 2016).

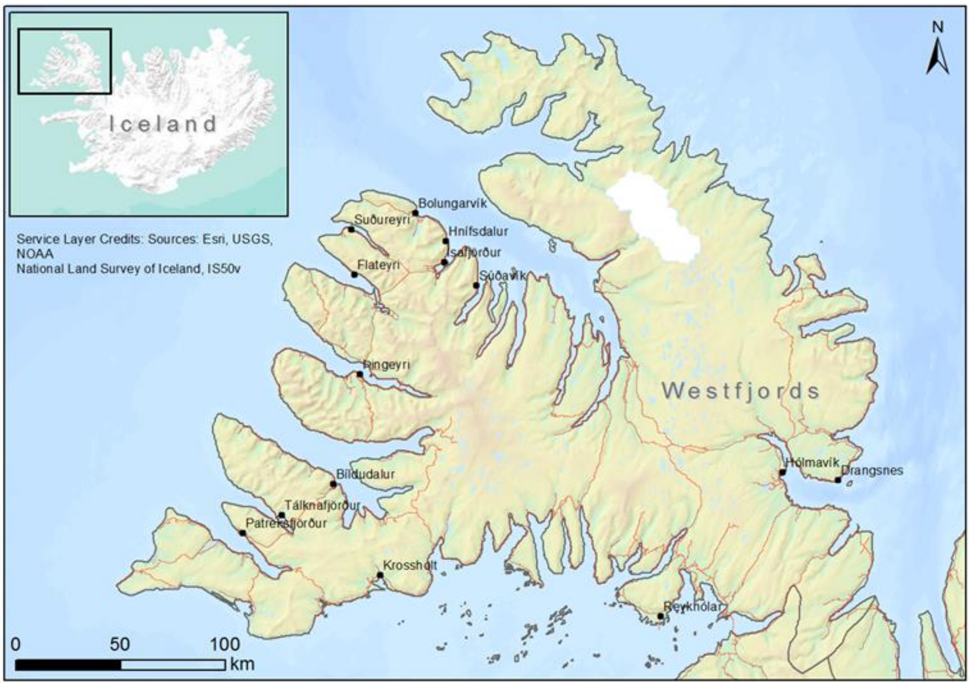

Figure 24. The Westfjords and its major settlements (Source: NLSI, n.d. 1)

The South part of the Westfjords, with 1.312 inhabitants, will be the research area for the fish farming hub. In recent years, there has been rapid development of cultivating Norwegian salmon in open sea cages. Four small villages are situated in the area; Reykhólar 104 inhabitants; 48 males and 56 females, Patreksfjörður, with 740 inhabitants; 386 males and 354 females, Tálknafjörður, with 236 inhabitants; 133 males and 103 females, and Bíldudalur, with 284 inhabitants; 175 males and 109 females (Statistic Iceland, 2022). The villages affected by the aquaculture are Patreksfjörður and Bíldudalur, but they form a municipality called Vesturbyggð and Tálknafjörður, which is a special municipality. The two

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municipalities, and three small villages are the research cases in Iceland (Figure 24). Two aquaculture companies operate in the villages, Arnarlax and Artic Fish (see figure 25: Industrial factsheet Vestfjords), which are now in majority owned by Norwegian aquaculture companies. These companies want to expand their production in the area, rationalising the expansion by positive economic impact for the communities, such as population migration and job creation (Teiknistofan Eik, 2016; Arnarlax, 2022; Arctic Fish, 2022).

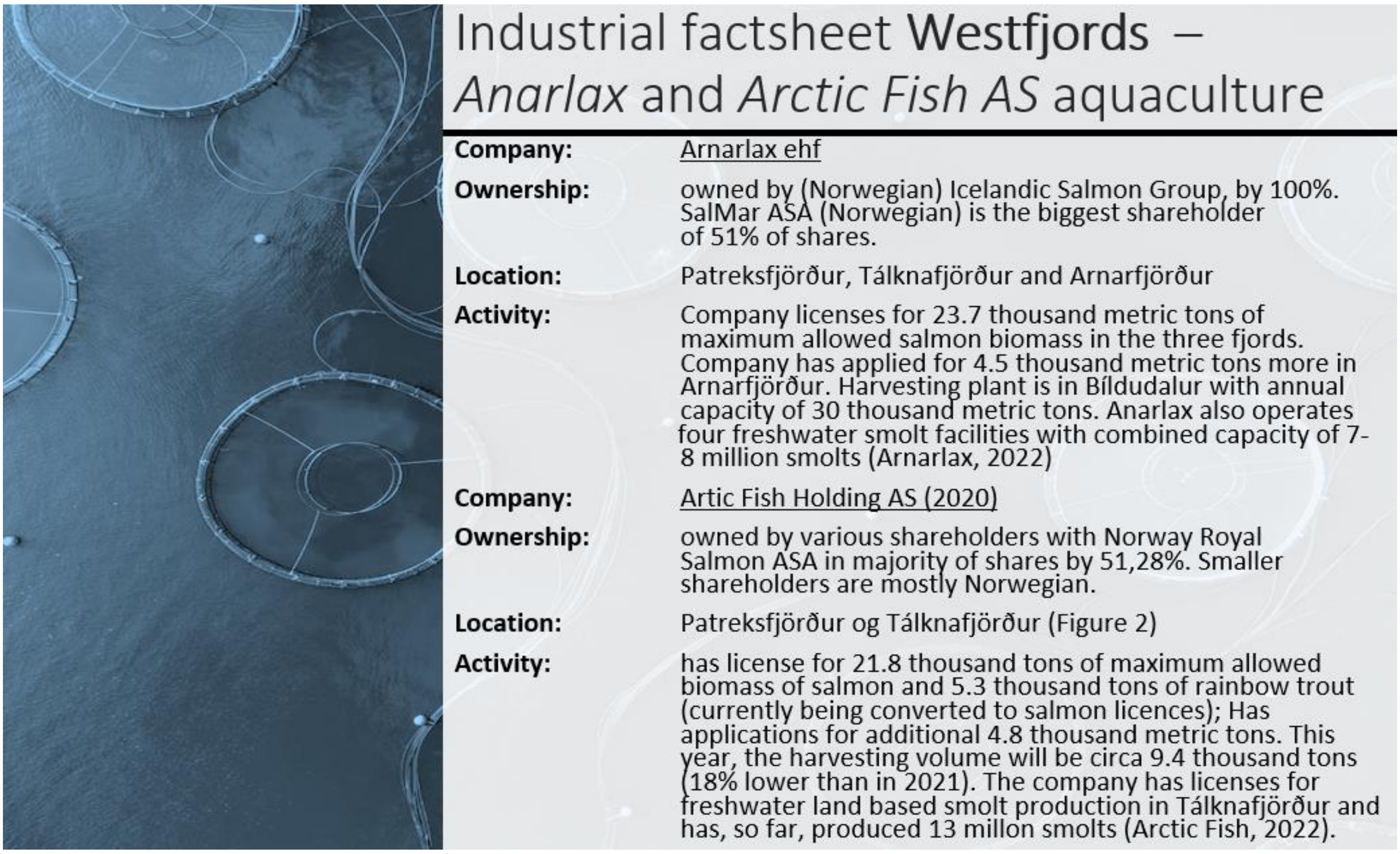

Figure 25. Industrial factsheet Vestfjords

More concretely, figure 26 presents the Arnarfjörður area including associated aquaculture sites. The fjord has a spatial extent of 285 km².

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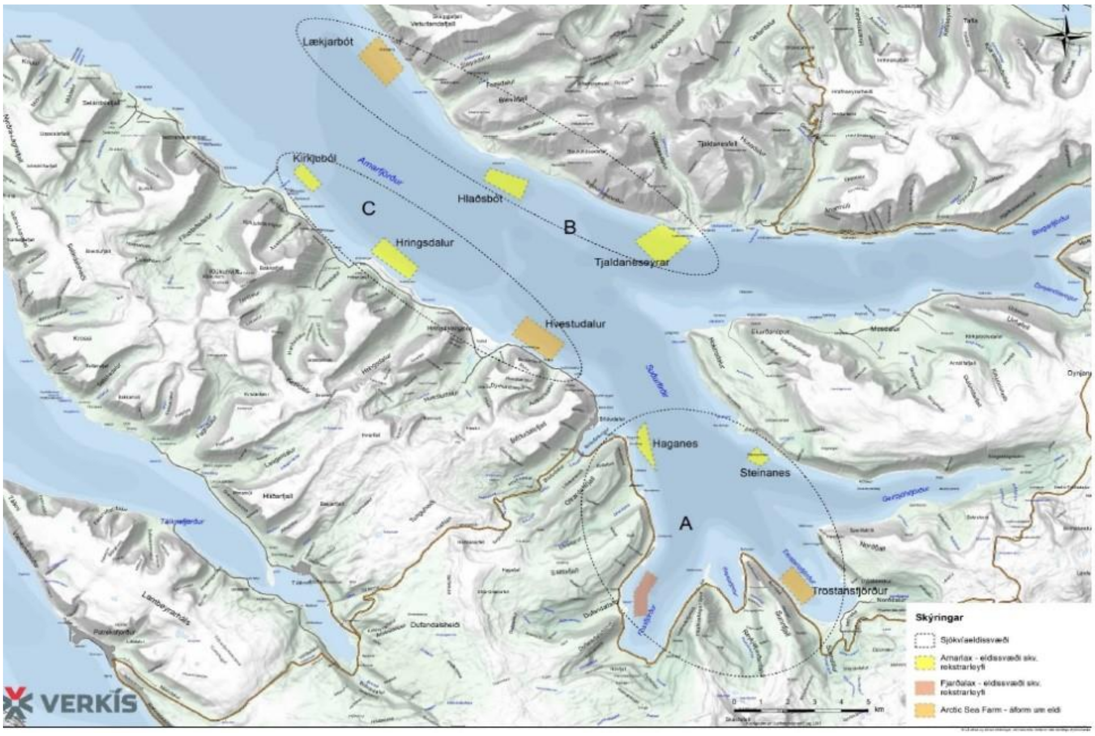

Figure 26. Aquaculture sites in Arnarfjörður (Verkís, 2019a)

Moreover, figure 27 presents the areas of Patreksfjörður and Tálknafjörður including here located aquaculture sites. Tálknafjörður is 30 km² and Patreksfjörður is 66 km².

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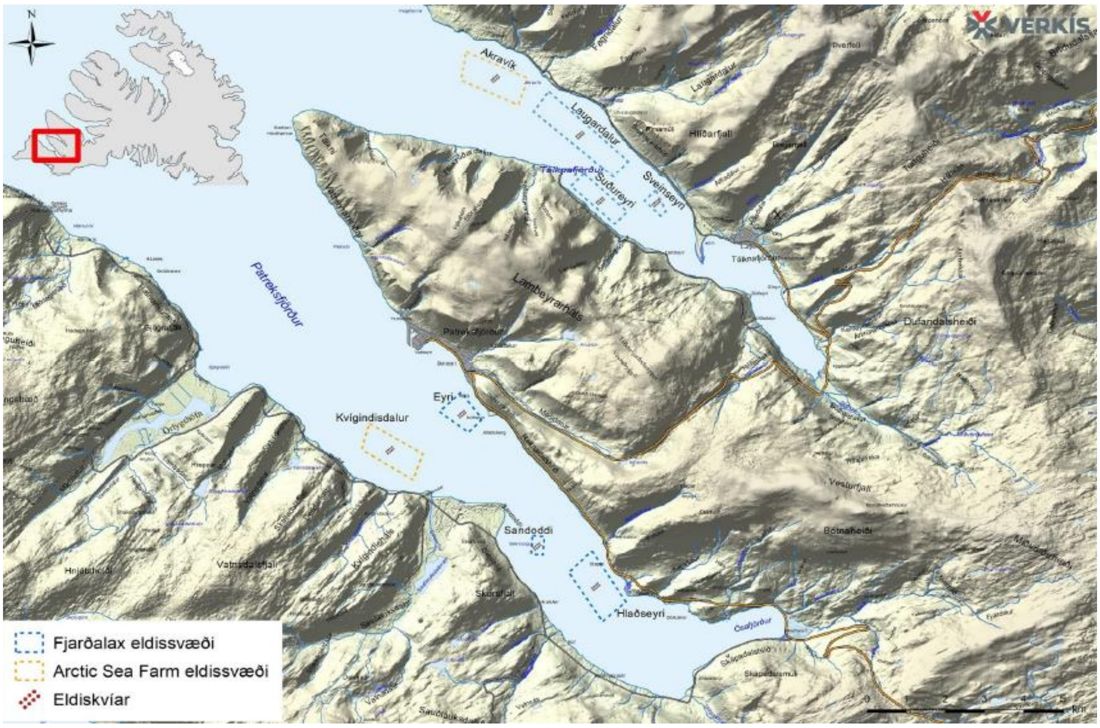

Figure 27. Aquaculture sites in Patreksfjörður and Tálknafjörður (Verkís, 2019b)

6.2.3.1. State of the art / environmental background

The Arnafjörður fjord is one of the Westfjords´ south fjords and cuts into the landscape in south-east direction. The fjord is around 40 km long and is surrounded by steep mountains. In the middle, the fjord is divided into two parts (Figure 26). South-west winds are dominant (50%) but north-east winds are about 30%. In Iceland, sometimes sea ice comes into the fjords, but very seldom into Arnarfjörður. However, land ice can be a problem, because it damages the sea cages, but in Arnarfjörður it is not common. Ocean waves in Arnarfjörður are not strong, but because the fjord is big, wind waves can become big and choppy (Marine & Freshwater Research Institute, n.d1).

On the bottom of the fjord, calcareous algae sediment can be found in large scales and a mining company was founded in 2006 to exploit the sediment. There is no conflict between these two industries and their operations in the fjord do not affect each other activities. The fjord is also a breeding ground for haddock and cod and there is also a local shrimp stock, which has for many years been below average (Marine & Freshwater Research Institute, n.d1).

On the other hand, Patreksfjörður and Tálknafjörður lie furthest to the south out of the Westfjords´ south fjords. Tálknafjörður lies south of Arnarfjörður and Patreksfjörður lies south of Tálknafjörður. They are divided by Tálkni, the mountain (Figure 28). Tálknafjörður is 15 km long and 4.5 km wide and

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it gets narrow further in. On the south side of the fjord there is not much lowland, but much more on the north side. A river, Botnsá, flows into the fjord innermost. Patreksfjordur is 20 km long. Both in Tálknafjörður and Patreksfjörður, small amounts of phytoplankton were found. Small boats can fish in the fjords and the catch is mostly cod, but also haddock, catfish, and plaice. North-east and north-west wind is dominant in both fjords. Sea ice very rarely comes into the fjords, but land ice can be a problem in both fjords, because it can damage the sea cages. Ocean currents in the fjords are strong, which means that oxygen flow through the sea cages and degradation of organic sediment is good (Marine & Freshwater Research Institute, n.d2; n.d3).

In Arnarfjörður, Tálknafjörður and Patreksfjörður, fishermen have reported that catch has increased in the fjords parallel with increasing fish farming of salmon in sea cages (Marine & Freshwater Research Institute, n.d1; n.d2; n.d3).

6.2.3.2. Environmental impacts

The following environmental impacts are based on the aquaculture industry operating in the fjords Arnafjörður, Patreksfjörður and Tálknafjörður in terms of fish farming.

A. <u>Habitat and landscape</u>

Before aquaculture companies can start to operate, they need to have their planned operation evaluated; called Environmental assessment. It is The National Planning Agency who determine whether an operation must undergo an evaluation. The agency´s decision is based on how much salmon the companies want to cultivate and whether it is believed that it would have negative environmental impact. If the companies want to expand their cultivation or their operation changes in any way, they must notify the agency, who decides whether an environmental assessment is needed or not. Environmental assessment is the companies´ responsibility and they must pay for the assessment. When the companies get the green light from the Agency, they apply for a licence from The Environment Agency of Iceland. When that has been approved the companies can apply for a licence to operate to another agency; The Icelandic Food and Veterinary Authority, who based on what has been done by The National Planning Agency, give the companies a licence to operate and see that the companies follow the rules and regulations (National Planning Agency, n.d.; The Environment Agency of Iceland, 2019; 2020; Icelandic Food and Veterinary Authority, n.d1; n.d2).In 2011 Arnarlax notified a cultivation of 3 thousand metric tons of salmon to the National Planning Agency who decided that, and Environmental Assessment was not needed. In 2018, the company notified an expansion in

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cultivation of 4.5 thousand metric tons of salmon to the Agency and it was decided that an Environmental Assessment must take place.

In 2011 the company notified a cultivation of 3 thousand metric tons of salmon to the National Planning Agency who decided that the operation did not need to undergo an environmental assessment. In 2018 when notifying the Agency an expansion in cultivation of 4.5 thousand metric tons of salmon, the Agency decided that an environmental assessment must take place. In 2021 Arnarlax notified the Agency about changes in its licence and changes in cultivation protocol and areas in Arnarfjörður, Patreksfjörður and Tálknafjörður. The Agency decided that an environmental assessment was not needed (National Planning Agency, n.d1.). Present licence from The Environment Agency of Iceland was issued in 2016 and is valid till 2032. There various demands about the operation are listed, such as a monitor plan (Environment Agency of Iceland, 2020).

In 2016, Arctic Fish notified a cultivation of 6.8 thousand metric tons of salmon in Patreksfjörður and Tálknafjörður to the National Planning Agency who decided that the operation had to undergo an Environmental Assessment. In 2018, the company notified to the Agency about a change in the location of sea cages in Patreksfjörður who decided that the operation did not need to undergo an Environmental Assessment. In 2019 when notifying the Agency an expansion in cultivation of 14.5 thousand metric tons of salmon in Patreksfjörður and Tálknafjörður, the Agency decided that an environmental assessment must take place (National Planning Agency, n.d.). The present licence from The Environment Agency of Iceland was issued in 2016 and is only valid for a cultivation of 6.8 thousand metric tons of salmon and is valid till 2035. There various demands about the operation are listed, such as a monitor plan (Environment Agency of Iceland, 2019). Present licence to operate from The Icelandic Food and Veterinary Authority was issued in 2016 and is valid for cultivation of salmon of 6.8 thousand metric tons and is valid till 2026. There are various demands about the operation that the company must fulfil to keep its licence (Icelandic Food and Veterinary Authority, n.d2).

As a result of latest assessments, from a habitat and landscape perspective, common environmental impacts are linked to land use and infrastructure development in terms of roads and buildings which is associated with habitat fractionation. Higher amounts of traffic are furthermore associated with disturbances of wildlife. However, these kinds of impacts are described as rather low. In addition, harsh weather circumstances, especially during winter, are associated with stronger impacts. Accordingly, potential road closures make it difficult to provide salmon cages with fish feed. Another consequence of extreme weather circumstances is that risks of fish escapes from cages are increasing.

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Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
Marine 1. sea tailings in the fjord	1. local destruction of bottom fauna	Low		1. local fishing, sea angling 3. salmon river fishing, sea angling, local fishing 5. treatment used to deal with sea lice can affect the shrimp stock	1. Aquaculture sites are monitored and after one generation of cultivating salmon the sites rests for 3 months	
	2. danger for spreading due to water currents	Low				
	3. parasite infection (sea lice)	High				
	4. impact on spawning areas, mostly cod	Low				
	5. impact on shrimp stock	Medium				

Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
Land use 1. infrastructure development – roads, buildings	habitat fractionation	Low (most infrastructure already existing)		1. recreation, tourism		
2. traffic	1. wildlife disturbance 2. Habitat fractionation	Low				
Wether	1. difficult wether condition during winter	High, road closure and difficult to feed salmon in cages, escapes from cages increases		1. tourism, recreation, local life, salmon river fishermen, local fishing		

B. Changes in biodiversity

Impacts on biodiversity can be described as rather indirect resulting from e.g., weather circumstances or increasing pollution. Weather circumstances can increase risks of fish escapes what might have negative impacts on the natural fish population dynamics in the aquaculture fjords (this can be linked to highlighted consequences in other hubs such as Varangerfjord). Moreover, pollution (see below) in terms of air-, sound- or vision pollution as a result of aquaculture operations can have negative impacts on wildlife and animal behaviour.

Besides, in Arnarfjörður, Tálknafjörður and Patreksfjörður, fishermen have furthermore reported that fish catches have increased in the fjords parallel with increasing fish farming activity of salmon in sea cages.

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C. Pollution

Environment	Environmental impact	Risk	Duration	Impact on other activities	Mitigation	Further needs
Air 1. dust		Low, most activities on sea		2. tourism, recreation, local life		
2. vehicles		Medium, boats run by oil and trucks by gasoline				
Sound	1. noise pollution	Medium, boats going out and comming into harbour and trucks driving in and out of towns		1. tourism, recreation, local life		
Vision	1. visual impact	Low, visual impact of sea cages can have affect		1. tourism, local life		

6.2.3.3. Conflicts

See tables above

6.2.3.4. Mitigation

See tables above

6.2.3.5. Ambitions

- Anarlax (2020). Icelandic Salmon AS. Consolidated financial statements 2020. Retrieved in June 2021 by: https://www.arnarlax.is/static/files/fjarfestar/icelandicsalmon-annual-report-2020_final.pdf (Unfortunately, web link is inaccessible)

6.2.3.6. Perceptions

There are several consultancy reports in Icelandic, done on behalf of Fjarðarla, Artic Sea Farm, and Arnarlax.

- Teiknistofan Eik. (2016). Salmon production in Patreksfjörður and Tálknafjörður (in Icelandic). Work done for Fjarðarlax and Artic Sea Farm Retrieved in June 2021 by https://www.mast.is/static/files/import/leyfi/matsskyrsla-patreks-og-talknafjorur-copy-1.pdf
- Verkís. (2014). Increase of salmon production in sea cages in Arnarfjörður (in Icelandic). Work done for Arnarlax. Retrieved in June 2021 by https://www.verkis.is/media/pdf/12308005-4-SK-0248-Arnarlax-fms.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

(Unfortunately, there is no access to the information, no web link)

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  (Unfortunately, there is no access to the information, no web link)
- Verkís. (2019). Salmon production in Patreksfjörður and Tálknafjörður. Additional information (in Icelandic). Work done for Fjarðarlax and Artic Sea Farm. Retrieved in June 2021 by Patreks-Talknafj-14500-tonn-vidbot-vid-frummatsskyrslu-og-kostagreining-Vefutgafa-ID-73737-.pdf

In addition there are suggested other data such as reports from fishermen about increased catches of cod and haddock with increasing fish farming, low shrimp stock and regular monitoring of sea bed quality and waste disintegration before and during production. Unfortunately, there is no access to the information, no web link, or other identifiable sources.

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6.2.4. Egersund

Egersund is located in the Magma Geopark in Southern Norway which comprises the municipalities Bjerkreim, Egersund, Lund, and Sokndal in the county of Rogaland as well as the municipality of Flekkefjord in the western part of the county Agder. Magma Geopark is a geographic area with a geology that has a major international importance, recognized by UNESCO, and where sustainable development plays an important role (Magma Geopark, 2022). The overall geographical extent of the park area can be seen in figure 28. The park has been a hub for fishing industries since before the Viking Age as the area is particularly rich in fish. The Egersund harbour has been one the biggest fishing harbours in Norway, and it is still a major fishing harbour today. Since the 18th century, the traditionally caught fish has been herring and there have been several herring oil factories in Egersund. Still today, there are several fish oil factories producing pellets for animal food.

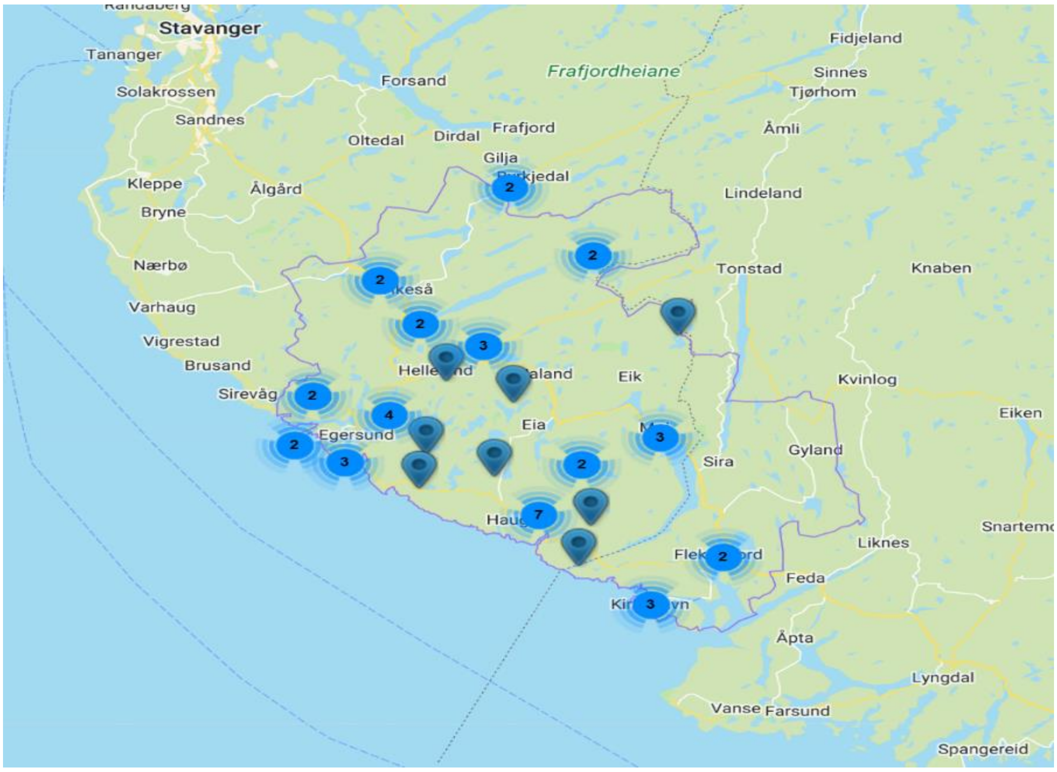

Figure 28. Area of Magma Geopark. Blue marks represent important sights of the park such as hikes, prehistorical settlements, old mining sides and more (Magma Geopark, 2022)

The county of Rogaland stated in the Regional Aquaculture Plan (a strategic plan for the development of the aquaculture industry and seafood production) that the regional policy goal was a doubling of

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seafood production from 2010 to 2020. Moreover, the national goal is a fivefold increase by 2050 (Rogaland fylkeskommune, 2019).

In addition to ocean and fjords, the area in and around Egersund has 4 salmon rivers which have been the main source of sustenance for local inhabitants as well as recreational and tourist fishing. The wider area is characterized by more than 6000 lakes which are rich in trout. Recently, one big fish farming industry has been established and one more is planned. Additionally, there are several projects that explore the possibility of land-based fish farming where sea water is pumped into land-based tanks, however, this kind of farming hasn't been established in the hub area yet. Moreover, Magma Geopark has been developing the GEO-food brand for local producers which supports" zero km" food and sustainability practices. One of the GEO-food partners is Norsk Ørret which is a small-scale fish farm using freshwater to reduce problems linked to e.g., fish parasites.

In terms of aquaculture, the biggest fish farm in Magma Geopark is MOWI ASA (see figure 31: Industrial factsheet Egersund) with an annual salmon production of 10000 tons (MOWI, 2022). With six fish farms located in the south-east of the park in Flekkefjord municipality (figure 29 and 30), the company is leading the Blue Revolution focusing on environmental practices linked to fish farm activities and cooperates to the Global Salmon Initiative, WWF and competes to acquire the Aquaculture Stewardship Council Certification for sustainable food production.

Figure 29. Geographical location o Mowi ASA fish farms in Magma Geopeark (source: Temakart, Miljødirektoratet)

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Figure 30. Geographical location of Mowi ASA fish farms in Magma Geopark (zoomed) (source: Fiskeridirektoratet)

Another company which is specialising in lake and freshwater fish farming is Norsk Ørret (see figure 31: Industrial factsheet Egersund) located in the municipality of Lund. The company has an annual production of 1000 tons of brown trout and has around 20 employees working in the case area (Fylkesmannen Agder, 2020).

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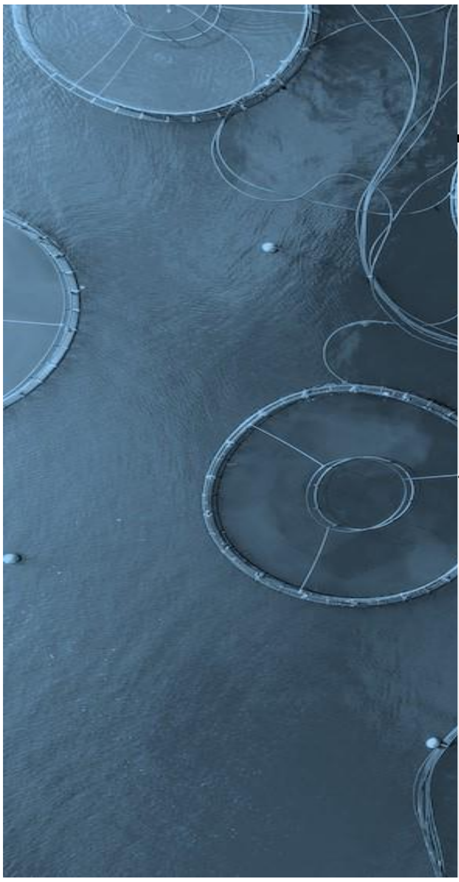

Industrial factsheet **Egersund** – *MOWI ASA* and *Norsk Ørret* aquaculture

Company:	Mowi ASA, Hidrasund
Ownership:	Norwegian
Location:	Hidrasund, Flekkefjord municipality
Water:	Sea
Production:	more than 10.000 tons of salmon annually
Employment expected:	44 employees

Company:	Norsk Ørret
Ownership:	Norwegian
Location:	Lund municipality
Water:	Lake, freshwater
Production:	1.000 tons of brown trout annually
Employment expected:	16 employees
Export:	US

Figure 31. Industrial factsheet Egersund

6.2.4.1. State of the art/ environmental background

Magma Geopark is part of a network consisting of 140 UNESCO worldwide Geoparks in 40 different countries on 5 continents. Although the background for a geopark is geology, the parks are primarily about people including both locals and visitors who are interested in experiencing and exploring the endless possibilities within both nature and culture (Visit Egersund, 2022)

The landscape within the Geopark is characterised by its rolling, bare rocks. The dominant rock, Anorthosite, is hard and compact. This causes the soil to be low in nutrients and consequently, the vegetation is rather sparse. Wider valleys with loose deposits from the last ice age can be found in the North and East of the Geopark. This provides a lusher landscape which makes the inland area well-suited for agriculture. In addition, many lakes, streams, rivers and waterfalls carve through the landscape creating a varied and appealing natural area (Magma Geopark, 2022).

In addition to the soil, the climate in the Geopark has a significant impact on the diversity of plant species. The coastal climate is suitable for plants that do not tolerate lower winter temperatures. Such

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plants prefer hot summers to allow buds for seed development and to mature before the winter frost comes. This means that many plant species can be found in the park that have very limited national distribution (Magma Geopark, 2022). Moreover, the park has 20 nature areas which vary in size and that are protected by law.

The coastal landscape was more wooded before the modern man started farming and maintaining livestock. The need for grazing habitats for contributed to the disappearance of forest which was replaced between 2 and 4 thousand years ago by the extensive areas of bogs. Another effect of deforestation was the increasing amount of marshland. As the forest has a significantly greater consumption of water than open fields, the removal of woodland resulted in large areas of marshes along the coast (Magma Geopark, 2022).

In terms of fish, the most characterising species are sea trout, garfish and turbot. The sea trout spends its childhood in a river. After 1-2 years it migrates to the sea gaining much weight, but seldom wanders far from its home river. The long garfish, with its characteristic beak-shaped mouth, migrates to the park area during the warmest time of the year. The species hunts in shoals at the surface, attacking sprat, herring, and sand lance. The turbot is a large species of flatfish which is often found on sandy seabed, commonly along sand beaches (Magma Geopark, 2022).

6.2.4.2. Environmental impacts

The following environmental impacts are based on the aquaculture industry operating in the Magma Geopark, mostly in the south-eastern area close to the Flekkefjord municipality.

A. Habitat and landscape

To monitor aquaculture activities and their impacts on the environment, the bottom impact in the construction zone is monitored with “B-surveys” according to the requirements of the Aquaculture Operations Regulations § 35 and they are carried out according to the Norwegian standard 9410. The B-survey is a risk-based monitoring tool to explore the bottom conditions in the construction zone. The survey is quantitative and includes three survey groups: fauna survey, chemical survey and sensory survey. The environmental status is based on environmental reports that are sent electronically via Altinn to the Directorate of Fisheries. The dataset is updated daily, and electronic reporting started in June 2009 (Fiskeridirektoratet, 2020).

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Regarding aquaculture in the Magma Geopark, the environmental data in the “Monitoring frequency for B-examination” has been considered “very good” at all aquaculture locations except Tarmevikodden, which received a “good” status[31] (Fiskeridirektoratet, 2020).

Moreover, the bottom impact in the transition zone (what is meant with transition zone??) is monitored with “C-surveys” according to the Norwegian standard 9410. The C-survey is a quantitative trend survey of soft bottoms in the transition zone. The most important part of the C-survey is its analysis of the associated fauna, carried out according to NS-EN-ISO 566-19 and NS-EN ISO 16665. The C-survey also includes additional support parameters including particle distribution as well as hydrography measures and places emphasis on the analysis of the benthic community and chemical profiles. The C-surveys must be performed accredited.

The environmental data in the “Monitoring frequency for C-examination” has been evaluated as “very good” at all aquaculture locations (Fiskeridirektoratet, 2016)

There are also other environmental surveys that do not fall into the aforementioned categories such as biodiversity mapping and regional fjord monitoring as well as modelling.

Besides, electricity surveys are carried out as requirements in the application for clearance of sites (water exchange current, spreading current and bottom current) and for conducting site surveys in connection with the issuing of construction certificates.

Furthermore, beach zone surveys can be divided into three categories: inspection-, semi-quantitative- and route surveys. Inspection includes a registration of the most dominant animals and algae in the coastal zone, often documented with photos. Semi-quantitative surveys include registrations of algae and animals in a small area of the beach zone and gives the quantity ratio between the species. Major changes over time are registered. Route analysis surveys consist of a comprehensive examination of the equatorial zone, here bolted frames are used. All animals and algae larger than 1 mm are registered. This allows records of more accurate changes over time (Fiskeridirektoratet, 2020).

[31] Monitoring frequency for B-examination:
1 - Very good: At the next maximum biomass
2 - Good: Before release and again at maximum load
3 - Poor: Before release If the pre-release survey gives:
condition 1 - examination is performed at the next maximum load
condition 2 - examination is performed at half maximum load and at maximum load
condition 3 - examination is carried out at half maximum load and at maximum load. In relation to the next production cycle, measures are planned. If any of the examinations show condition
4 - there will be congestion. 4 - Very bad: Overload In condition 4, the authorities decide on measures (Fiskeridirektoratet, 2020)

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In terms of environmental impacts, MOWI has a challenge with sea lice and has developed a strategy against sea lice. The strategy aims to limit the number of medical treatments per farm, per cycle, according to requirements of the ASC standard, but also aims to reduce the dependency of treatments involving fish handling (MOWI, 2021).

B. Changes in biodiversity

In general, all aquaculture companies have smaller problems with escapes and, accordingly, have a zero-escape strategy. Only one of the MOWI farms reports a smaller escape on 5-18 salmon which is regarded as rather low (e.g., MOWI, 2021).

C. Pollution

An Environmental challenge linked to pollution is considered the management of fish antibiotics. The fish farms aim to reduce the application of antibiotics following the more specific recommendations of the Aquaculture Stewardship Council (ASC). Regarding the aquaculture companies in Magma Geopark, environmental assessments show "very good" or "good" quality when it comes to water quality, biomass quality and similar.

In addition, a big problem is associated with microplastics in the marine food chain. Consequently, the control of produced fishmeal is regarded as crucial and will probably be a major challenge for the aquaculture and fisheries industry in the upcoming years. People are increasingly concerned about the plastic problem and microplastics are continuously found in large parts of slaughtered salmon. As a result, the risk of plastics entering the fishmeal products rises (Gündoğdu et al, 2021).

6.2.4.3. Conflicts

Potential conclicts with tourism because of stron smell from the aquaculture. Also a potential conflict between aquaculture and cruise tourism in the harbour.

6.2.4.4. Mitigation

- Development of biodiversity mapping
- Development of sea lice strategy
- Plastic pollution controls

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6.2.4.5. Ambitions

MOWI seafood is a large global aquaculture company and the largest Norwegian salmon farmer in Norway. They are trading on a global market and the homepage includes information about sustainability policy and environmental measurements

According to their homepage, Mowi is named most sustainable protein producer fourth year in a row and has been ranked the most sustainable protein producer by the Coller FAIRR Protein Producer Index. The Coller FAIRR Protein Producer Index is the most detailed assessment of the largest meat, dairy and farmed fish producers in the world. Rankings for each of the 60 companies assessed are determined bys a seafood company, both producing in and harvesting from the sea, and it is an absolutely imperative for the Group to keep the oceans clean and healthy. According to the homepage, the company strive to reduce the environmental footprint and minimise their influence on wild habitats including wild salmon stocks.

- https://mowi.com/mowi-sustainability-strategy_a4_march-2021/

6.2.4.6. Perceptions

Mowi company information can provide information about the company's ambitions as well as self-perception.

- https://mowi.com/no/

Norwegian trout is another fish framing company. Newspaper articles about Norsk Ørret (Norwegian trout), text only available in Norwegian, but refers to expanding production and increasing employment:

- Norsk ørret website: https://sirdalsorret.no/?fbclid=IwAR1ikLASD_fKsG8xP17ZGdIT4kKUiNIXiTx752ytK7iqEyx3n5vr9bAbsFw

- Offisiell åpning av Norges største anlegg for ørretproduksjon: https://www.kyst.no/article/offisiell-aapning-av-norges-stoerste-anlegg-for-oerretproduksjon/
- New employment in trout production: https://www.avisenagder.no/tillatelser-pa-plass-flere-nye-arbeidsplasser/s/5-99-995721
- Permits in place: https://www.avisenagder.no/pion-rarbeid-i-sirdalsvannet-gode-fremtidsutsikter-for-norsk-orret/s/5-99-895174

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6.3. Tourism

ArcticHubs includes 8 tourism hubs in 6 northern European countries, and 2 learning hubs in Italy. Four of the hubs are co-located with fish farming hubs, 6 with mining hubs, and 2 with indigenous hubs. Tourism has been well established in the Finnish hubs and in Svalbard, but is still being developed in Nuuk, Suðuroy and the Westfjords. The tourism industry has an impact on the environment and can affect other natural resource users in the same area. However, tourism is also itself affected by the environmental impacts of other activities in the area. Common environmental impacts caused by tourism that occur in all locations are associated with the general carbon footprints of traveling (greenhouse gas emissions) as tourists tend to travel far to visit the Arctic environment. The industry is also commonly associated with the disturbance of Arctic wildlife, erosions of vegetation by trampling, the impact of waste and litter pollution, and the consequences of infrastructure development. When it comes to interactions and conflicts with other industrial activities and natural resource users, cases have usually their specific dynamics in each hub.

6.3.1. Svalbard

Svalbard is an archipelago in the high-Arctic. Despite its remote location, Svalbard has attracted tourists for more than a century. After Year 2000, tourism has increased substantially (Hovelsrud, Kaltenborn & Olsen, 2020). Longyearbyen is the largest settlement at the archipelago and is the major hub for tourism in Svalbard. In 2019, around 111 different businesses were associated with the tourism sector. Tourists arrive to Svalbard either by plane or by ships. Most tourists arriving by plane will also explore the archipelago from the sea. They will go onboard boats in the Port of Longyearbyen, either for daytrips or longer journeys. Official statistics from the Port of Longyearbyen confirm an immense increase in boats and passengers at the port from 2007 to 2019. During this 12-year period, the number of shipping arrivals tripled from 499 in 2007 to 1474 in 2019. Similar trends can be seen in the number of passengers which rose from around 32,000 in 2007 to nearly 90,000 in 2019 (Port Longyearbyen, 2021)

While the number of cruise ships and tourist boats have not changed much during this period, a major increase in so-called day-tour boats (local boats that bring tourists who arrive by plane on day trips out of Longyearbyen) can be detected. The number of yachts has also increased incredibly, more than 7 times since 2007. This has resulted in a tourist boom in Longyearbyen. The main street is full of tourist attractions - from outdoor clothing shops to nice bars and restaurants, often complemented with flight-borne professional musicians.

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The number of person years within tourism and tourism-related business such as culture increased from 291 in 2010 to 518 in 2019, according to official statistics. During the same time, the number of person years in the mining industry was reduced to only one fourth of what it was in 2010. Now, there are less than 100 person years in the mining industry, so tourism and tourism-related activities are currently a much more important business in Svalbard, at least until the outbreak of Covid-19. While most tourists visit Longyearbyen during their stay in Svalbard, most nights are spent outside of Longyearbyen. Multi-day cruising programs visit sites all around the archipelago, but there are more visits to the western side, especially to the areas “Barentsburg”, “Pyramiden” and “Ny-Alesund” (Figure 33). As a short wrap-up, figure 32 presents an industrial factsheet of the current tourism sector in Svalbard.

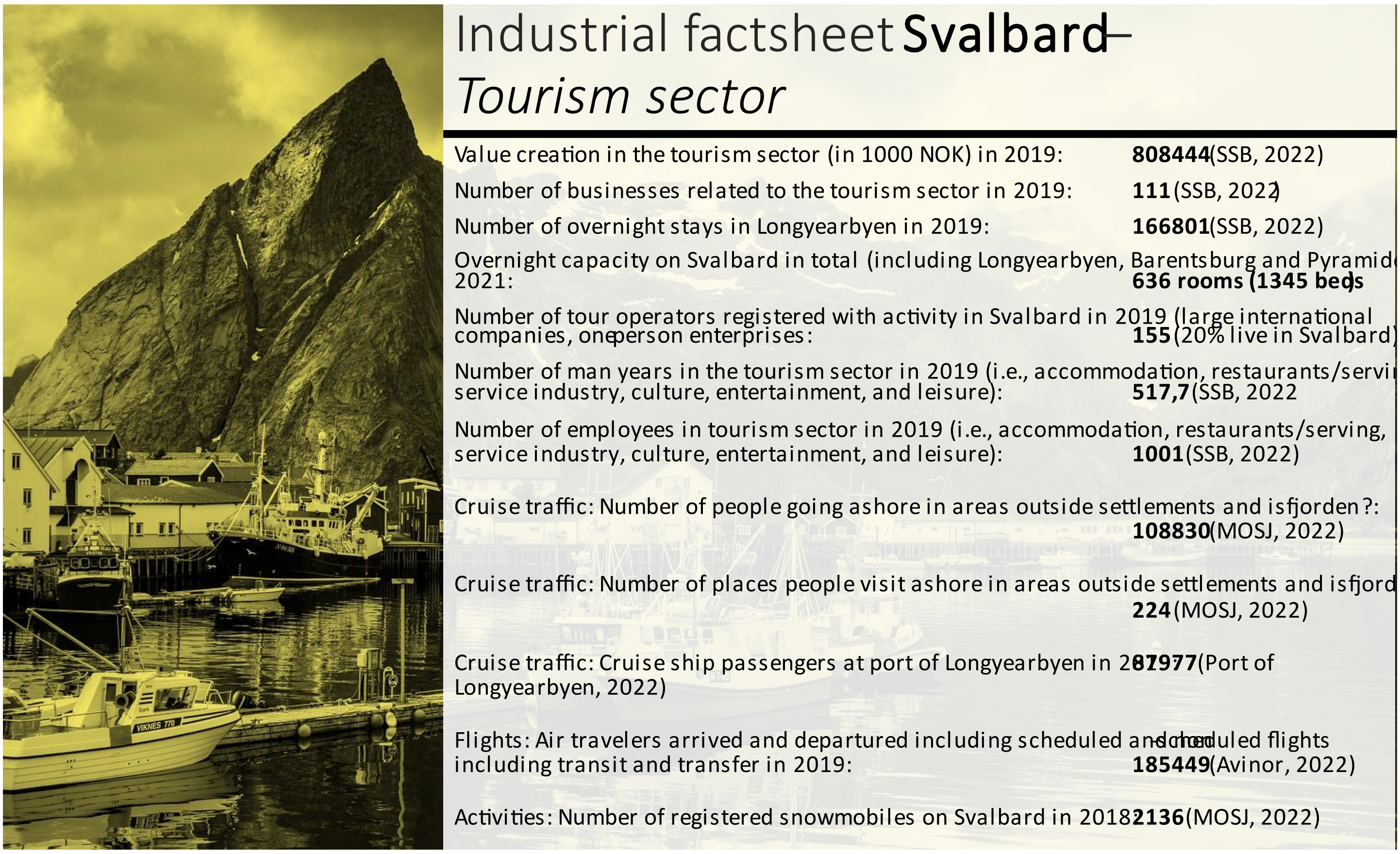

Figure 32. Industrial factsheet Svalbard

Many of the popular sites are cultural heritage sites, which are distributed all around the archipelago (figure 34). Several studies indicate that vulnerable cultural remains are affected by the many visitors and there is also evidence that tourism has negative trampling impacts on the slow-growing Arctic vegetation which can cause increased soil instability and erosion (Norwegian Polar Institute, 2015).

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Tourists also contribute to the transport of alien species to the island, for example as seeds are attached to their boots. Tourists are keen on seeing arctic wildlife. There are some studies indicating that both marine and terrestrial wildlife are disturbed by the many tourist boats and tourists walking in the terrain. This induces increased stress on wildlife (Øren et al, 2018).

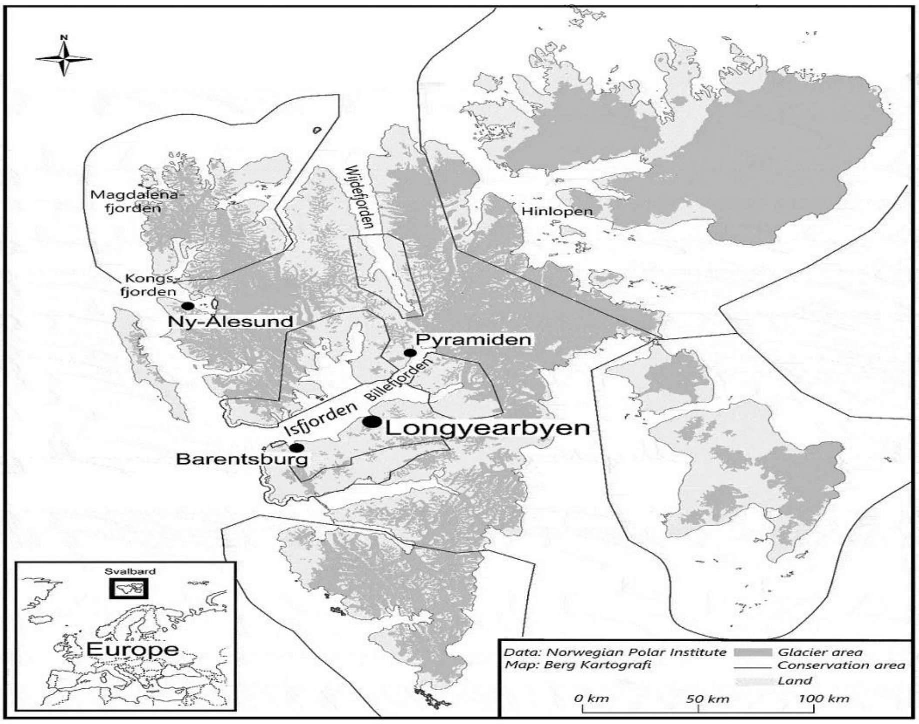

Figure 33. Map of Svalbard (Hovelsrud, Kaltenborn & Olsen (2020)

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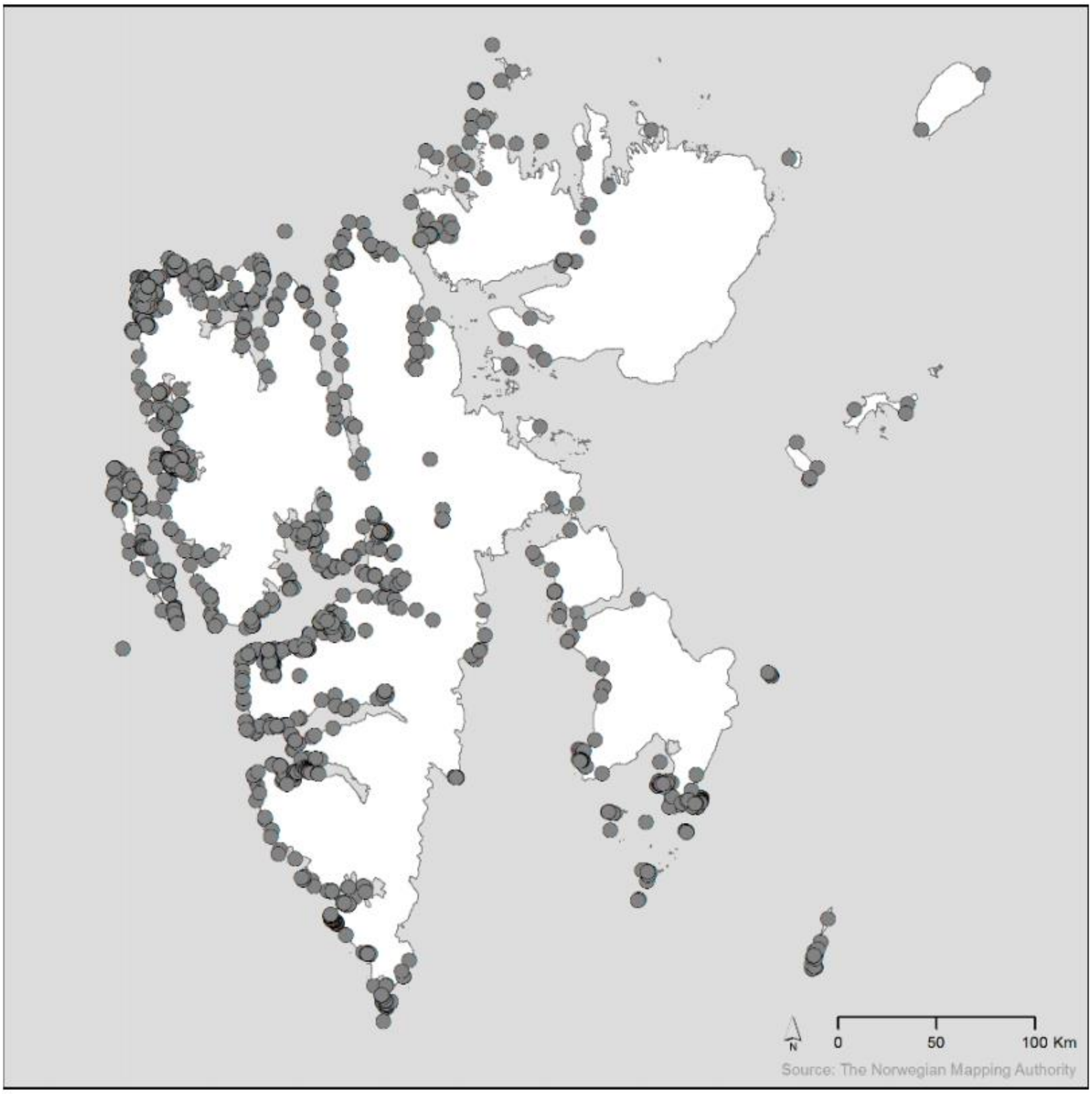

Figure 34. Documented cultural heritage sites in Svalbard. Map retrieved from Holmgaard et al. (2019)

6.3.1.1. State of the art / environmental background

The Svalbard archipelago consists of islands and skerries between 74° and 81° north latitude and 10° and 35° east longitude of which Spitsbergen is the largest. Svalbard is surrounded by the Barents Sea, the Greenland Sea, and the Arctic Ocean. The whole archipelago covers 61 022 km², of which 98 per cent contains the largest continuous wilderness in Norway (Undelstvedt, 2014). Around 61,7 percent

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(37453.49 km2) of Svalbard's area consists of glaciers and permanent snow while 24.3 per cent (14746.20 km2) consists of open and firm ground with several inland waters (5 per cent) and bare rock, gravel and blockfields (7 per cent) (SSB, 2020). The residential areas in Svalbard of which most are located in and around Longyearbyen, make up 0.23 km2. Recreational facilities comprise 0.12 km2 while industrial, commercial, and service areas comprise 0.22 km2. A more detailed distribution of different land-use areas and landcovers can be seen in table 11.

Table 11. Different land use areas and land covers (SSB, 2020)

Residential areas	**0.23 km2**
Recreational facilities	**0.12 km2**
Built-up areas for agriculture and fishing	**0.01 km2**
Industrial, commercial and service areas	**0.22 km2**
Education and day care facilities	**0.07 km2**
Health and social welfare institutions	**0.01 km2**
Cultural and religious activities	**0.01 km2**
Transport, telecommunications and technical infrastructure	**1.80 km2**
Emergency and defence services	**0.09 km2**
Green areas and sports facilities	**0.01 km2**
Open firm ground	**14746.20 km2 (24.3 per cent)**
Wetland	**1224.21 km2 (2 per cent)**
Bare rock, gravel, and blockfields	**4284.00 km2 (7.1 per cent)**
Permanent snow and glaciers	**37453.49 km2 (61,7 per cent)**
Inland waters	**3006.42 km2 (5 per cent)**

The Svalbard Archipelago is characterised by a magnificent Arctic landscape and relatively easy accessibility (figure 35) which attracts visitors, tourists, and researchers from around the world. In addition, climate change such as increasing ocean temperatures, changing cryosphere conditions including retreating sea ice, and similar significantly impact the environment. The high Arctic terrestrial and marine fauna and flora as well as the rich cultural heritage are therefore increasingly vulnerable (Hovelsrud, Kaltenborn & Olsen, 2020). Marine mammals that can be found in the Svalbard area are whales, seals, and polar bears. While seals dominate in number, the whales do so in biomass. Regarding polar bears, a population of 975 animals was estimated in 2015, but these figures are taken with considerable uncertainty (Norwegian Polar Institute, 2019). Moreover, Svalbard has a rich and diverse bird life. Seabird species dominate in numbers, but there are also many species in the terrestrial ecosystem (Norwegian Polar Institute, 2019). Furthermore, Svalbard's isolation combined with an Arctic climate, has resulted in freshwater sites with very few species of plankton and benthic animals. Arctic charr the only freshwater fish (Norwegian Polar Institute, 2019). Besides, the Svalbard

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reindeer occurs in varying densities in most parts of Svalbard that are not covered by glaciers. New estimates of the total population of Svalbard reindeer were published in 2019 based on a comprehensive population count. The population is estimated to consist of around 22,000 animals. Eventually, there are more than 160 plant species, 380 moss species and 600 lichen species known in Svalbard (Norsk Polar Institute, 2018).

The shipping traffic is a major feature of the tourism in Svalbard. Figure 35 shows all existing disembarking sites distributed over the archipelago. Accordingly, ship traffic ranges all around the archipelago and makes the inland more accessible. As mentioned before, the number of places that people visit ashore in areas outside settlements and isfjorden is 224 (MOSJ, 2022).

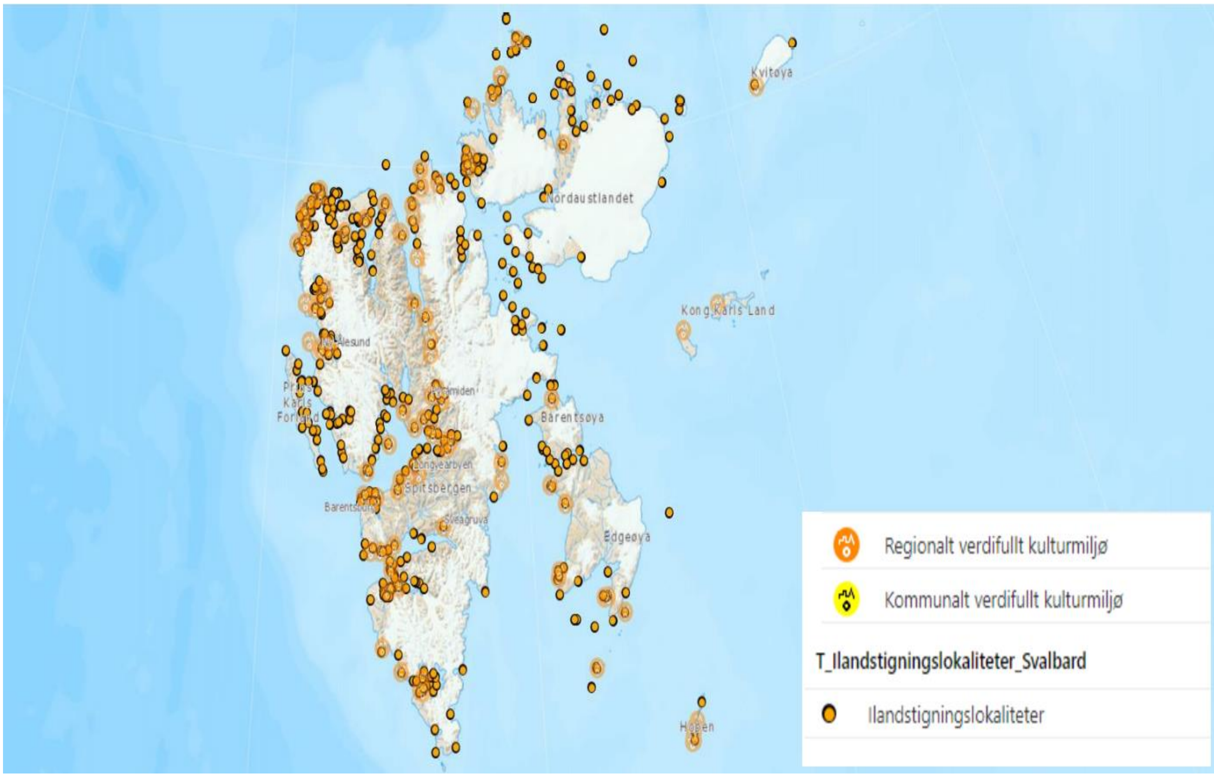

Figure 35. Disembarking sites and cultural heritage spots (Norwegian Polar Institute)

At the same time, Svalbard is characterised by its several nature conservation areas. There are 7 national parks and 24 nature reserves including also essential bird protection sites and geotypes. A more detailed distribution of protected areas is presented in figure 36.

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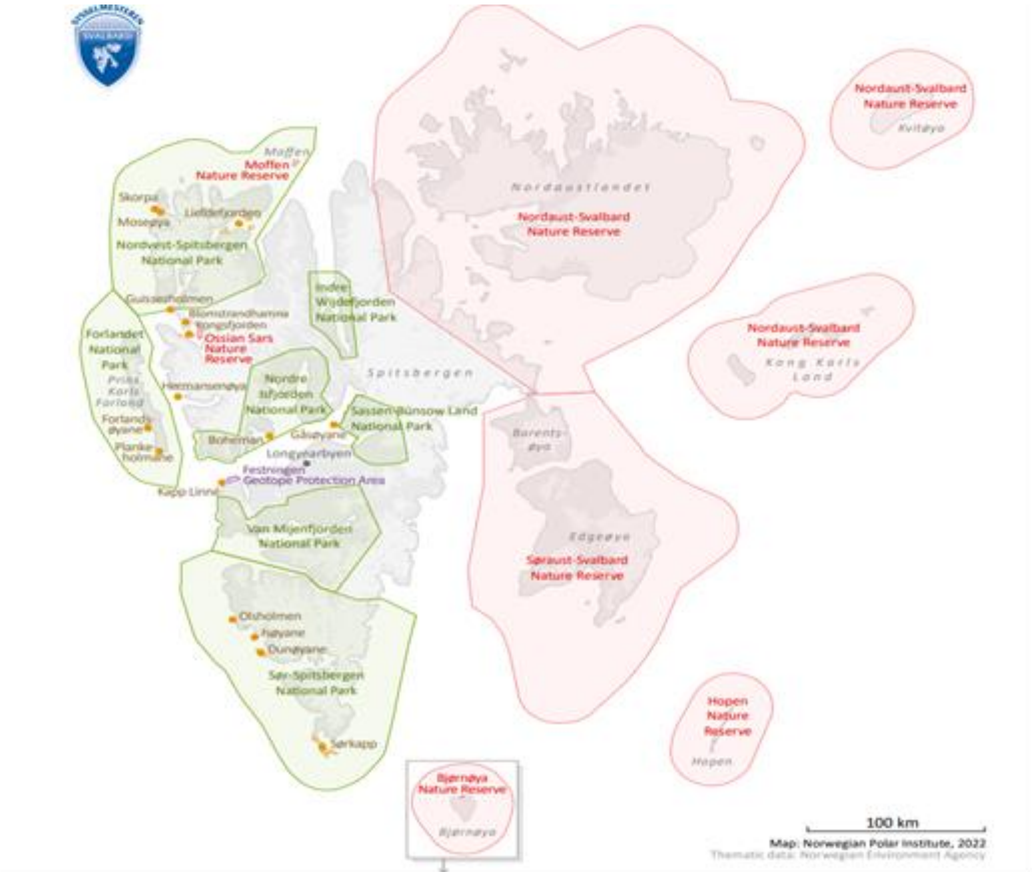

Figure 36. Protected areas in Svalbard (Norwegian Polar Institute, 2022)

Protected areas in Svalbard

- Nature reserve for birds
- National park
- Nature reserve
- Geotope protection area

Most (guided) explorations by tourists are organised with snow scooters. 2136 snow mobiles were registered in Svalbard in 2018 and the trend increases more. In the context of nature protected areas on the archipelago, figure 37 shows restricted areas for snow mobiles.

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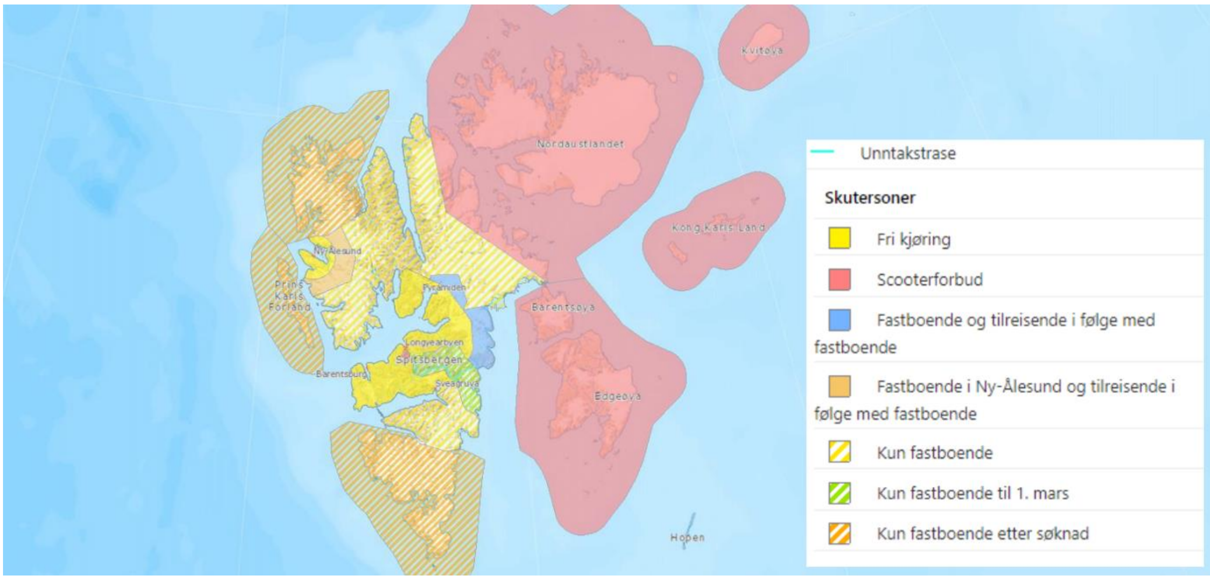

Figure 37. Restricted areas for snow scooters (Norwegian Polar Institute)

6.3.1.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating on Svalbard archipelago.

A. <u>Habitat and landscape</u>

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
Marine	Cruise traffic	Disembarking sites				They illustrate how citizen science programs on-board expedition ships can successfully collect robust scientific data and contribute to enhancing the knowledge and stewardship capacity of cruise passengers		Taylor et al. 2019
	Slow cruising in Isfjorden, with more disembarkations and increased offer of activities.	Isfjorden and surrounding areas	Potential. Several ships in the Icefjord at the same time. Consequently, a question arises as to what effects this has with regard to traffic on land, not least in the protected areas inside the fjord.					Øian & Kaltenborn, 2020

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Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
		Shorelines				Several initiatives are carried out each year to clear marine litter from the Svalbard coast, with contributions from both residents and tourists who travel around the archipelago.		The governor of Svalbard: https://www.sysselmannen.no/en/the-governor-of-svalbard/environmental-protection/pollution-waste-and-chemicals/ Thematic map with shores cleaned around the archipelago, available from Svalbardkartet
		Disembarking sites	Significant increase in number of sites since 1990s					Hagen et al., 2012
	Tourist fishing/harvesting							
Land	Damage to natural vegetation from tourism traffic						methods for monitoring pristine environments and climate impacts on vegetation are available	Hans has access to data on vegetation changes 1990-today, satellite NDVI Tømmervik et al. 2014, Treharne et al 2020
	Vehicular tracks	Mainly in relation to mining and drilling activities				Established this data collection as a reference for future monitoring	Monitoring of existing and new tracks	Råheim, 1992
	Cruise traffic disembarking sites	Increased number and use of landing sites across most of Svalbard				Marked paths or physical installations can reduce geographical distribution of ground impact	Especially important at most vulnerable and popular sites. But lack of support for such installations.	Hagen et al. 2012 (see table 1 for specific studies on the subject). Number of tourists per site, Hans has statistics on this?

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		harbour facilities are at present insufficient for accommodating the increasing demand	Development of port facilities - more calls are made for larger ships, which will increase the number of cruise tourists and thus increase negative consequences, such as congestion and infrastructure overload					Hovelsrud et al., 2020 Øian & Kaltenborn, 2020

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
							„Several interviewees highlight the importance of promoting the Management Area 10 (Isfjorden area – see Figure 1) as a dedicated destination. This is an area that is regulated for tourism by the national authorities, and it is close to town and search and rescue (SAR) facilities."	Hovelsrud et al., 2020
	Infrastructure development – roads, buildings						Svalbard reindeer can be a possible parameter for monitoring the effects of disturbance from human traffic. This would require studies designed for this purpose, and no such studies are planned. Population data from the current monitoring will, however, provide an important basis for such studies.	from https://www.mosj.no/en/fauna/terrestrial/svalbard-reindeer-population.html
	Snow mobile traffic	Nordenskiöld Land	Snowmobile traffic has changed the diurnal activity of the Arctic fox in Nordenskiöld Land, Svalbard. However, the study did not prove negative impacts at the population level since the abundance of foxes did not decline.					Fuglei et al. 2017

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B. Changes in biodiversity

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
		Walrus haul-out sites	No particular disturbance found from tourists nearby in boats or on land					Øren et al., 2018
	Invasive species impact on biodiversity, native populations							
			wildlife avoiding sites, tourist moving to other locations					

C. Pollution

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
	Heavy fuel oil spill in Longyearbyen	Potential. Marine traffic areas along Svalbard shoreline	Spilling risk, more severe if located in hard-to-reach areas			Ban to avoid heavy fuel oil spills and limit pollution from shipping accidents. Ships in these areas must use light marine diesel		(https://www.sysselmannen.no/en/heavy-fuel-oil-ban-in-the-protected-areas/), NILU should have open access data in relation to this, especially interesting for the 2020 season due to covid-19.

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	Waste issues	Litter, water pollution				ACAP and the Sustainable Development Working Group (SDWG) are cooperating on scaling up solid waste management activities by working closely with local communities, developing capacity building planning tools and a template for a community standards model.		https://arctic-council.org/en/explore/topics/pollutants/
	Waste issues	Litter, water pollution						
	Disturbance of wildlife and vegetation	See map and report for mapped Continuous wilderness areas.						Supplement report for the Svalbardkartet theme layer for wilderness areas, (Norwegian only) https://www.miljodirektoratet.no/globalassets/publikasjoner/m703/m703.pdf (Miljødirektoratet, 2017)
	Invasive species impact on biodiversity, native populations							

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs	Reference
Air	Air, water and land pollution	Time series on air quality measurements (CO2, methane, N2O) (Ny Ålesund)						https://www.mosj.no/en/climate/atmosphere/climate-gases-in-svalbard.html
	Aviation		Carbon amounts					
Sound	Traffic	noise pollution – disturbing wildlife, other tourists						

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6.3.1.3. Conflicts with other activities

Cultural heritage sites are among the main tourist attractions on Svalbard (Hagen et al. 2012, Barlindhaug et al. 2017) and tourism is now one of, if not the principal human activity in many cultural sites. A report from the UN Environmental Program highlights challenges related to the growing tourism in Arctic Areas (UNEP 2007). From a management perspective, the combined impact of increased tourism and ongoing environmental processes is challenging as the effects are detrimental to cultural heritage assets in Svalbard. A white paper also stresses the need to develop tools to regulate and manage increased human activity on Svalbard, as well as the necessity for mapping and monitoring (Anonymous 2007). Results from an RCN-funded research project Cultural Heritage in Polar Regions - natural and human impact on cultural heritage sites and environments (CULPOL) (Thuestad et al. 2015a, Thuestad et al. 2015b, Barlindhaug et al. 2017) have shown that tourism is impacting cultural heritage assets as well the environment in Svalbard.

6.3.1.4. Mitigation

(See also tables above)

“[The Norwegian] government in 2019 unveiled a strategy for the future development of Svalbard, emphasizing the impact of tourism on nature and the seasonal pattern associated with the tourist industry. To enhance sustainability, the strategy recommended to utilize existing capacity as much as possible, so that tourism displays less of a seasonal trait on the islands. In this way, it is hoped that the stream of tourists will be smoothed over the year, in turn leading to a larger proportion of jobs in the tourist industry that employ people all year round.” (Glomsrød et al., 2021).

Furthermore, the AECO (Association of Arctic Expedition Cruise Operators) has developed specific guidelines that aim for the safeguarding of the environment, its cultural remains as well as the allowance for the possibility to experience great nature in the Arctic (AECO, 2022). Accordingly, AECO members are obligated to operate in accordance with national and international laws and regulations and have, in addition, agreed to follow an extensive set of guidelines to ensure operations are in accordance with our objectives, including several site-specific guidelines and guidelines for visitors to the Arctic. The AECO has established operational guidelines as well as site-specific guidelines for Svalbard (AECO, 2022).

The AMAP Arctic Monitoring and Assessment Programme is a special working group of the Arctic Council. Since its establishment in 1991, AMAP has produced a series of high-quality reports and related communication products that detail the status of the Arctic with respect to climate and pollution issues and that include policy-relevant science-based advice to the Arctic Council and

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relevant governments (AMAP, 2022). Besides, the Arctic council addresses pollutants trough several projects (Arctic Council, 2022). Eventually, Svalbard is more specifically protected by the Svalbard Environmental Protection Act (the Norwegian government 2001).

6.3.1.5. Ambitions

Svalbard documents, including plans expressing ambitions, are compiled in the main section. The web pages listed below is mainly in Norwegian will therefore not be compiled with comments, other than some general remarks.

Ambitions are related to sustainable energy transition and transformation of the Russian company town Barentsburg from mining town into a centre for the Russian Arctic and tourism.

- Energistabiliserende tiltak: https://www.lokalstyre.no/energistabiliserende-tiltak.509622.no.html
- Barentsburg aims to move from dirty coal to become gateway for Russia's Arctic tourism. Thomas Nilsen, The Barents Observer, 3.9.2018. https://thebarentsobserver.com/en/node/4314

6.3.1.6. Perceptions

This is local information/local newspaper article in Norwegian which discusses discharge of raw sewage. This can be an environmental problem even though it is done on 50 meters depth. Sysselmannen, now Sysselmester, represents the Norwegian government on Svalbard and is responsible for plans and monitoring reports from Svalbard, including plans for handling sewage.

- Discharge of raw sewage: I et av verdens største områder med uberørt natur: Flere tusen innbyggerne skjiter rett i havet, https://www.nord24.no/svalbard/longyearbyen/kloakk/i-et-av-verdens-storste-omrader-med-uberort-natur-flere-tusen-innbyggerne-skjiter-rett-i-havet/s/5-32-85170
- Information from local authorities on sewage: https://www.lokalstyre.no/vann-og-avloep.467003.no.html

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6.3.2. Egersund

(For more background information about Egersund and the surrounding Magma Geopark, see also chapter 5.2.4 about the Egersund hub from an aquaculture perspective.)

Magma Geopark area is characterized by rural activities and a lower population density, most of the inhabitants have a low education level and the involvement into research projects has always been difficult. Through the EU H2020 RURITAGE project, the Magma Geopark reached a good level of participation with local public and private stakeholders by involving them into local activities associated with the promotion of cultural heritage. In general, there is a lack of local public transport due to a rather low population density, this makes it difficult to increase the amount of tourist visitors in the Magma Geopark locations. Consequently, these locations are better accessible by car since they are located far away from the main villages. Moreover, the Magma Geopark area can be characterized by a lack of strategy when it comes to the promotion and availability of sustainable tourism offers linked to the existing Regional Destination Company which focuses on event management. In addition, the area is characterized by poor local cooperation between municipalities and stakeholders: The Magma Geopark is acting as a coordinator for project development and activities but is also the main provider for guided tours and activities in the area. Nevertheless, Magma has also become a strategic focal point for supporting local companies active in the food industry and outdoor activities.

In table 12 below, the total number of annual overnight stays in 2013-2020 in Magma Geopark is presented. While the number of total overnight stays was highest with 53272 in 2017, this number decreased to 48673 in 2020. However, the number of holiday overnights per year has been increasing continuously (figure 38).

Table 12. Overnight stays in Magma Geopark from 2013 until 2020

Year	Purpose	Magma		Magma		Magma	Rogaland		
2013	**Course/ conference**	3180	**Professional**	24649	**Holiday**	10931	491901	**Total magma**	38760
2014	**Course/ conference**	3052	**Professional**	25119	**Holiday**	11976	520042	**Total magma**	39147

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2015	**Course/ conference**	2813	**Professional**	24311	**Holiday**	15024	589607	**Total magma**	42148
2016	**Course/ conference**	2825	**Professional**	20904	**Holiday**	18321	608627	**Total magma**	42050
2017	**Course/ conference**	9009	**Professional**	27365	**Holiday**	16898	562629	**Total magma**	53272
2018	**Course/ conference**	3568	**Professional**	26579	**Holiday**	21355	570273	**Total magma**	51502
2019	**Course/ conference**	3693	**Professional**	23868	**Holiday**	25224	709081	**Total magma**	52785
2020	**Course/ conference**	2854	**Professional**	17824	**Holiday**	27995	568511	**Total magma**	48673

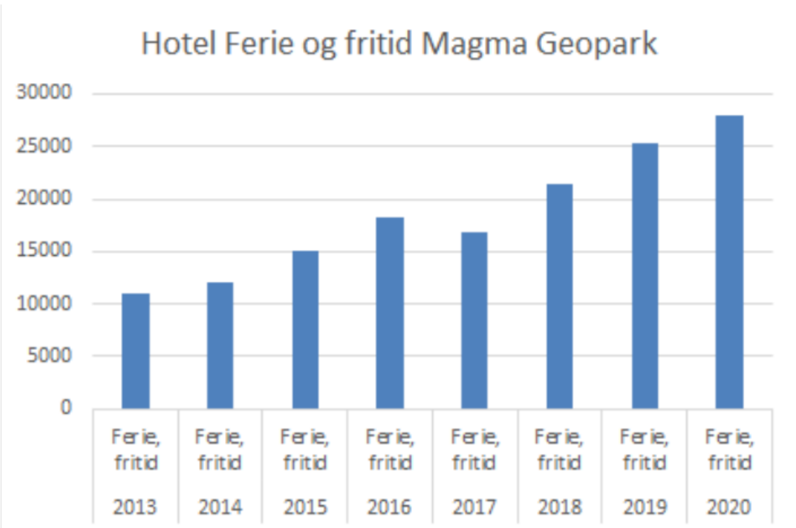

Figure 38. Tourism with numbers of overnight stays in the Hotels in Magma Geopark from 2013 until 2020 showing a solid growth

With a more local focus on the municipality of Egersund, the tourist company *Visit Egersund* registered more than 100.000 views and a regular growth on social media. Moreover, automatic counters and counting on parking lots have indicated a yearly growth of visitors. Meanwhile, there has been only a

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couple of cruise ships visiting the Egersund hub, but for 2022 and 2023 there will be 5 cruise ships arriving in Egersund annually.

6.3.2.1. State of the art/ environmental background

(For more background information about the environmental-/landscape profile of Egersund and the surrounding Magma Geopark, please see chapter 5.2.4.1.)

Abitions to create all year around tourism and to secure product development in collaboration with Innovasjon Norge. After this area became a part of Norges Nasjonale turistveier the has been a growth in overnights stays.

6.3.2.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in Egersund and the Magma Geopark.

A. Habitat and landscape

The Magma Geopark area is much used for the breeding of sheep and cows. Moreover, about 20 smaller and larger areas within the 2300 km2 Geopark are protected by law.

B. Changes in biodiversity

There is no data about environmental impacts on biodiversity.

C. Pollution

The Magma Geopark has almost no heavy polluting industry. The polluting industries are mostly found in the mining- and fish oil industry as well as entrepreneurial companies.

Moreover, litter and garbage have to be collected via a pick-up schemes where companies in charge must collect litter every week. Litter and garbage collection must be divided in 7-8 different categories: plastic, food waste, cardboard, beverage carton, paper, and rest. Clothes, batteries, metal, and glass must be delivered individually.

6.3.2.3. Conflicts

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There are conflicts between tourism interests and mining industries in this area. Also, there is a potential conflict between a new planned battery factory and tourism industries as the battery factory is not seen as a aesthetic infrastructure.

6.3.2.4. Mitigation

-expert meetings on task-based coordination to develop sustainable a tourism destination (Innovasjon Norge)

6.3.2.5. Ambitions

One central ambition is to develop all year tourism.

The web pages relevant for ambitions and perceptions in Egersund are all in Norwegian and the documents will therefore not be compiled with comments, other than some general remarks. Tourism is an investment area in the region. Sustainability, growth and quality are key words in Rogaland and Agder will put particular emphasis on activities for children.

Local and national planning documents:

- Reiselivsstrategi for Rogaland 2013-2020, Rogaland Fylkeskommune (in Norwegian):
- https://www.rogfk.no/_f/p1/ia1a4a8ba-d404-438a-bd64-c46ad3ce1343/reiselivsstrategi-for-rogaland-2013-2020.pdf
- Besøk Agder 2030, regional plan Agder 2020 (in Norwegian): https://agderfk.no/_f/p1/icb87c60c-54b4-4068-948c-1d36c70fa75b/besoek-agder-2030.pdf
- Nærings- og fiskeridepartementet – Skal lage strategi for reiselivet: https://www.regjeringen.no/no/aktuelt/skal-lage-strategi-for-reiselivet/id2684879/
- Innovasjon Norge – Nasjonal reiselivsstrategi, 2021: Skal bidra til tusenvis av nye jobber og halvere klimautslippene i reiselivet: https://www.innovasjonnorge.no/no/om/nyheter/2021/nasjonal-reiselivsstrategi-skal-bidra-til-tusenvis-av-nye-jobber-og-halvere-klimautslippene-i-reiselivet/

Local information:

- Information on tourist activities in Lund Kommune: https://www.lund.kommune.no/reiseliv.534146.no.html

Tourism strategy, in Norwegian

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- Eigersund Næring og Havn: Reiselivestrategi – valg av fire fyrtårn, 2020: https://enhkf.no/nyheter/reiselivsstrategi-valg-av-fire-fyrtarn/

6.3.2.6. Perceptions

There is no more detailed information about perceptions

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https://www.rogfk.no/vare-tjenester/planlegging/gjeldende-planer-og strategier/naringsutvikling/reiselivsstrategi-for-rogaland-2013-2020/

Agder County (2020). *Besøk Agder.* Retrieved in 2022 by https://agderfk.no/_f/p1/icb87c60c-54b4-4068-948c-1d36c70fa75b/besoek-agder-2030.pdf

Lund County (2022). *Reiseliv.* Retrieved in 2022 by (https://www.lund.kommune.no/reiseliv.534146.no.html

News:

https://enhkf.no/nyheter/reiselivsstrategi-valg-av-fire-fyrtarn/

https://www.dalane-tidende.no/reiseliv/reiselivspris-til-magma-geopark/s/5-101-100527

https://www.innovasjonnorge.no/no/om/nyheter/2021/nasjonal-reiselivsstrategi-skal-bidra-til-tusenvis-av-nye-jobber-og-hal vere-klimautslippene-i-reiselivet/

https://www.regjeringen.no/no/aktuelt/skal-lage-strategi-for-reiselivet/id2684879

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6.3.3. Varangerfjord

Varangerfjord is an important centre in the Barents region with ice free ports and all year round access to the Barents sea itself. During winter, activities like dog-sledge trips, snowmobile tours, northern light and king crab safaris are offered. In spring and summer, cruise ship tourism and fishing tourism are the most popular. There is a growing concern that fish tourism affects the local fish stocks of cod, king crab and halibut and this is regarded as a potential conflict with tourism products and the Sámi angler, a criticism that has been raised recently. In the hub, these themes will be investigated and documented.

See chapter 5.2.2 for background information about Varangerfjord.

6.3.3.1. State of the art/ environmental background

See chapter 5.2.2.1 for information regarding the environmental background of the Varangerfjord area. There was no additional data available from a tourism perspective.

6.3.3.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in the Norwegian area of the Varangerfjord.

A. Habitat and landscape

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Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Marine 1. *e.g. Cruise traffic – waste issues*	1. *water pollution*		*Water quality measurements*		1. 2.	1.	
	2. *wildlife disturbance*		*Effect on marine populations*				
	3. *invasive species*		*Which species, effect on native species*				

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Land 1. *infrastructure development – roads, buildings*	*E.g. 1. habitat fractionation, destruction* *2. impact on populations/biodiversity* *3. impact on ecosystem services*		*e.g. population X reduced with x%, loss of wilderness by x%, landuse/landcover change*		1. 2.	1. 2. 3.	
2. *traffic at sites*	*1. trampling, damage to natural vegetation* *2. erosion* *3. wildlife disturbance*		*e.g. data on loss of species, loss of land*				

B. Changes of biodiversity

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
2. *tourist fishing*	6. *impact on fish stocks*		*E.g. Reduction of fish stocks*				
4. *invasive species*	*1. impact on native populations* *2. impact on biodiversity*	*Extent of spreading*					

C. Pollution

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Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Marine 1. *e.g. Cruise traffic – waste issues*	1. *water pollution*		*Water quality measurements*		1. 2.	1.	
	2. *wildlife disturbance*		*Effect on marine populations*				
	3. *invasive species*		*Which species, effect on native species*				
3. *waste issues*	1. *litter* 2. *water pollution*		*Water quality measurements*				

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Air 1. *e.g. smoke from cruise ships*	1. *air, water and land pollution*		*Air quality measurements*		1. 2. 3.	1.	
2. *Flights*			*e.g. amount of carbon*				
3.							
Sound 1. e.g. *traffic*	1. *noise pollution – disturbing wildlife, other tourists*		*e.g. data on wildlife avoiding sites, tourist moving to other locations*				

6.3.3.3. Conflicts

No data about conflicts available

6.3.3.4. Mitigation

No data about conflicts available

6.3.3.5. Ambitions

There is no detailed information about ambitions.

6.3.3.6. Perceptions

There is no more detailed information about perceptions

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No references are available

6.3.4. Vestfjords

The Icelandic Westfjords are currently the most scattered populated region of Iceland. The region has been facing a gradual migration of people since the 1930ies reaching and comprises a current population of circa 7000 inhabitants sparsely distributed along the coastline. The largest townships today are Ísafjörður (~ 2600 inhabitants), Bolungarvík (~ 930 inhabitants), both located in the northern part of the Westfjords, and Patreksfjörður (~700 inhabitants) which is located in the southern part. Throughout the ages, agriculture and fishing were the main industries, but also sheep grazing has become a subsequent major land-use. In recent decades, the Westfjords have been experiencing major changes in economic activities. Aquaculture and tourism have grown very rapidly and have largely taken on a dominant role in the local economy. Consequently, the area's traditional land-use and population composition (nationalities, gender, age, professions) have changed as well. In addition, the industries are characterised by their sensitivity to climate change and their dependence on international markets. The geographical location of the Vestfjords is highlighted in figure 39. In the context of tourism activities in ArcticHubs, the Westfjords hub focuses on the two municipalities Vesturbyggð and Tálknafjarðarhreppur which are located in the southern part of the Westfjords peninsula.

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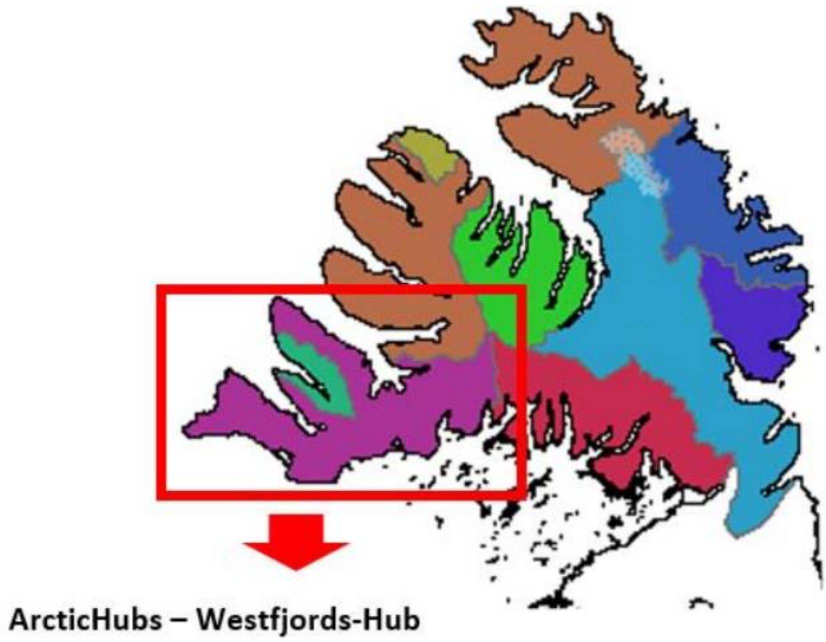

Figure 39. Location of the Westfjords on Iceland

Since the millennia, overnights in hotels have increased with over 400%, however, Westfjords share less than 5% of total overnight stays in Icelandic hotels. Seasonality characterizes the tourism industry and the three summer months highlight the high season for tourists. Skiing has long been practiced in Isafjörður and has been growing as important tourism activity in the northern part, but not in the southern part. Nature is by far the largest factor attracting tourists to the Westfjords and the area's wilderness is extensively used in tourism marketing emphasizing its value for the industry. Subsequently, all kinds of outdoor recreation activities are rapidly growing including hiking, running, biking, horse riding, racing, skiing, kayaking, sea angling or bird watching. Also, the event tourism (e.g., film and music festivals) is growing. Before the Covid-19 pandemic, cruise ship tourism has been growing exponentially over the past two decades as well.

The southern part of the Westfjords can be reached by flight to Bíldudalur once a day and six days a week (Vesturbyggd, 2020). Furthermore, there is a car ferry from Stykkishólmur to Brjánslækur which operates every day during the summer season, but with restriction during the wintertime. Public transport is available from Reykjavík to Stykkishólmur and from Reykjavík to Ísafjörður (via Hólmavík)

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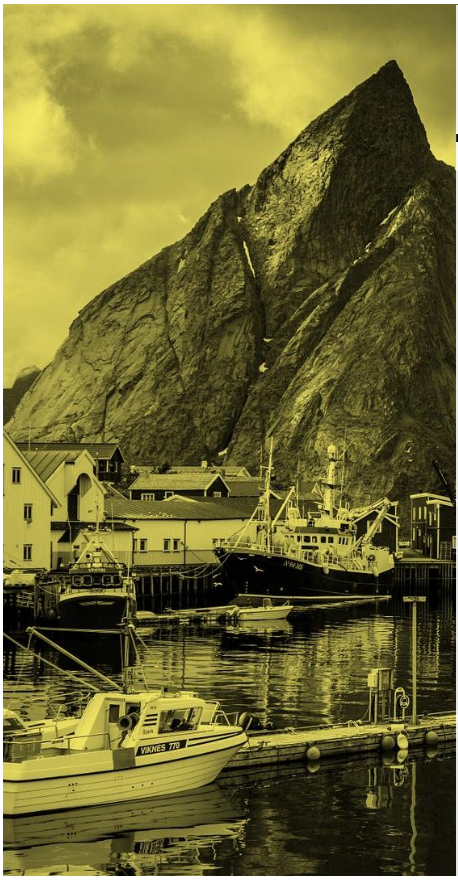
on Fridays and Sundays during summertime. Further deliveries from Ísafjörður to Patreksfjörður are available on Mondays, Tuesdays and Thursdays during the summertime (Visit Westfjords, 2020).

An industrial factsheet from a tourism perspective (Figure 41) presents more quantitative information about the tourism sector in the Vestfjords area.



Industrial factsheet **Westfjords** – Tourism sector

Number of tourism companies registered at the Westfjords Regional Development Office: 2014=37; 2015=46; 2016=50; 2017=47; 2018=50; 2019=51: 2020=60; 2021=65), but not all enterprises are registered there.

Numbers for accommodation and restaurant licenses of each municipality in the Westfjords. For Vesturbyggð and Tálknafjarðarhreppur the numbers are: **2017=7; 2018=23; 2019=29; 2020=33; 2021=34.**

Most tourism companies are **small and medium sized, operated locally**

Ownership: Mainly local and/or regional

Activities: Nature-based and adventure tourism: Visiting natural and historical sites, hiking, running, biking, horse riding, backpacking, racing, skiing, kayaking, sea angling, bird watching, (other wildlife: seals and arctic foxes), boat trips, scooter touring, cruise tourism, event tourism (film festival)

Spatial extent: The tourism companies are located around the coastline, tourism activities use the whole area (both terrestrial and marine)

Natural resources used: Natural ecosystems, remote wilderness, abandoned lands, fishing areas

Figure 40. Industrial factsheet Vestfjords (Tourism)

6.3.4.1. State of the art / environmental background

Fjords are prominent in the Westfjords providing magnificent mountains in between picturesque landscapes. The landscape is characterised by its tertiary basalt of volcanic origin, the oldest geological formation is no more than 15 million years old. The fjords are formed by glacier erosion that has played an important role in giving the region its present form of rugged rock and steep sided fjords. During the Holocene, coastal erosion has developed numerous large bird cliffs along the shores. In the southern part, the cliffs at Látrabjarg which are located at the westernmost point in Iceland, comprise the longest bird cliff in the northern Atlantic Ocean. At many of the steep fjords, the risk of snow

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avalanches is high. In addition, the lack of flat lowlands limits the potential for agriculture which has mostly been restricted to low-intensity sheep grazing near the fjords throughout the ages. The vegetation cover is currently dominated by grassland and heaths while mosses and various types of lichens dominate the vegetation in many of the higher elevations. Historical and current land use such as sheep grazing, human use of natural woodlands, wetlands drained for farmland, and the planting of non-native tree species, has altered the ecology in the Westfjords. The Increasing tourism is associated with threats to the region's sensitive flora. The more detailed landcover and vegetation characteristics is presented below in figure 41.

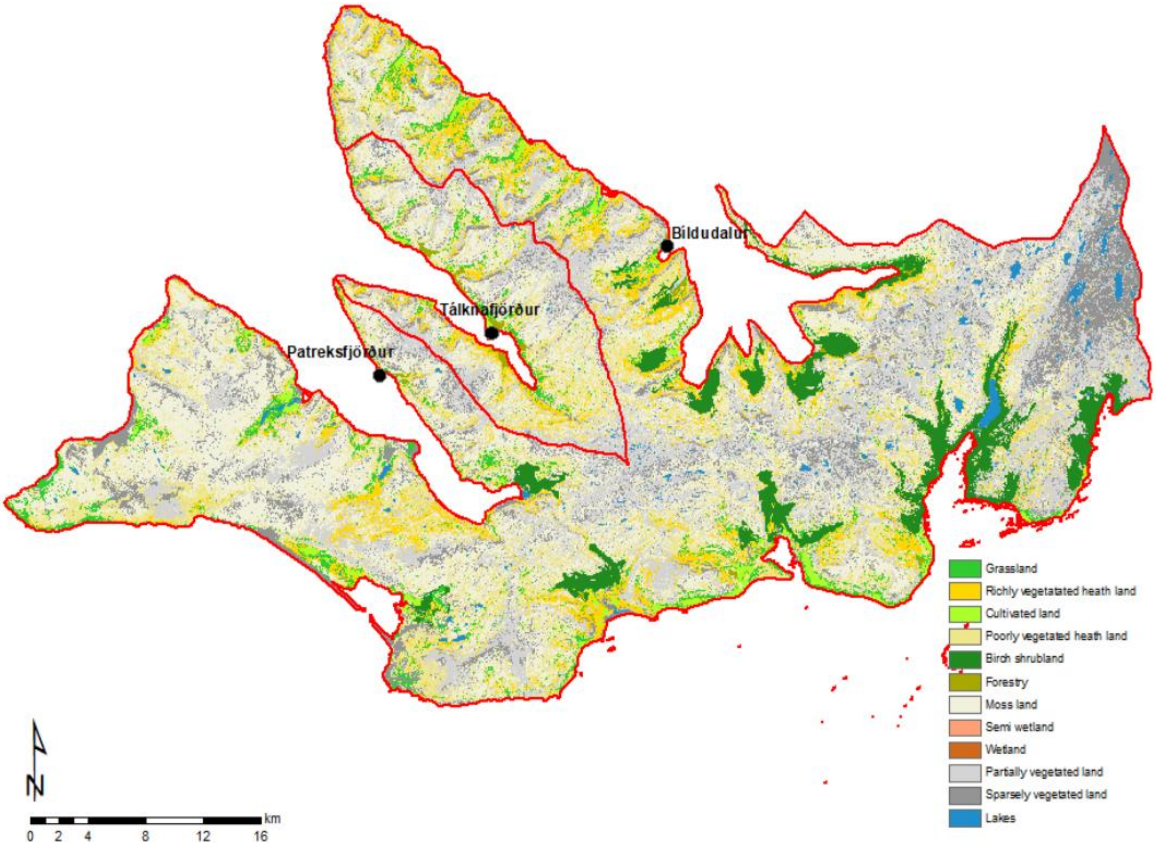

Figure 41. Land cover in the Westfjords area (Vesturbyggð and Tálknafjarðarhreppur municipalities)

Currently, there are several environmentally protected areas within the Westfjords hub. The 20000 hectares big Vatnsfjörður nature reserve and a natural monument called Surtarbrandsgil which is also characterised by fossilized tertiary plant leaves, are both preserved since 1975. Furthermore, there are several protected seascapes along the southern shores. In 2021, the 14 km long and high cliffs of Látrabjarg received the status of a protected nature reserve (figure 42). The reserve is an essential breeding environment for millions of birds (Umhverfis Stofnun, 2022). Currently, preparations have started for the establishment of a new national park in the southern part of the Westfjords which will eventually be Iceland's second largest national park. It also includes already existing nature reserves; the extent of the park is presented in figure 43. Figure 42 provides an overview about all natural monuments, nature reserves and protected land- as well as seascapes. Besides, it shows also the road net which links protected areas and nearby towns in the Vesturbyggð and Tálknafjarðarhreppur municipalities. In general, the protected areas and nature reserves are a magnet for the tourism industry and therefore an important pillar for the industry. At the same time, tourism has a continuous impact on the protected natural areas.

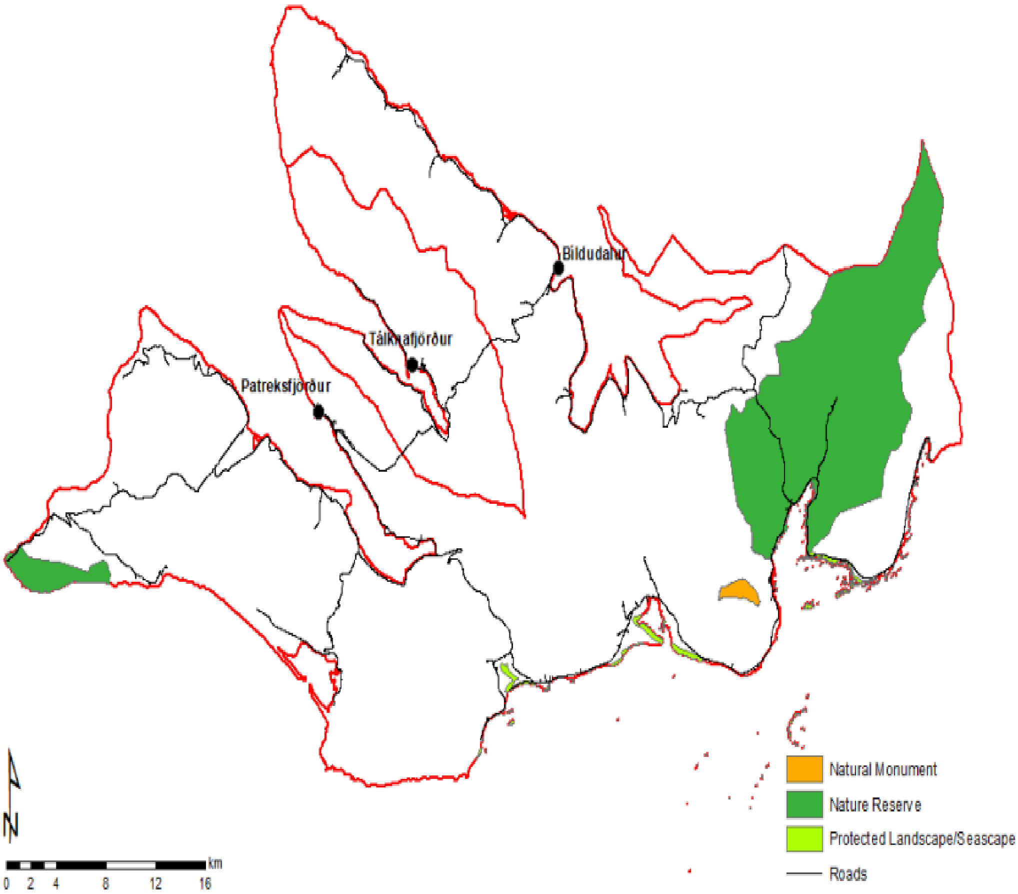

Figure 42. Protected areas in the Westfjords hub (Vesturbyggð and Tálknafjarðarhreppur municipalities) (data from the Environment Agency of Iceland)

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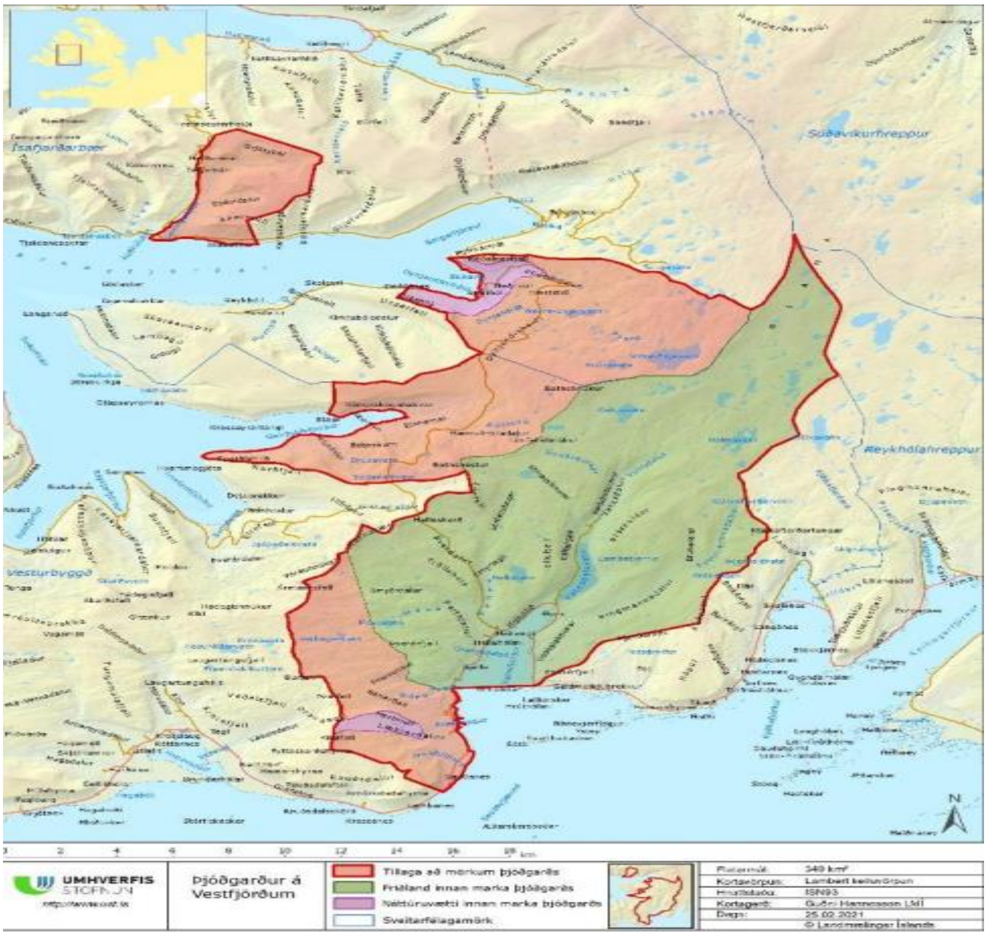

Figure 43. Designated spatial distribution of the proposed national park, the green area corresponds to the existing nature reserve. (Environment Agency Iceland, 2021)[32]

6.3.4.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in the Icelandic Vestfjords.

[32] Link should be specified (leads only to jgf): Thjogardur_vest_1.jpg (2481×3509) (ust.is)

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A. Habitat and landscape

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Land 1. *infrastructure development – roads, trails, buildings*	*1. impact on populations/biodiversity* *2. impact on ecosystem services* *3. Visual impact in pristine areas that changes tourists' experiences*		*landuse/landcover change*				*No data exists*
2. *traffic at sites*	*1. trampling, damage to natural vegetation* *2. soil erosion* *3. wildlife (birds; seals) disturbance*		*Land degradation*				*No data exists*

All tourism companies need operational permits from the Icelandic Tourism Board (ITB) (according to the Act on the Organization of Tourism no. 73/2005). There are two types of licences/permits: Permits that grant a permission to operate a travel agency as well as permits exclusively for day tour travel providers (Icelandic Tourist Board, 2022). Within the two focus municipalities, there is only one company listed with permission to operate a travel agency which is Westfjords Adventures. There are three companies with permits to operate as day tour travel providers (*Iceland Sailing*; *Harbour Inn Guesthouse/Beffa Tours* and *Eaglefjord Travel*).

Environmental impact assessments are not required for tourism companies in the Vestfjords area.

B. Changes of biodiversity

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
2. *traffic at sites*	*1. trampling, damage to natural vegetation* *2. soil erosion* *3. wildlife (birds; seals) disturbance*		*Land degradation*				*No data exists*
4. *invasive species*	*1. impact on biodiversity*						

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

C. <u>Pollution</u>

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Marine *1. Cruise traffic – waste issues*	*1. potential water pollution and wildlife disturbance*	*Patreksfjörður Arnarfjörður*	*Cruise traffic were just starting in the southern Westfjörds before Covid, with 21 cruiseship visiting Patreksfjörður in 2019. No impact measurement exists*				*No data exists*
3. waste issues	*1. litter*						
Air *1. smoke from cruise ships*	*1. air, water and land pollution*					1.	
Sound *1. traffic*	*1. noise pollution – disturbing wildlife, other tourists*		*data on tourist moving to other locations*				

When it comes to waste production, since the last six years, all municipalities in the Westfjords have been participating in the EarthCheck environmental certificate program (Westfjords Regional Development Office – Vestfjarðastofa, 2021). This certificate requires the municipalities to reduce their environmental impact and work towards achieving sustainable development. This applies only for the public sectors, but residents and the companies operating within each municipality are not required to follow the EarthCheck guidelines.

An important feature of the certification are initiatives that reduce the impacts of waste production from cruise shipping, waste from transport (e.g., ferries, flights, cars …) as well as waste from accommodations and restaurants. According to the Progress Review of Corrective Actions Requests Report that was conducted for the Westfjords, a certification was authorized in 2020 (Elín Vignisdóttir, 2020).

6.3.4.3. Conflicts with other activities

No data has been found on conflicts.

6.3.4.4. Mitigation

Development of certification programs (e.g. Earth check)

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6.3.4.5. Ambitions

Most of the material relevant for ambitions and perceptions is in Icelandic. The Islandic material and tourist information is not commented in the compilation. The English material is commented.

One ambition is to be certified in the Earthcheck environmental certificate program. The Earthcheck environmental certificate program express an ambition of assessing sustainable practise by Vottunarstofan Tún (or Tún). This is an independent conformity assessment body, specializing in the inspection and certification of sustainable practices in agriculture, fisheries and related processing and trading activities. Tún was founded in 1994 as a grass-roots initiative supported by farmers, local communities, consumer and trade associations, as well as companies involved in food processing and commerce. Tún works with the Icelandic competent authority, i.e. the Food and Veterinary Authority , on the implementation of organic regulations. In 2020 The Westfjords has been assessed against the EarthCheck Standard. The organisational commitment to compliance with the EarthCheck Standard is commendable and certification recommended for one year.

- https://www.vestfirdir.is/is/verkefni/umhverfisvottun-vestfjarda
- Progress review report: Vignisdóttir, E., 2020. Earthcheck - Progress review of corrective actions requests conducted for Westfjords. (https://www.vestfirdir.is/static/files/Umhverfismal/Bensmarkskyrlsur/authorised-progress-review-of-cars-report-westfjords-6-apr-2020.pdf)

The Environment Agency operates under the direction of the Ministry for the Environment and Natural Resources. Its role is to promote the protection as well as sustainable use of Iceland's natural resources, as well as public welfare by helping to ensure a healthy environment, and safe consumer goods.

The environment agency of Iceland:

- Main website: https://ust.is/english/?
- Protected areas in the Westfjords: https://ust.is/nattura/natturuverndarsvaedi/fridlyst-svaedi/vestfirdir/

6.3.4.6. Perceptions

Local tourist information is both an expression of how the region perceive itself and an ambition of what the region aims to be. The webpages below provide practical information for tourists and the tourism industry.

- General tourist information: https://www.westfjords.is/

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- Transport: https://www.westfjords.is/static/files/westfjords-buses-long-distance-summer-2021.pdf).
- Local travel agency website: https://www.westfjordsadventures.com/

Permits/licenses:

Icelandic tourist board, legal information and permits for day tour providers and travel agencies: https://www.ferdamalastofa.is/en/licences-legislation/travel-agency

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Visit Vestfjords (2021) *Public transport summer 2021.* Retrieved in 2022 from Westfjords

Umhverfis Stofnun (2022). *Latrabjarg.* Retrieved in 2022 from Umhverfisstofnun | Látrabjarg (ust.is)

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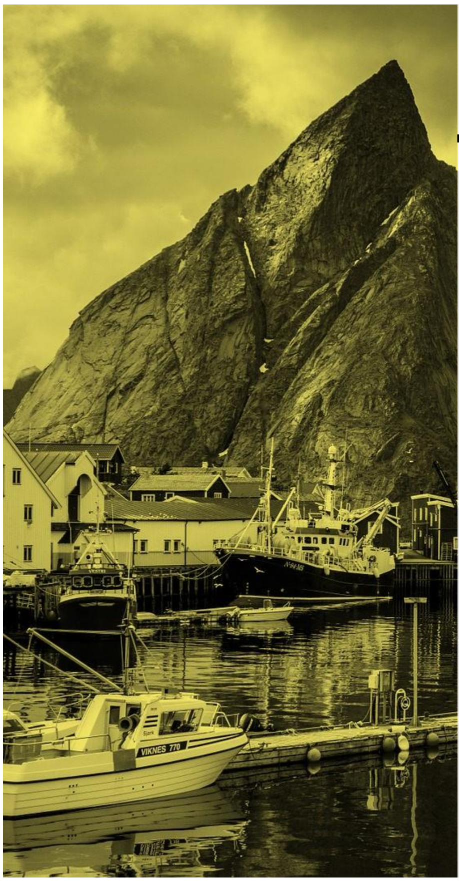
6.3.5. Suðuroy

Suðuroy is the southernmost island in the Faroe Islands. Total area is 165 km2 or 11.8 % of the total area of the Faroe Islands, and the population is 4660. Suðuroy is today considered a periphery of the Faroe Islands without migration, limited skilled employment opportunities, and other general issues also characterizing the Arctic periphery and associated hubs. Historically, Suðuroy was a centre for the Faroese transition from an agricultural subsistence economy to an industrial fisheries economy. Since the 1990s the local fisheries sector has declined in the sense that fewer fishing vessels are in operation, and ownership of the operating businesses is increasingly non-local. As the traditional composition of the marine industries is changing, becoming part of the aquaculture and tourism industries is increasingly seen as a viable solution to secure income and local livelihoods in the future. At the same time, both aquaculture and tourism may come into conflict with other land use activities, both at sea and on land.



Industrial factsheet **Suðuroy** – Tourism sector

Company :	Tourism in Suðuroy is not dominated by big companies or actors. There are two hotels in Suðuroy, 3 guesthouses and 4 B&Bs listed on Visit Suðuroy 's website. Municipalities have invested in camping sites and cottages.
Public transport:	Getting toSuðuroy is possible by public transport by either ferry (Strandfaraskip Landsins) or helicopter.
Ownership :	Local and national (except for AirBnB and such)
Locations :	Spread around the island
Activity :	Cruise tourism (limited to mid -sized cruise -ships in Tvøroyri), adventure tourism, nature tourism.
Natural resources :	The outfields and coastal areas (for adventure and nature tourism). Fishing (Ara tours)
Employment :	Employment directly from tourism is limited. Hotel and restaurant business are estimated to employ between 20-30 people full time.

Figure 44. Industrial factsheet Suðuroy (tourism)

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The tourism sector has been generally increasing on the Faroe Islands. Local efforts and more investments are made to increase tourism in Suðuroy, overnight stays in Suðuroy have been reported to have increased very rapidly[33] [34]. Tourism in Suðuroy is rather not dominated by big companies or actors. There are two hotels in Suðuroy, 3 guesthouses and 4 B&Bs are listed on the website of Visit Suðuroy (see figure 44). Moreover, municipalities have invested in establishments of camping sites and cottages that are spread around the island. Facility ownerships are usually local or national. Getting to Suðuroy is possible by public transport, either by ferry (Strandfaraskip Landsins) or helicopter. In general, the tourism industry is mostly characterised by cruise tourism (limited to mid-sized cruise-ships in Tvøroyri) as well as adventure- and nature tourism. The employment that is linked to the tourism sector is rather limited. The hotel and restaurant business is estimated to employ between 20-30 people on full time basis.

6.3.5.1. State of the art / environmental background

The landscape in Suðuroy is dominated by grassland. Figure 16 shows a map of Suðuroy with areas classified as: Bøur (infield), Hellusvað (rock exposure), Lyngur (heather), Mýra (bog), Svarðloysi (land not covered with vegetation) and Vatn (water). The Suðuroy landscape is used for traditional agricultural subsistence activities, mostly sheep rearing. Likewise, small-scale fisheries and household fisheries have been important for the local economy. (For additional information, see also chapter 5.2.1.1.)

There are no officially protected nature areas or preserves, however, nature conservationists have opposed the open-access approach to nature of the tourism industry. As a result, tourists and the public are now encouraged to use only older paths between villages (bygdagøtur.fo, 2022)[35] (the old paths can be explored via the link in the footnotes).

When it comes to nature protection, Hvannhagi which is located at the north-east coast of Suðuroy has been proposed as a national park a few years ago, however, the plan did not go through. The area is also used extensively for sheep rearing.

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33 https://vagur.fo/eitt-einastandandi-ferdavinnusummar-er-farid-framvid/ (Error link: Must be updated)
34 https://kamping.vagur.fo/closed-for-the-winter/ (Error link: Must be updated)
35 Maps of pathways and hiking trails per location: Hiking - Hiking (whatson.fo)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

6.3.5.2. Environmental impact

The following environmental impacts are based on the tourism industry operating in Suðuroy.

There is not enough overview about pollution and ecological changes. There are limitations of research on this matter.

A. Habitat and landscape

There is no Environmental Impact Assessment necessary for tourism companies. Further, no significant data available.

B. Changes in biodiversity

Some environmental data have been collected in the Hvannhagi area. Other similar data of the area by Vatnsnesvatn have also been collected (see footnote links below, however, the information is in Faroese) [36]

C. Pollution

There is no significant data concerning pollution from the perspective of the tourism industry

6.3.5.3. Conflicts

The big dispute over tourism in the Faroe Islands during the past years has been access to nature. The tourism industry has branded the Faroes as a nature tourism destination, but particularly the agricultural sector has opposed, and argued that the Faroese outfields are their production space. Likewise, nature conservationists have opposed the open-access approach to nature. Open access for tourists are seen as a problem by farmers, and there is a growing concerned that more tourists are putting a risk on natural habitats.

[36] Fylgiskjal_2_Livfrodil_margfeldid_OkiC_Vatnsnesvatn_2018-3.pdf (error link: Must be updated)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

6.3.5.4. Mitigation

To decrease conflict potential with the agriculture sector as well as nature conservationists, tourists and the public have been encouraged to use older pathways and not to access nature openly too much. there are attempts to establish a strategy that keeo tourists in official hiking trails.

6.3.5.5. Ambitions

There is no accessible material relevant for ambitions. The two listed web pages below were not accessible and is in Faroese.

- https://kamping.vagur.fo/closed-for-the-winter/

https://vagur.fo/eitt-einastandandi-ferdavinnusummar-er-farid-framvid/

6.3.5.6. Perceptions

Local tourist information is both an expression of how the region perceive itself and an ambition of what the region aims to be. The webpage below is a Visit Faroe Islands Website with mapped hiking routes showing where people have access to nature

- https://www.whatson.fo/hiking?

REFERENCES

* Umhvørvisstovan www.us.fo (Environment Agency of the Faroe Islands). Map database www.kortal.fo

* ENVOFAR Environmental data on terrestrial and marine ecosystems in the Faroe Islands www.envofar.fo

Bygdagøtur (2022). *Hiking in the Faroe Islands.* Retrieved in 2022 from Hiking - Hiking (whatson.fo)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

Hvannhagi (2010). *Støðislýsing av flora og fauna.* Retrieved in 2022 from Hvannhagi 2010 (d3b1dqw2kzexi.cloudfront.net)

(additional links in footnotes)

6.3.6. Inari

Inari is one of the most important tourism destinations in Lapland and the largest municipality in Finland. It has a surface area of more than 17,000 km2. As a tourist destination it is also multifaceted: **Saariselkä** is a ski resort with an abundance of tourism services from accommodation to activity programme and resides beside the UKK national park, **Inari** is a village located at Lake Inari and is one of the main areas of the indigenous Sámi people, while **Ivalo** is a bigger village with bigger variety of services. Figure 46 presents the spatial extent of Inari including popular towns, villages and the important road network of the highway E75. A popular place among hikers is Kiilopää which is near Saariselkä and very close to the second-biggest national park in Finland. The park comprises an area of 2550 km2 of which 62 km2 are in Inari, and more than 370 000 visitors came to the park in 2020. Day visitors near Saariselkä make up the biggest visitor group in the national park. Altogether, 72% of the municipality's area is protected wilderness, 13% of this is water. Inari is also a popular place to stop for tourists traveling to the most northern tip in Europe, the North Cape.

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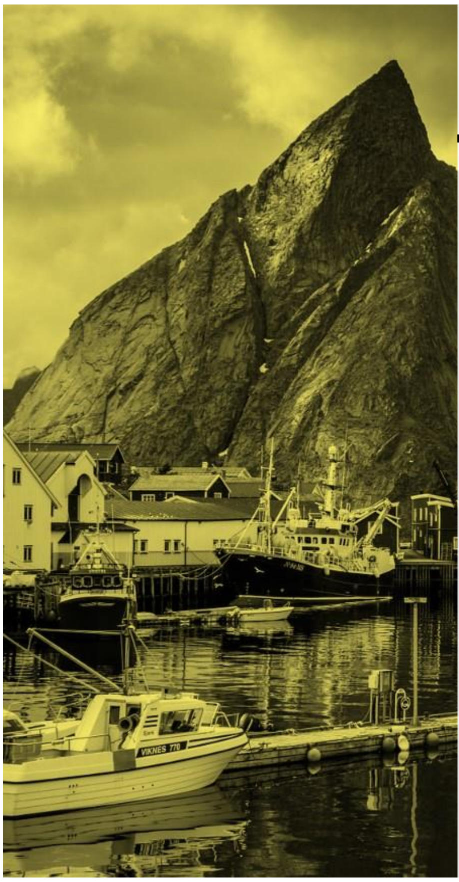

Industrial factsheet **Inari** – Tourism sector

Company (ies):	Around 100; most of them regionally or locally owned and 3 -5 belong to the biggest tourism enterprises in Finland
Ownership:	Mainly local or regional
Location:	Around lake Inari
Activities:	Dog sledding, scooter tours, hiking, skiing, fishing, hunting, cycling
Spatial extent:	Inari municipality (17,334 km²)
Natural resources used:	Remote wilderness areas, national park, village environments, Lake Inari, other waterways; fish, game, sceneries
Production:	NA
Employment:	collected in WP3

Figure 45. Industrial factsheet Inari (tourism)

Together with the attractiveness of Lake Inari, this makes the area a popular tourist destination not only in winter which is the high season in other parts of Lapland, but also in summer. A specific activity related to tourism has been gold spanning, both mechanized and manual. The mechanized digging has been prohibited lately. Annually, around half a million tourists visit the area arriving mainly by plane or private car. Hiking, skiing, cycling as well as snow mobile- and husky safaris are the most important activities. Lake Inari is also popular among fishers. Besides the tourism industry, the main livelihoods are reindeer herding, fishing, forestry, training services and other private services. A new addition to the traditional business sectors in the past ten years is cold technology and especially car and tyre testing in arctic conditions which also uses quite large land areas. Figure 47 shows a map of Inari and associated villages and towns including housing areas, holiday resorts, and the national park.

The area has a history of huge conflicts between reindeer herding and forestry as reindeer pastures are seen as threatened. Also, tourism and reindeer herding are conflictual especially due to the use of dogs in safari activities.

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There are around 100 tourism companies in Inari which are mostly regionally and locally owned. 3 to 5 tourism companies make up the biggest tourism enterprises in Finland (see also figure 45).

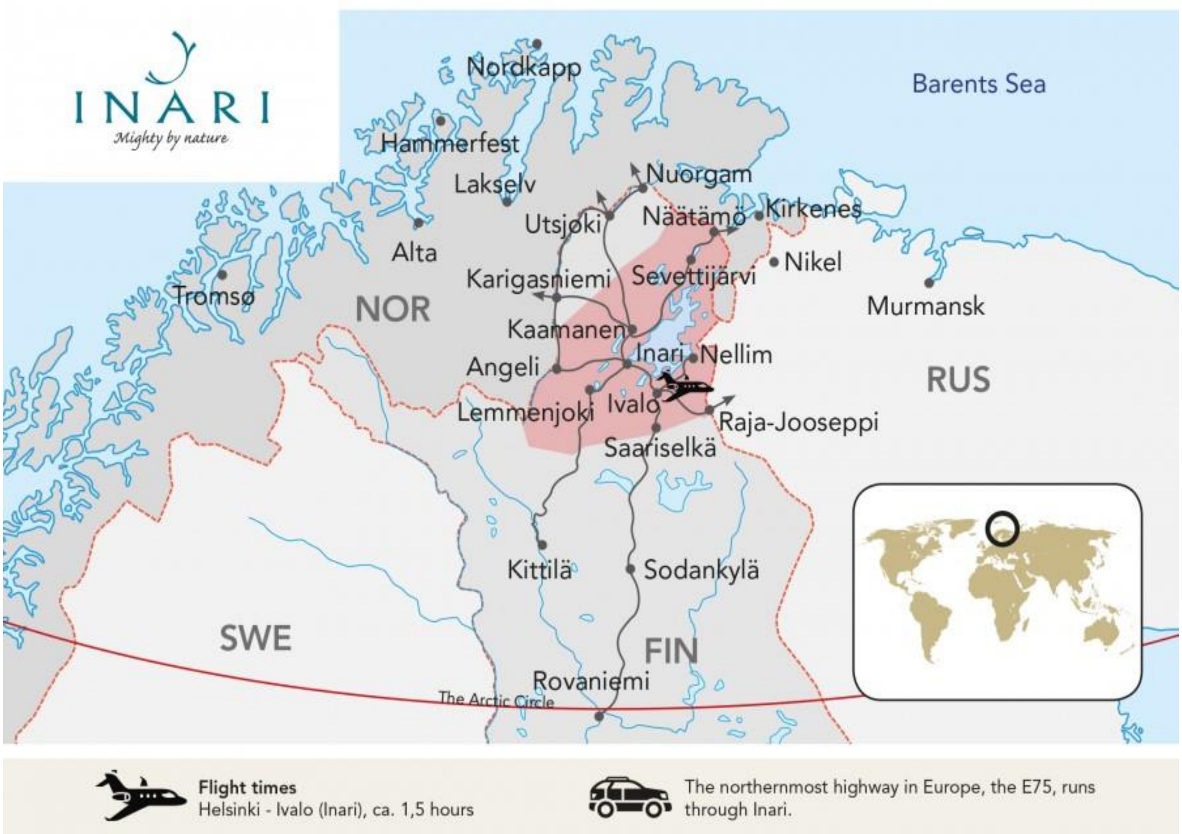

Figure 46. Municipality of Inari - Most visitors arrive by plane and private car via the highway E75

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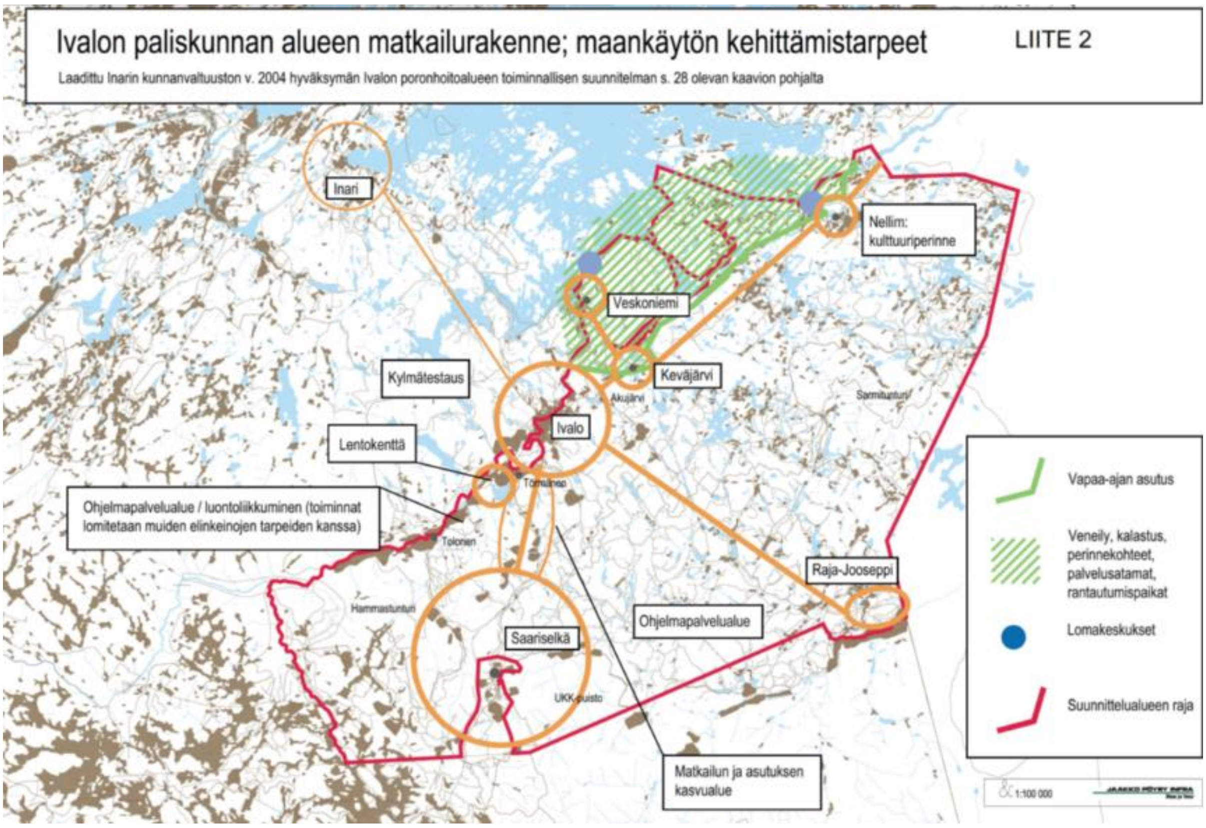

Figure 47. Housing, tourist resorts and national park in Inari municipality. Some of the markings in English: Vapaa-ajan asutus = second home area; Lomakeskukset (blue dot) = holiday resorts; Matkailun ja asutuksen kasvualue = Tourism and housing development area (yellow lines); Suunnittelualueen raja (red line) = limits of the plan

Over time, the area of Saariselkæ has seen a strong development of new infrastructure facilitating the tourism industry. This includes new roads, ski-lifts, buildings, and car parks. A more detailed map about new infrastructure- and service developments can be seen in figure 48.

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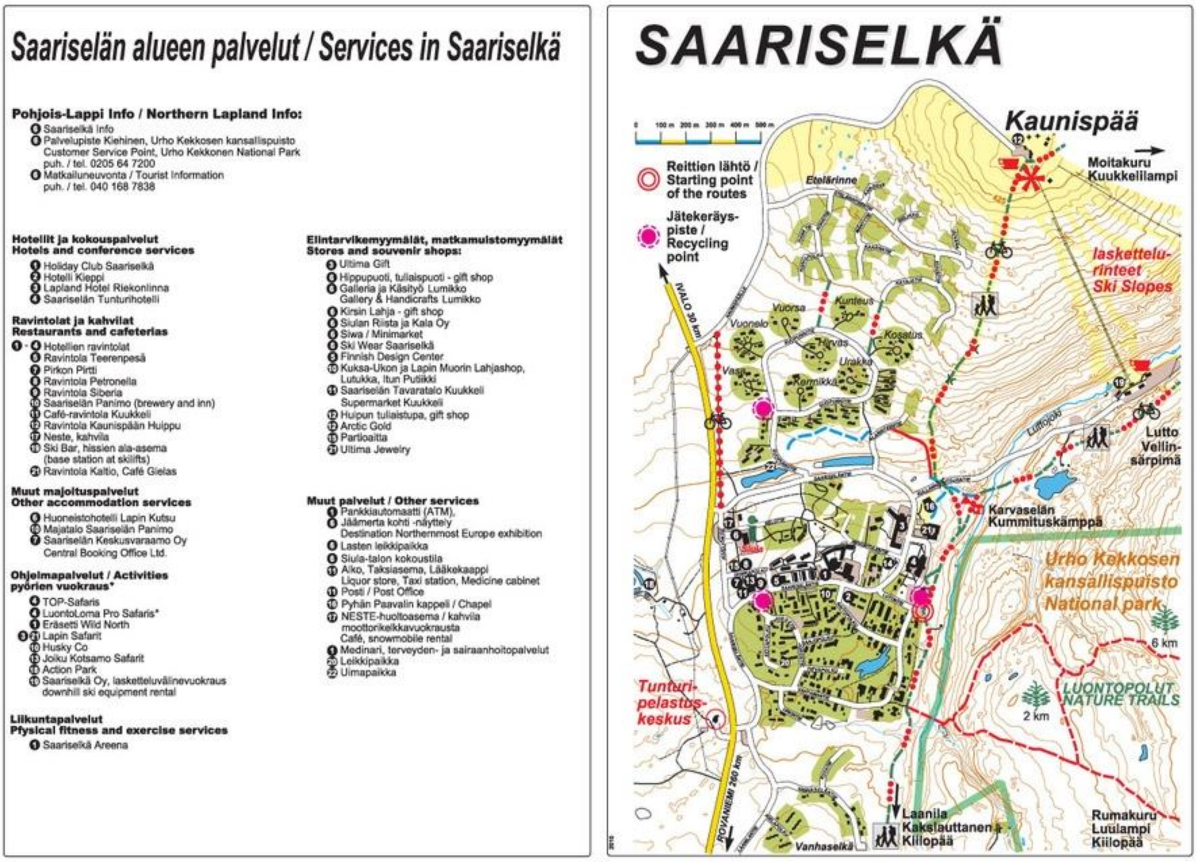

Figure 48. Tourism infrastructure development in Saariselkæ

6.3.6.1. State of the art / environmental background

Inari has over 100 named fells. The northern spruce forest dwindles out in the southern parts of the municipality due to the latitude and the pine forest in its northern parts. The forest and fell scenery in Inari are crossed by several water systems that flow northeast to the Arctic Ocean. There are over 10 000 lakes in the Inari region of which lake Inari is the third largest lake in Finland. Its length is about 100 km, the average depth is 14 metres, and the deepest points go down to almost 100 metres. Moreover, lake Inari has over 3 300 islands. Regarding the landcover of Inari, during snowless seasons, tourism trails conquer more and more land surface from plants, and they need to be covered. Nature protection areas can be especially found close to the biggest tourist resort Saariselkä, which is located beside the UK national park. Here, the trail network is dense in and around the national park. In addition to skiing and hiking trails, the trails for mountain biking are continuously expanding as the popularity of the activity increases. The map (figure 49) below shows the trail network close to the Saariselkä tourist resort.

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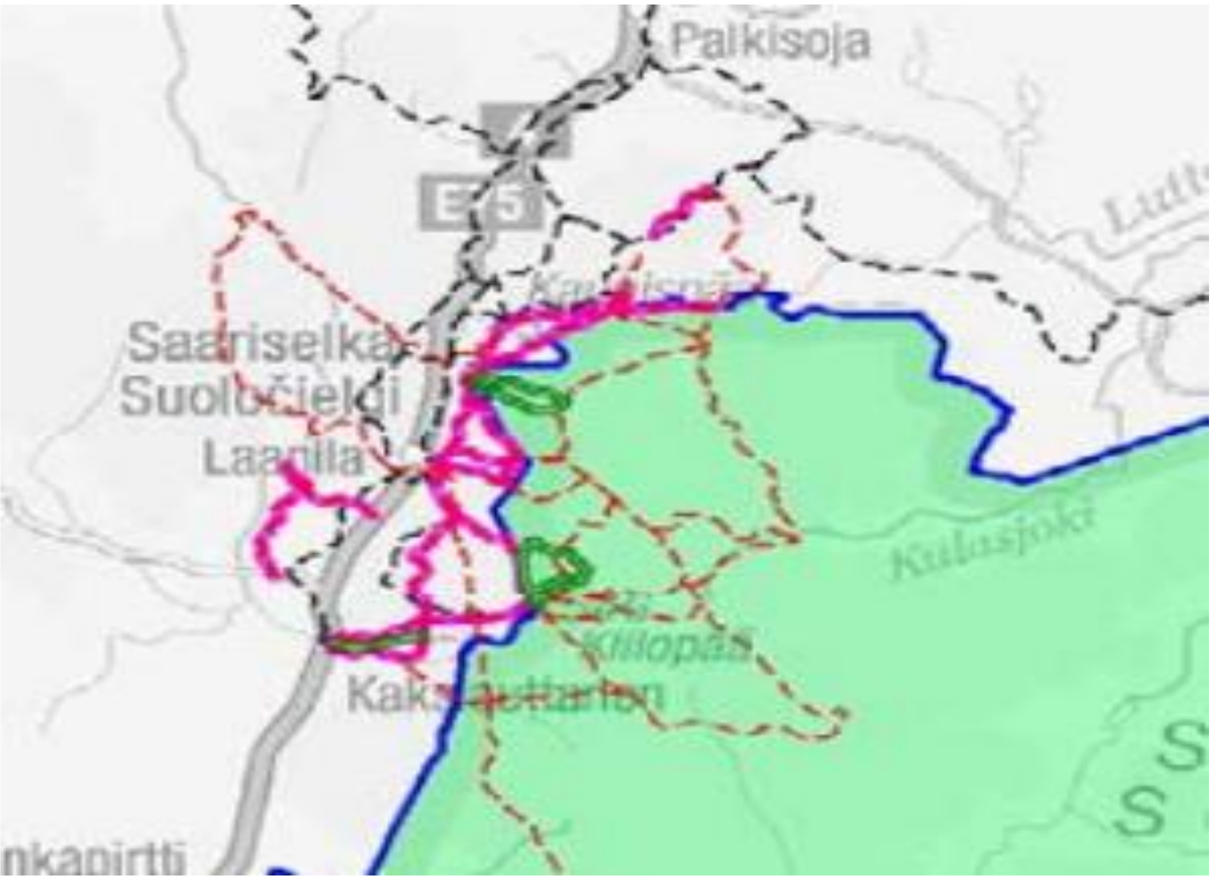

Figure 49. Trail network in Saariselkä: pink = biking routes, brown dashed line = hiking route, black dashed line = snow mobile trail, green line = nature trail and the green area is the national park lined with blue

In addition to national parks, four of 12 Finnish Wilderness areas (Hammastunturi, Kaldoaivi, Vätsäri and Paistunturi,) are partially located in Inari. These wilderness areas were established in 1991 to protect the wilderness characters of the areas, to safeguard Sámi culture as well as traditional subsistence uses and to develop more potential for a diversified use of nature. Traditional means of livelihood such as hunting, fishing and reindeer husbandry, can be practised in the wilderness. Lake Inari belongs partly to Vätsäri Wilderness area and is partly a Natura 2000 area. Here, the area is protected by the nature conservation programme on shorelines.

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6.3.6.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in the municipality of Inari.

A. <u>Habitat and landscape</u>

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Land 1. *infrastructure development – roads, buildings*	*Increase in roads and tourism buildings; new hotels in quite pristine areas*	Saariselkä ski resort; the shores of Lake Inari; Inari village	risk for the pristine nature of Lake Inari		1. Reindeer herding: especially increase in dog sledding disturbs reindeer 2. Dwelling: people are increasingly disturbed by the behaviour of tourists in Inari village (trespassing, littering, waste problems)	1. 2. 3.	- More research on the actual disturbances - Negotiations between reindeer herders and dog sledding companies
2. *traffic at sites*	*1. trampling, damage to natural vegetation*						No EIA made for any tourism constructions

B. <u>Changes in biodiversity</u>

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
4.- urban sprawl - *invasive species*	*1. Ski resorts induce urban sprawl of bird species to wilderness*	*Saariselkä ski resort*[i]					
	2. impact on biodiversity						

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C. Pollution

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
3. *waste issues*	1. *litter*	Inari Lake					
Air *1. Flights:* Most of the flights from Helsinki but the number of charter flights from London (100 in Christmas season in 2018), Paris and Amsterdam and other locations is increasing.	*Carbon foot print*		*Air traffic has increased: the number of flight passangers has doubled from 1998 to 2019 (the number of foreign passangers has increased from 3000 in 1998 to 56 600 in 2019); **international landings 24 in 1998; 236 in 2019)**[ii] → carbon foot print increased accordingly?*		1. 2. 3.	1.	
Sound 1. e.g. *traffic*	1. *noise pollution*		*e.g. snow mobile traffic and rented jet skis disturbs residents*[iii]				

6.3.6.3. Conflicts

See tables above

6.3.6.4. Mitigation

No mitigation data available

6.3.6.5. Ambitions

The compiling contains documents in English and Finnish. It is only the English that are compiled as expressions of ambitions.

One ambition for Inari tourism industry is to is to get sustainable destination certificate

- Sustainable Travel Finland (STF) label (https://www.inarisaariselka.fi/sustainability/).

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So far 13% of the companies has got the Sustainable Travel Finland (STF) label according to (https://www.businessfinland.fi/en/do-business-with-finland/visit-finland/sustainable-travel-finland-label)

Planning documents can be considered as expression of ambitions:

- *Metsähallitus management plan for UK national park (in Finnish, Swedish summary):* *https://julkaisut.metsa.fi/assets/pdf/lp/Csarja/c143.pdf*

This is Management and use plan for Urho Kekkonen National Park, Sompio Nature Reserve, Kemihaara wilderness area and Vaaranaapa, Nalka-aapa and Uura-aapa marsh protected areas are from 2016. Based on the Swedish summary; the care and use plan include a description of the current situation, where one presents the protection and cultural values of the planning area. Based on the description of the current situation an assessment is made of the central threats to the area and measures are proposed to prevent the threats. In the chapter Setting goals, it is presented how to follow up how the measures are implemented and assess the effects and effectiveness of the measures. In the Realization chapter the measures for which the Forestry Agency is responsible and the resource requirements for these are presented. The main changes in the plan concern the zoning of the national park, cycling, off-road traffic during the summer and during the winter as well as horse riding.

- *Action Plan Pasvik-Inari Trilateral Park 2019-2028:* *https://prosjekt.fylkesmannen.no/Documents/Pasvik%20-%20Inari/Dokument/Signed_Action%20plan%202019-2028_Pasvik-Inari%20trilateral%20park-min.pdf;*

Action Plan for Pasvik-Inari trilateral park cooperation 2019-2028 presents the background of the international cooperation, the mutual vision and mission for our cooperation, as well as the main and specific objectives, and concrete development ideas of the cooperation. The plan is considered as an advisory plan focusing on common long-term guidance and cooperation. The vast cooperation area referred to as the Pasvik-Inari trilateral park comprises of six protected areas in the Lake Inari and Pasvik river vicinity and their close surroundings in three countries of Finland, Norway and Russia. The protected areas are Vätsäri Wilderness Area and Lake Inari Natura2000 area in Finland, Øvre Pasvik National Park, Øvre Pasvik Landscape Protection Area and Pasvik Nature Reserve in Norway and Pasvik Zapovednik in Russia.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

The trilateral park has been certified as EUROPARC transboundary park since 2008 (re-certified in 2013 and 2018). This action plan was compiled by the cooperation partners as part of the regular cooperation in 2018. There will be a mid-term evaluation of the plan, after 5 years, in 2023. Our vision is "Pasvik-Inari Trilateral Park is a unique cooperation for the benefit of nature and people". Our mission is: *Through transboundary cooperation we cherish nature and raise awareness on biodiversity conservation and living cultural heritage. We promote sustainable development in the joint border area of Finland, Norway and Russia, as well as human health and wellbeing*.

The main objectives of this international, transboundary nature protection cooperation are: 1. Enhance transboundary cooperation and contacts at all levels. 2. Conserve natural and cultural values of the Pasvik-Inari region on a long-term basis. 3. Raise awareness and promote recognition of the area. 4. Contribute to the sustainable development and create positive local economic impact. 5. Facilitate for health and wellbeing of the people.

In addition to ambitions, the plan also contains statistics, relevant scientific literature references and IUCN Protected Area Categories System.

- Metsa/Metsähallitus provides information and statistics about environment and sustainable management in Finland https://www.metsa.fi/en/about-us/organisation/

Metsa/Metsähallitus is a state-owned enterprise that produces environmental services for a diverse customer base ranging from private individuals to major companies. As part of our sustainable management and use of natural resources, we see to the fulfilment of general social obligations by addressing the protection of biodiversity, facilitating the recreational use of nature and meeting the requirements of promoting employment. Additionally, we coordinate the management, use and protection of natural resources in the Sámi Homeland whilst safeguarding the prerequisites for pursuing the Sámi culture and in the reindeer herding area while fulfilling the obligations laid down in the Reindeer Husbandry Act.

The plan only accessible in Finnish is not reviewed.

- *Regional land use plan for northern Lapland (in Finnish): https://www.lapinliitto.fi/wp-content/uploads/2021/05/Pohjois-Lapin-maakuntakaavan-2040-kaavaselostus-.pdf*

- *http://www.lappi.fi/lapinliitto/valkky-hanke*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

6.3.6.6. Perceptions

This document is only accessible in Finnish.

- *Metsähallitus visitor survey for UK national park (in Finnish): https://julkaisut.metsa.fi/assets/pdf/lp/Muut/UKpuisto-kavijatutkimus-2017-tiivistelma.pdf*

REFERENCES

National databases: 1) Finavia (flight statistics); 2) Statistics Finland (accommodation numbers)

Planning documents:

1) Metsähallitus management plan for UK national park (in Finnish):

https://julkaisut.metsa.fi/assets/pdf/lp/Csarja/c143.pdf

2) Pasvik-Inari action plan.

https://prosjekt.fylkesmannen.no/Documents/Pasvik%20-%20Inari/Dokument/Signed_Action%20plan%202019-2028_Pasvik-Inari%20trilateral%20park-min.pdf

3) Metsähallitus visitor survey for UK national park (in Finnish):

https://julkaisut.metsa.fi/assets/pdf/lp/Muut/UKpuisto-kavijatutkimus-2017-tiivistelma.pdf

4) Regional land use plan for northern Lapland:

https://www.lapinliitto.fi/wp-content/uploads/2021/05/Pohjois-Lapin-maakuntakaavan-2040-kaavaselostus-.pdf (in progress)

Consultancy reports

ArcticHubs PPGIS inquiry, June 2021

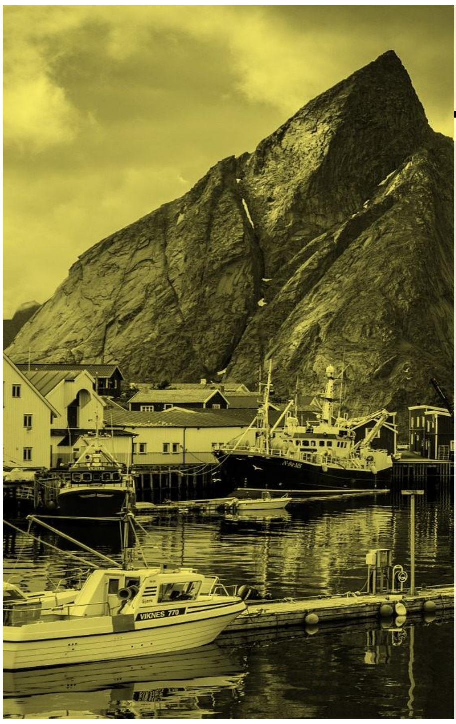
Action Plan Pasvik-Inari Trilateral Park 2019-2028

https://prosjekt.fylkesmannen.no/Documents/Pasvik%20-%20Inari/Dokument/Signed_Action%20plan%202019-2028_Pasvik-Inari%20trilateral%20park-min.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

6.3.7. Alagna Valsesia

Alagna ("Im Land" in Walser German language) is an alpine town of Upper Valsesia in the NW Alps and is the access point to the North face of Monte Rosa. It was settled by Walser colonists from Valais, Switzerland, in the 14th century and since then it has preserved its Alemannic language, culture and architecture. At present day, the permanent resident population consist of circa 600 inhabitants while during the winter season over 5000 tourists come to Alagna Valsesia per day. Due to its alpine geomorphological conditions, Alagna Valsesia is nowadays internationally known for being the freeride ski capital of the Alps. The local tourism industry included Alagna Valsesia in the "Monterosa Paradise Ski", a huge ski-resort (180 km of runs) at the foot of Monte Rosa with a series of cable cars and ski-lifts. A further development of the tourism sector is now under regional and local debate from an environmental point of view, because of possible issues related to: 1) A sharing of grounds with the Sesia Val Grande UNESCO Global Geopark and Alta Valsesia Regional Park; 2) climate change effects on both mountain environment and consequently, the potential of ski resorts; and; 3) energy consumption and waste production associated with increasing tourism infrastructure. By conducting research on local natural and cultural resources and developing discussions among public administrators, environmental managers, and other stakeholders, it is aimed to establish a participating environmental assessment and sustainable tourism planning in the Alagna Valsesia area.



Industrial factsheet **Alagna Valsesia** – Tourism sector

Company:	Monterosa 2000 Ownership: regional - publicly owned company with the participation of the Piemonte region.
Location:	Frazione Bonda, 19 13021 Alagna Valsesia (VC), Italy
Activity:	Alpine ski resort, public transport (mountaineers, trekkers, bikers)
Spatial extent	Ski area ca 5 km2, ropeways 9 km
Natural resources used	Soil, water
Production (winter):	Circa 116.000 annual first entrances (skiers starting from Alagna), ca 1.100.000 annual transits (in total, also coming from the neighboring valleys)
Employment (winter)	Circa 50 employees
Energy demand	Artificial snow production ca 350.000 kWh, ropeways ca 1,5 mln kWh.
Energy production	Hydroelectric power plant 800.000 kWh, the other required amount coming from certified green energy

Figure 50. Industrial factsheet Alagna Valselsia

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The “Monterosa Paradise ski” resort is operated by the regional company Monterosa 2000 which is publicly owned with the participation of the Piemonte region. While the resort promotes alpine skiing, it is also popular among mountaineers, trekkers and bikers which can make use of a well-established public transport system. The ski area comprises 5 km2 and 9km long ropeways. In the winter season around 116000 first entrances as well as 1100000 transits are annually registered in the Alagna ski area including visitors from the neighbouring valleys. The employment in the resort during the winter season makes up around 50 employees.

Since 2000, there has been a continuous infrastructure development in and around the Monterosa 2000 ski resort. In this context, table presents an overview about some important milestones over time.

Table 13. Since the year 2000, Monterosa 2000 started the renovation of the ski resort. Milestones are presented below (Monterosa 2000, 2022).

YEAR	TOURISM INFRASTRUCTURE DEVELOPMENT
2000	demolition of the old cable car replaced by one gondola and one fixed-grip chairlift
2004	interruption of the old Punta Indren cable car service, building of the funifor allowing the high-altitude connection with Monterosa Ski resort (Aosta Valley)
2003-2004	Creation of the Olen ski track
2005	Programmed snow-making system building of the Bocchetta delle Pisse-Pianlunga-Alagna sector
2017	building of the Cimalegna detachable chairlift to increase skiers’ flow

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2019	building of the Mullero Competition ski track and the related snow-making system, completion of the programmed snow-making system on the Cimalegna plateau
2020	artificial water reservoir construction to support and empower the existing snow-making system

6.3.7.1. State of the art / environmental background

The hub area is located in the inner side of the Alpine range, in the Pennidic Domain (Piana et al., 2017). From a geological and geomorphological perspective, according to the classification scheme of the Piemonte geological map (Lombardo et al., 2016), it consists of continental crust units from the European continental margin and oceanic crust units from the Ligure-Piemontese Ocean. The area is a significant tectonic intersection between major structural and paleogeographic domains of the Alpine orogen, with (from north to south) (i) the Monte Rosa nappe (continental crust), constituted of garnets and chloritoid-rich micaschists, metabasites, orthogneiss, paragneiss and marbles; (ii) the 'Zermatt-Saas' and 'Combin Zone' units (oceanic crust), constituted of serpentinites, metagabbros, metabasites, metasediments and calcschists (Dal Piaz, 2001; Gasco et al., 2011; Handy et al., 2010; Piana et al., 2017; Steck et al., 2015). Within the Alagna Hub, the modelling of the geomorphological landscape in the higher mountains has been mainly driven by glacial processes, although erosional and depositional landforms related to gravitational processes currently represent the most active geomorphic agents in the area. The preservation of glacial horns and periglacial landforms such as blockfields and block streams on the higher plateaux indicate that this mountain area contained nunataks and/or was located below a cold-base glacier during the last glacial maximum (LGM).

When it comes to landcover, according to the Corine Landcover Maps (2018) the area is dominated by natural grasslands (code 321), bare rocks (332), sparsely vegetated areas (333) and land principally occupied by agriculture, with significant areas of natural vegetation (243). No changes have been mapped between 2000-2018 (Copyright Copernicus Program, 2018).

Alagna Valsesia is characterised by several nature protection areas. A part of the territory of Alagna Valsesia is included in the Parco Naturale Alta Valsesia, a regional naturally protected area covering the highest part of the Sesia valley. Moreover, there are two Sites of Community Importance (SICs) defined by the habitat Directive of the European Union: A Special Area of conservation as well as a

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Special Protection Area[37]. In the former area, 79 species of birds are known of which 11 are included in the EU Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. In the latter area, there are different environments recognized by the Habitat Directive such as peat bogs (code 7140) and glaciers (code 8340). Eventually, the municipality of Alagna Valsesia is part of the Sesia Val Grande UNESCO Global Geopark which protects the geodiversity and geo-heritage of the area (Pimonte Region, 2022).

When it comes to the biodiversity characteristics of Alagna Valsesia, the Cimalegna plateau area located in the alpine tundra, is included in the research sites of the Istituto Mosso[38] and hosts several permanent plots for the monitoring of atmospheric deposition, soil, ponds and plant phenology and biodiversity (DEIMS-SDR, 2022). The soils in the area are quite evolute and act as an important carbon stock. The ponds reveal a potential contribution of chemical elements (e.g., nitrate) from the permafrost degradation. Within the plateau, the vegetation is composed by a mosaic of three main phytosociological associations: (i) Androsacetum alpinae (Br.Bl. in Br.Bl. et Jenny 1926) on the steeper slopes with medium or large silicic debris; (ii) Caricetum curvulae (Rübel 1911) with acidic grasslands species on windy ridges and gentle slopes; and (iii) Salicetum herbaceae (Rübel 1911) on snow beds with longer snow cover duration and deeper soils. More than 50 plant species have been classified and represented in a habitat map. The monitoring activities are carried out not only to investigate the impact of global warming and/or extreme meteorological events on the ecosystem functioning but also to verify the potential impact of human activities connected to the management of the ski area (DEIMS-SDR, 2022).

With special focus on geodiversity and abiotic ecosystem services, the presence of different lithologies (belonging to continental and oceanic units), landforms and processes related to different morphogenetic agents (gravitational, fluvial and fluvio-glacial, ice and snow related features, glacial and periglacial and nival) together highlight the unique geodiversity of the study area. Considering abiotic ecosystem services, the Monte Rosa massif plays an important role in terrestrial processes (tectonic and erosional processes). The importance of flood regulation is recognised both for natural

[37] This has been translated from Italian. For more information on the characterization of these areas, see the following link: [Official website of the Piedmont Region - Parks (regione.piemonte.it)]

[38] The institute in the higher latitudes of Alagna Valsesia hosts several laboratories and additional research facilities and includes staff from the University of Turin as well as research groups that operate at the site and contribute to data collection and activities for CNR-IRSA, Alpine Troops Command-Service Meteomont, Monterosa 2000 SpA and Monterosa SpA (Monterosa Ski), Protected areas of Valsesia, ARPA Piemonte, ARPA Valle d'Aosta and Sesia Val Grande Geopark (DEIMS-SDR, 2022)

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(e.g. alluvial/proglacial plain) and man-made (e.g. reservoir) landforms. Moreover, the area is almost entirely encompassed in different protected areas highlighting its environmental value as habitat provision services. Land as a platform for human activities is strongly linked to ski resort activities (lift stations and pylons), residential activities and pastoralism. Glaciers and lakes play a relevant role as freshwater reservoirs, feeding valley streams and aquifers. Cultural services include several leisure activities, skiing, but also geo-tourism, hiking, climbing, mountaineering. The learning case area has an Alemanic influence in language, culture and architecture. Numerous religious symbols (e.g., chapels, roods) are spread in the area. Several scientific studies, meteorological and glaciological data series are continuously carried out by the Mosso Institute. In terms of education and employment, the Sesia Val Grande UNESCO Global Geopark promotes education and dissemination activities.

More concretely, the table below (table 14) shows a more detailed overview about existing ecosystem services associated with the Alagna Valsesia municipality.

Table 14. Overview of ecosystem services in Alagna Valsesia

TYPE	SERVICE	
Regulating	Atmospheric and oceanic processes	x
	Terrestrial processes	x
	Flood regulation	x
	Water quality regulation	x
Supporting	Soil processes	x
	Habitat provision	x
	Land and water as a platform for human activity	x
	Burial and storage	x
Provisioning	Food and drink	
	Nutrients and minerals for healthy growth	
	Fuel	x
	Construction material	
	Industrial minerals	
	Ornamental products	
	Fossils	
Cultural	Environmental quality	x
	Geotourism and leisure	x
	Cultural, spiritual and historic meanings	x
	Artistic inspiration	
	Social development	x
Knowledge	Earth history	
	History of research	x
	Environmental monitoring and forecasting	x
	Geoforensics	
	Education and employment	x

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6.3.7.2. Environmental impact

The following environmental impacts are based on the tourism industry operating in the Italian municipality of Alagna Valsesia.

A. Habitat and landscape

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities (positive, negative)	Mitigation, enhancement	Further needs
Land 1.infrastructure development and maintenance (ski runs, ropeways, accomodation facilities)	re-modeled slope	Punctual	medium	perennial	1. (-) impact on alpine landscape for tourism 2. (+) new fruition path for other tourism activity (downhill) 3. (+) new area for pastures 4. (+) territory monitoring and surveillance (avalanches, hydrogeological risks) 5.(+) vegetation maintenance (selective trees cut)	(+) best practices in management strategies of soils and vegetation	proper application of environmental laws and regulations
	wildlife disturbance	widespread	low	seasonal			
	habitat fractionation	Punctual	low	decades			
	impact on bio-geodiversity and related services	punctual	medium	perennial (geo) decades (bio)			
	change in surface drainage	widespread	medium	decades			
2. infrastructure obsolescence	release of inert material	punctual	low	decades	(-) impact on alpine landscape for tourism	(+) reuse for scientific and dissemination activities	
					3. (+) soil protection (medium-high altitude) in case of weak snow coverage winters	(+) water reservoir building	
	2.delayed vegetational season (at low elevation)	widespread	low	seasonal			

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B. Changes in biodiversity

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities (positive, negative)	Mitigation, enhancement	Further needs
Land 1.infrastructure development and maintenance (ski runs, ropeways, accomodation facilities)	re-modeled slope	Punctual	medium	perennial	1. (-) impact on alpine landscape for tourism 2. (+) new fruition path for other tourism activity (downhill) 3. (+) new area for pastures 4. (+) territory monitoring and surveillance	(+) best practices in management strategies of soils and vegetation	proper application of environmental laws and regulations
	wildlife disturbance	widespread	low	seasonal			
	habitat fractionation	Punctual	low	decades			
	impact on bio-geodiversity and related services	punctual	medium	perennial (geo) decades (bio)			

C. Pollution

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities (positive, negative)	Mitigation, enhancement	Further needs
Air vehicles (cars, busses- shuttles, snow groomers)	air quality	widespread	medium	seasonal		Air quality measurements 1. full electric operation and use of hydropower 2. Electric vehicles 3. new diesel technology (AdBlue) for snow groomers	
Sound snow groomers, ropeways	noise pollution – disturbing wildlife, other tourists	Punctual	medium/high	seasonal			

6.3.7.3. Conflicts

See tables above

6.3.7.4. Mitigation

See tables above

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6.3.7.5. Ambitions

No relevant material has been found.

6.3.7.6. Perceptions

Local tourist information is an expression of how the region perceive itself and a self presentation of what the region aims to be. This hub presents itself through the company background data for Monterose 2000, a destination company.

- https://www.monterosa2000.it

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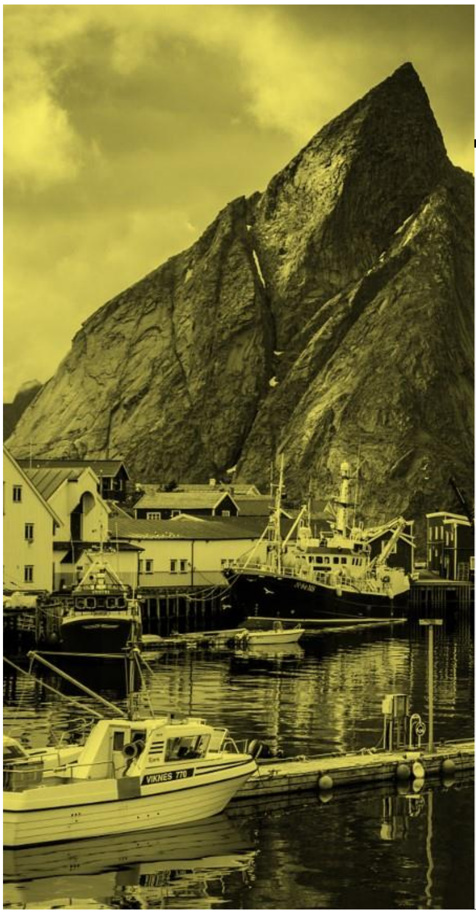
6.3.8. Kittilä

Kittilä is the municipality with the biggest ski and tourist resort in Finland, Levi. Tourism in Levi has long roots: it started in the village of Sirkka (the name of the village beside Levi fell) already before the II World War. The starting point has been ski tourism but nowadays there are all kinds of activities from snow mobile and husky safaris to hiking and mountain biking. Levi also has a plenty of services, e.g. a spa and 58 restaurants. The progress of Levi has been very fast in recent years, and there are around 2,5 million overnights per year, 23 000 beds in hotels and a lot of unregistered cottage accommodation. In addition to Levi and its surroundings there are few villages with tourism activities. River Ounasjoki runs through Levi and through the whole municipality (Kittilae Puhdasta Kultaa, 2022). Kittilä is located in western Lapland between Sodankylae and Kolari (see figure 52 for more detail).



Industrial factsheet **Kitilae** – Tourism sector

Activities:	Cross-country and downhill skiing, cycling, hiking, dog sledding, snowmobiling, fishing etc.
Spatial extent:	Kittilä municipality's total area: 8263,9 km2, including 168,6 km2 of water;
Natural resources used	gold mining, forestry, nature-based tourism, reindeer herding, wind power plants
Production:	*NA*
Employment:	*Collected in WP3*
	https://kittila.fi/kunta-ja-paatoksenteko/tietoa-kittilasta/kittila-perustiedot

Figure 51. Industrial factsheet Kittilae (tourism)

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Tourism and mining are the most important businesses in Kittilä. Agnico Eagle gold mine is located about 20 kilometres from Levi. Many of the workers of the mine live in Levi. There is also cooperation between mining and tourism: e.g. there is a new grant fund established by the mine to support the environmental certification of the tourism companies in Kittilä (Lapland Business, 2022).

Figure 52. Geographical location of Kittilae

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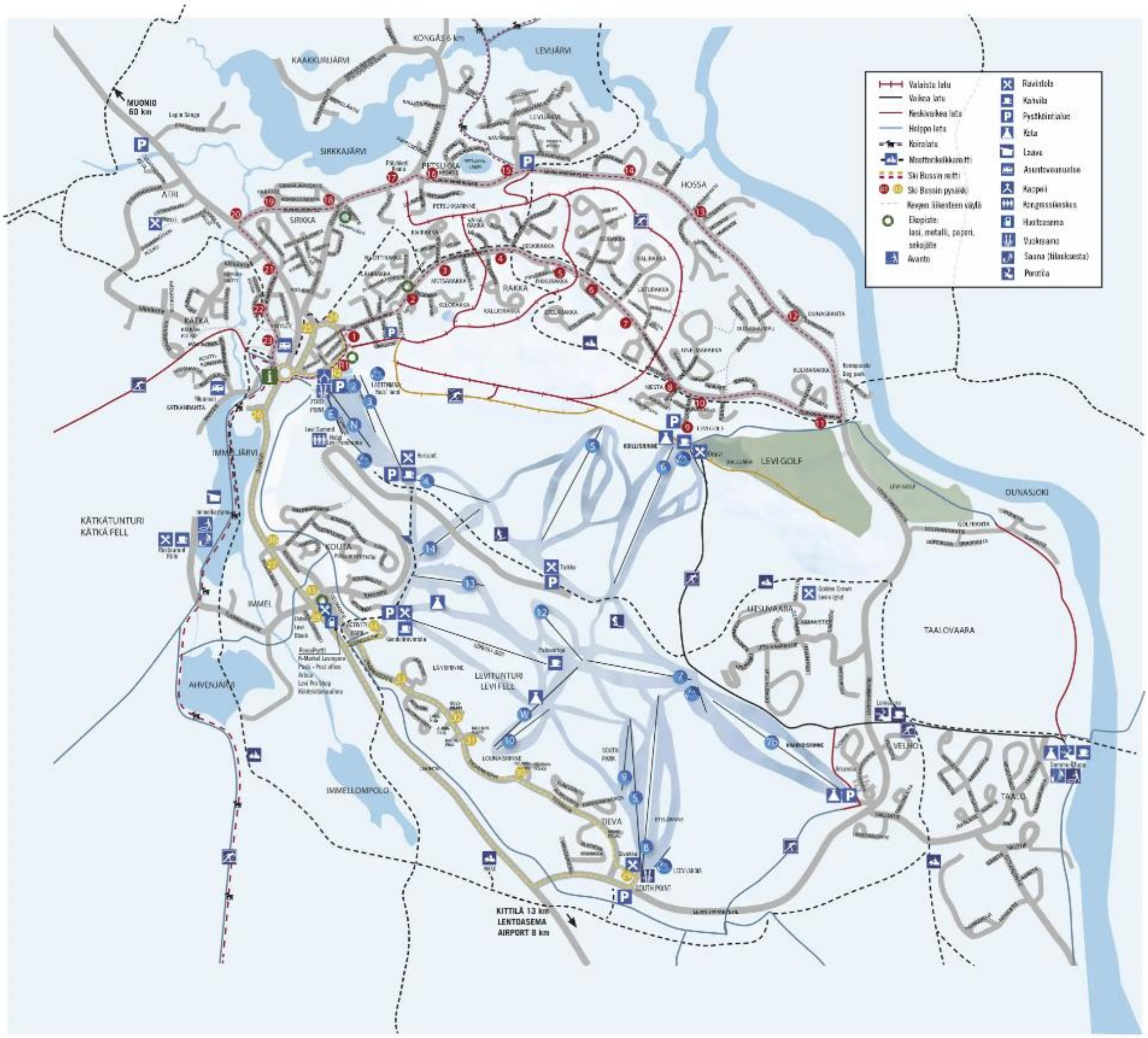

Figure 53. A map of Levi resort and tourism infrastructure (Maps Finland, 2022).

6.3.8.1. State of the art / environmental background

The northern parts of Kittilä belong to the area where fells dominate the landscape. One third of Finland's most visited national park, the Pallas-Ylläs national park, is located in the municipality of Kittilä. The geography of Levi is characterised by hill landscape. The biggest free-flowing river within Finnish borders, the Ounasjoki, flows beside the resort village and all the way southward from the municipality of Kittilä to Rovaniemi where it flows into Kemijoki (Kantola et al, 2018). The southern parts of the municipality are covered by boreal forests and mires. The forests are used both for forestry and reindeer herding. Recreational activities and tourism are important economic features in the Levi

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area. Besides, in Kittilä's village Pokka, the coldest temperature in Finland was measured -51.5 °C on January 28, 1999[39].

The landcover in the area of Kittilä is 8263.9 km2 in size, of which 168.6 km2 is water. There are in total 718 lakes and 10 fells.[40]

When it comes to nature protection areas, a part of Finland's most popular national park, Pallas-Yllästunturi National Park, is located in Kittilä[41]. Finland's third largest national park was established in 1938 and was expanded in 2005, when the Ylläs–Aakenustunturi area was joined to the park. The landscape of Pallas-Yllästunturi National Park is dominated by the fells and the surrounding natural environment consists of forests and swamps[42]. In total, there are 19 Natura 2000 sites in Kittilä (figure 54). Some of the Natura sites cross municipal boundaries and they are not only located in Kittilä[43].

Natura 2000 Sites in Kittilä:

- *Hammastunturin erämaa*
- *Kerpuajärvi*
- *Kivijärvi - Pikku-Kivijärvi*
- *Kumputunturi*
- *Kuortano-Saivinvuoma-Launijärvi*
- *Lemmenjoen kansallispuisto*
- *Leppävuoma-Murtovuoma-Saattoporanvuoma*
- *Loukisen latvasuot*
- *Naatsukka-aapa*
- *Näätävuoma - Sotkavuoma*
- *Ounasjoki*
- *Pallas-Ounastunturi*
- *Pomokaira*
- *Puljun erämaa*
- *Siukatanjärvet*
- *Tollovuoma-Silmäsvuoma-Mustaoja-Nunaravuoma*
- *Tornionjoen-Muonionjoen vesistöalue*
- *Ylläs-Aakenus*
- Ahvenvuoma

Figure 54. Natura 2000 sites in Kittilae

[39] https://kittila.fi/kunta-ja-paatoksenteko/tietoa-kittilasta/kylat/pokka
[40] https://kittila.fi/kunta-ja-paatoksenteko/tietoa-kittilasta/kittila-perustiedot
[41] https://kittila.fi/kulttuuri-ja-vapaa-aika/liikunta-ja-ulkoilu/luonto-ja-ulkoilureitit
[42] https://www.luontoon.fi/pallas-yllastunturi/luonto
[43] https://www.ymparisto.fi/fi-FI/Luonto/Suojelualueet/Natura_2000_alueet?f=Lapin_ELYkeskus

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6.3.8.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in the Finnish municipality of Kittilae.

A. Habitat and landscape

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Land 1. *infrastructure development – roads, buildings, mining industry*	The expansion of the built environment	e.g water bodies, flora and fauna around Kittilä	The built enviroment of ski resorts affect e.g. water quality of lakes[14]		e.g for other forms of land use, reindeer husbandry,	1. Identification of carbon sinks, environment protection and its increase, emission compensation[15]	

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
2. *Tourism activities e.g. skiing, hiking, snowmobiling, horse riding, sport events*	Harm habitats by damaging vegetation and compacting soils	Constructed ski trails and ski slopes	*e.g. artificial snow increases the nutrient concentrations in the soil[16]*			2. Sustainable method of constructing and managing minimize machine grading and fertilization. 3. Circular economy purchases and responsible materials supply chains	

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B. Changes in biodiversity

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Land 1. *infrastructure development – roads, buildings, mining industry*	The expansion of the built environment	e.g water bodies, flora and fauna around Kittilä	The built enviroment of ski resorts affect e.g. water quality of lakes[14]		e.g for other forms of land use, reindeer husbandry,	1. Identification of carbon sinks, environment protection and its increase, emission compensation[15]	
2. *Tourism activities e.g. skiing, hiking, snowmobiling, horse riding, sport events*	Harm habitats by damaging vegetation and compacting soils	Constructed ski trails and ski slopes	*e.g. artificial snow increases the nutrient concentrations in the soil*[16]			2. Sustainable method of constructing and managing minimize machine grading and fertilization. 3. Circular economy purchases and responsible materials supply chains	

C. Pollution

Environment	Environmental impact	Area affected	Impact (quantitative) or Risk (if planned activity)	Duration	Impact on other activities	Mitigation	Further needs
Air *1. Flights: Most of international tourists arrive by air (total number of landings in 2021, 1024*[17]*)*	Carbon foot print	Climate, global	*International air traffic has increased after covid-19 pandemic*			Introducing smart and low-carbon travel chain options	
Sound 1. e.g. *traffic, huskies*	Noise pollution		*e.g. snow mobile traffic and dogs*				

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6.3.8.3. Conflicts

See tables above

6.3.8.4. Mitigation

See tables above

- management plan for Pallas-Yllæas, circular economy and circular supply chains, promotion low-carbon traveling
- Identification of carbon sinks, emission compensation, geothermal heating in all hotels, storing snow under insulation mats.

6.3.8.5. Ambitions

The compiling contains documents in English and Finnish. It is only the English which are compiled as expressions of ambitions. Environmental certification of Levi ski resort is one step toward sustainable tourism.

- https://www.levi.ski/en/environment

Several plans are expressing ambitions for Kittilä, most of them are in Finnish, and it is only the ones which has an English or Swedish summary that is reviewed.

- Metsähallitus management plan for Pallas-Ylläs national park 2008 (in Finnish; English summary as an appendix) https://julkaisut.metsa.fi/assets/pdf/lp/Csarja/c36_teksti.pdf

According to the Swedish summary, the management and use plan for Pallas–Yllästunturi National Park is from 2008. This area is the third largest of Finland's national parks and the park that is most important in view of the nature tourism values. It forms a very important whole in view of the preservation of Finland's northern nature – forests, bogs, mountains and waterways – and is what the species concerns in many respects unique in international comparison. The nature park is one of the international the most famous nature tourism areas in Finland thanks to the large tourist centers that surround the park. In accordance with the legislation, *the most important goal for the planning is the care and use of Pallas–Yllästunturi to preserve and improve the natural state of the forests, bogs and mountains in the area that has been preserved in its natural state as well as the viability of the populations of species according to the directives. Other goals are to develop sustainable tourism, nature guidance and environmental education, to promote the local population's use of nature according to the principles of sustainable use, to secure the conditions for the Sami culture through* *adaptation of other forms of land use so that the conditions for practicing culture are ensured in the part of the national park that belongs to the Sami home area and to secure the conditions for research taking into account the protection values.* The plan has been implemented in accordance with the principles of participatory planning. In the plan, you try coordinate the different forms of use in the area so that the goals of establishing the national park is achieved. An important way to achieve the goals is the zoning in the plan, which regulates land use and the management of the entire area well into the future.

- Wilderness areas of Pulju (https://www.nationalparks.fi/pulju)

According to the Swedish summary of the management and use plan the Natura 2000 area in Pulju wasteland that the management and use plan concerns includes Pulju wasteland area and Raakevuoma–Vuossijänkä marsh protected area. The plan is from 2018 and the Pulju wasteland area is characterized by extensive marshes and numerous forested hills and mountains. The mountains are quite low and flat. The area constitutes an important protection area for it boreal mountain nature (mountain moors, mountain birch forests) as well as for our northernmost natural forests and aapa mires, in the direction of the Lapland arm. *The central values of the planning area are the protection values (nature types, plant and animal species), the wasteland character of the area, the Sami culture, reindeer husbandry and recreational use. of the area the host is not threatened by any such use that could be influenced by means of the plan.* The entire planning area consists of the basic zone – i.e. visitors are not directed there actively and there no new service equipment is built. There are only a few outdoor facilities in the planning area (deserted cabin, turf hut, wind screen protector).

- Wildernes areas of Hammastunturi https://www.nationalparks.fi/hammastunturi

Hammastunturi Wilderness Area is located in the forest and fell area between Urho Kekkonen National Park and Lemmenjoki National Park. Before the Inari - Pokka road was built, the areas of Hammastunturi Fell and River Lemmenjoki formed one of the largest roadless backwoods in Finland. In the past, the area has been used for reindeer herding, there has been a gold rush and, later, roads and villages have been built. Gold digging has left permanent marks in Hammastunturi Wilderness Area. Nowadays, in addition to offer wilderness tourism activities, Hammastunturi area is still important in reindeer herding, with the reindeer owners' associations of Hammastunturi, Ivalo, Lappi, Kuivasalmi and Sallivaara working in the area. Reindeer herding is one of the most important means of livelihood, and the principal and additional income, which it brings, makes it possible for the villages to stay inhabited.

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- Regional land use plan for Federation Lapland 2010 (in Finnish): https://www.lapinliitto.fi/wp-content/uploads/2020/11/Tunturi-Lapin-maakuntakaavaselostus-lainvoimainen.pdf

Provincial planning is governed by the Land Use and Building Act and the regulation (MRL 5.2.1999/132, MRA 10.9.1999/895). The aim of the law is to organize regions use and construction in such a way that it creates the conditions for a good living environment and promotes ecological, economic, social and cultural sustainable development. The goal is also to ensure everyone's opportunity to participate in case preparation, the quality and interactivity of planning, the versatility of expertise and open information on matters to be dealt with (MRL § 1) (our translation Finnish-Norwegian-English).

6.3.8.6. Perceptions

- Lappand Above Ordinary (https://www.lapland.fi/business/mining-and-tourism-support-each-other-in-kittila/ : *Mining and tourism support each other in Kittilä*

The coexistence of tourism and Europe's largest gold mine is working out nicely in Kittilä. Active cooperation and transparent communications make it easier for the municipality's two cornerstones to operate in the same area, responsibly and sustainably. One example of cooperation between Agnico Eagle Finland's Kittilä mine and tourism in the area is the grant fund established by the mine to support the environmental certification of the tourism companies in Kittilä. With this support, the Kittilä mine wanted to help companies in the area through difficult times by supporting the sustainable operation of the companies. Levi's tourism and companies in the area are also important for the mine. Levi is a driving force in the area that also increases the attractiveness of the Kittilä mine as a workplace.

In 2017–2021, the Kittilä mine will invest a total of approximately 70 million euros in energy efficiency, water treatment and tailings management. In addition to this, the mine has acted as a test environment for electric mining machinery as part of the EU-funded SIMS project. The Agnico Eagle gold mine also maintains an active dialogue with other local operators. The cooperation group with 25 members that meets regularly includes representatives from the municipality of Kittilä, Kittilän Luonto ry, Lapland Education Centre REDU, the entrepreneurs of Kittilä, the parish, the Kuivasalmi reindeer herding cooperative and the village associations and residents of the surrounding area.

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– The cooperation group has about 25 members, and all the main interest groups in the region are represented. We strive to be open and transparent in all our communications at the mine, Kankkunen says.

https://www.lapland.fi/business/the-mining-industry-in-lapland-has-tremendous-potential-sustainability-must-be-ensured/

A mine doesn't have to be located all that far away from a tourist resort before it no longer causes harm. It even supports tourism. For example, Levi is located 40 km away from the Kittilä mine, which means that the mine actually supports tourism in Levi through the development of infrastructure and purchasing power. We should also keep in mind that just like the mining industry, tourism won't grow without leaving a carbon footprint – this is affected by flights, for example.

The statistics are only accessible in Finnish. Updated statistics are recommended.

- Metsähallitus visitor survey for Pallas-Ylläs national park 2016 (in Finnish): https://julkaisut.metsa.fi/assets/pdf/lp/Bsarja/b230.pdf

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6.3.9.Nuuk

Nuuk is Greenland's capital. The tourism industry in Greenland is slowly increasing but is still very low compared to e.g., Iceland. Much of the tourist activities are focussed on the coastal and fjord environment; the main tourist activities in Nuuk are nature-, adventure-, and cultural tourism (e.g., wildlife watching, northern lights, photography, boat sightseeing, fishing, hiking, kayaking, mountaineering, mountain biking, skiing). Significant infrastructural development measures have been launched. The airport and harbour in Nuuk have been upgraded, a permanent luxury wilderness camp is planned in one of the remote fjords around Nuuk, and a couple of new hotels are opening in the town. The local municipal and national government wish to further develop the tourism industry in a sustainable way to increase employment and income from tourism in Nuuk. The tourism strategy report 2021-2023 further recommends a quality assessment for the tourism industry, strengthening education for employment in tourism, increasing analysis and research of tourism facilities and activities, and establishing visitor centres and infrastructure (e.g., paths) around national attractions.

6.3.9.1. State of the art / environmental background

The region of Nuuk is dominated by a group of defining marine and terrestrial environmental factors: The Davis Strait of the North Atlantic Ocean and the long Nuup Kangerlua fjord running to the active outlet glaciers of the Greenland Icesheet where cold and warmer climate processes meet. On land, the mountain peaks (1300-2000 m.a.s.l.) of the southern part of the region, the lower lands of the northern part, and arid regions close to the Icesheet.

The West Greenland Current runs through the Davis Strait transporting warm and saline water along the sea bottom and into the fjords and in many cases below the sea terminating glaciers. The glaciers and the Icesheet produce cold fresh melt water and turbid water with glacial sediments. Micro algae blooms and upwelling provide a marine environment for deep water fish and micro-organisms eaten by marine mammals, and abundant humpback whales are a dominant feature of the Nuup Kangerlua fjord and an attraction to tourism activities (Høgslund and Christensen, 2020). Blocks of ice from the outlet glaciers are attractive to tourists but can also be a challenge to maritime transportation. The inhabitants of the capital Nuuk and the village Kapisillit are using the fjord system as a common waterway toward fishing spots, cabin areas, and hunting grounds. A boat ferry runs between Nuuk and Kapisillit.

The mountains of the Nuuk region is predominantly of pre-Cambrian granite and gneiss. The Ivinnguit Fault splits the region in the northern Akia terrain and the southern Akulleq terrain. Akia is lower in altitude than the Akulleq terrain, and the Isukasia landscape on the border between the two terrains

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in the north-eastern part of the region includes the oldest rock forms of the Earth, c. 3.8 billion years, and they include carbons possibly from plankton organisms and thus a source to our knowledge of the earliest geological development of Earth and the origin of life. Isukasia is a now a subject of international studies and a potential tourist attraction. The small island Akilia south of Nuuk is of similar properties and age, and a potential tourist attraction.

Trekking in the mountains is a possibility in the region. Trekking maps and books exist and to some extent marked routes and shelters or small cabins (Abermann, J., 2018). The routes are generally steep and long suitable for experienced or very experienced trekkers including many kilometres to the nearest village. The inlets of the fjord provide pick up points for boat transport from Nuuk.

The local snowmobile association and the Kommuneqarfik Sermersooq municipality have laid out a corridor for snowmobiling from Nuuk to Kapisillit (Anon., 2020). Driving with ATV's or similar is prohibited in the landscape due to the vulnerability of the vegetation ecosystem.

The only endemic stock of Atlantic Salmon in Greenland is located in the Kapisillit River, and consequently of great vulnerability to catch, disturbances and competing foreign stocks of Atlantic Salmon from Canada or Pink Salmon from Norway and Russia.

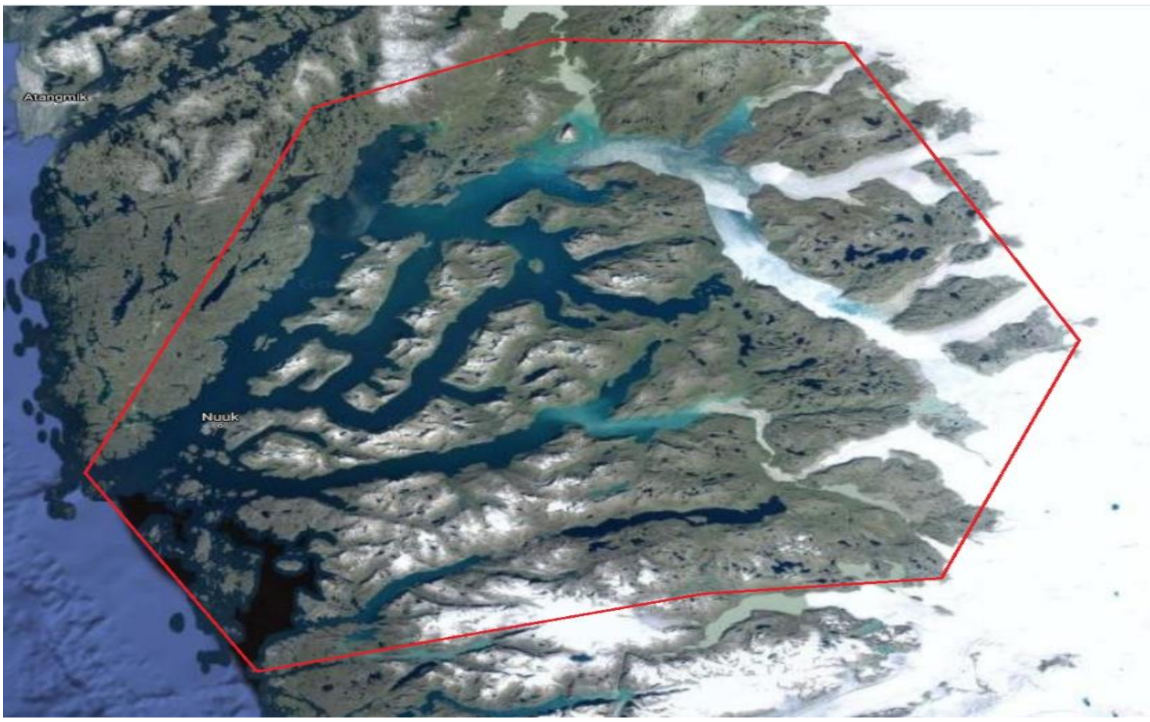

Figure 55. Extent of the Nuuk hub (source: google maps, 2022)

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6.3.9.2. Environmental impacts

The following environmental impacts are based on the tourism industry operating in the Greenlandic municipality of Nuuk. Tourism in the Nuuk region involves environmental impacts on the landscape, wildlife and local use of areas. Compared to other regions of Greenland, there is a large human population in the region and consequently a high level of activities from local use. Due to the landscape characteristics, it is not possible to drive between or from inhabited places, so the fjord system is the waterway from town to landscape, and the inlets and anchorages of the fjord the hotspots of traffic outside the town. From the anchorages, footpaths created by traffic from humans and caribou leads into the landscape. The tourism growth materializes in bigger infrastructural project, like a bigger air port and also new lodges and hotels along the fjord coast.

A. Habitat and landscape

Increased activities from tourism can lead to increased activities at sea through a higher demand for boat transportation and boat trips into the landscape, and consequently a higher degree of disturbance to wildlife in the marine ecosystem: seabirds, humpback whales and seals (Andersen et al., 2017, Christensen et al., 2015, Boye 2009).

More activity on land from trekking, camping and cabins can increase the attrition of the vegetation, which in the region is only slowly regaining. Archaeological remains of Norse and Inuit cultures are abundant in the inner Nuuk fjord but are unmarked and can be difficult to identify for layman, and thus prone to attrition and demolition (Gulløv et al., 372). Terrestrial wildlife (caribou, hare, fox, white-tailed eagle, falcons, and other birds) can be disturbed from increased human activity, and the

daily and seasonal routes of caribou interrupted and changed or decreased energy intake and thus their survival rate and gestation success, particularly if a steady traffic from walking, motorized vehicles or helicopters is introduced (Parker et al., 2009).

B. Changes in biodiversity

Nature-adventure tourism has increased together with trophy hunting. Also there are more cruiseships and supply shipping due to tourism growth which leads to more noise pollution. Overcrowding by tourists has negative impacts on sensitive vegetation and archaeological sites. The increased water taxi actitivites are also potentially disturping whales and seabirds.

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C. Pollution

Increased cruise ship, boat and helicopter traffic will lead to higher degree of aerial pollution in the region. The winds of the region are strong, so much of the pollution will be dispersed and transported to other regions. In periods and areas will still weather, it could be possible to experience local pollution if a cruise ship is situated there for a time. Activities by humans on land will lead to more disposal of garbage distributed to the landscape during strong winds if not mitigated and managed properly. On locations for camping or cabins for tourists as well as popular trekking routes, accumulation of faeces, urine, and toilet paper disposals is a risk, if likewise not properly managed, and thus lead to local pollution and possible local conflicts with other users.

6.3.9.3. Conflicts

Locals are concerned that external investors and tourism actors will dominate the tourism development. There is a local wish for well regulated tourism to ensure local anghoring and ownership. As the tourism industry has grown, many foreign newcomers have come to join the industry. Local voices stresses the need to protect indigenous livelihoods, culture and the Greenlandic language.

6.3.9.4. Mitigation

There are no more detailed data about mitigation available to ensure indigenous interests and local ownership.

6.3.9.5. Ambitions

A central ambition in Nuuk is to develop a tourism law and to overcome problems with overcrowding and lack of infrastructural capacity. There are also public discussions of a potential use of a zooning instrument to regulate the conflicting cruiseship routs and whale hunting routes.

There is a rich and varied collection of literature related to Nuuk, relevant here is tourist company reports and policy plans. Most of these documents are in English and some in Danish. Only the material in English will be commented.

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Visit Greenland is a marketing company and is owned by the Government of Greenland. The main message in the new strategy is growth in the tourism industry. The aim is to combine this with sustainable development, to take good care of nature and small communities in the towns and settlements and to have dialogue and collaboration with all business stakeholders.

- "Visit Greenland's strategy for marketing and market development 2021 – 2024".

Local consultancy reports written as policydocuments can be read as an expression of ambitions. The goal for Semersooq Municipality is a sustainable future with strong destinations, a wide range of businesses that make a living from tourism, with a competent workforce, framework conditions that support the profession and a tourism industry that grows bigger and stronger and is part of many citizens' everyday lives and Greenland's future. The vision is through targeted destination development and business-oriented framework conditions, to make tourism a sustainable profession with strong skills and a clear financial contribution to the economy of Kommuneqarfik Sermersooqs and the country.

- Sermersooq Municipality tourism policy link: https://sermersooq.gl/kl/turismepolitik/

The two plans mentioned below is in Danish, they are more than 10 years old and the web link is missing. The plan for environment policy is accessible by searching on google, the other is not accessible.

- Sermersooq Municipality construction and environment policy: "Politik for Anlæg og Miljø Kommuneqarfik Sermersooq 2009-12"
- Sermersooq Municipality plan for the city's recreational areas: "Plan for byens rekreative områder Kommuneplan" from 2007.

A municipality plan supplement describes expectations for development of a tourism area in Icefjord. The business application is not available.

- Municipality plan supplement "KOMMUNEPLANTILLAeG-L7-1-NUUK-ICEFIORD-LODGE-KAPISILLIT-NUUK".
- Topas Explorer Group - Nuuk Icefiord Lodge project application "ProjektansÃ¸gning-WOG-Kapisillit-SERMERSOOQ-endelig-DK (002)" (weblink not available)

6.3.9.6. Perceptions

Local tourist information is an expression of how the region perceive itself and a picture of what the region aims to be. Here is the mix of urban life and nature is highlighted.

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- Sermersooq business – Destination marketing Organisation for Nuuk: https://colourfulnuuk.com/sustainable-nuuk/

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6.4. Mining

Mining in the European Arctic is a highly controversial topic: On the one hand, there is a growing demand for metals and industrial minerals and a need for more employment opportunities. The growing demand is the result of global population growth, industrialisation, and an increasing demand for 'green' technology[44,45]. In addition, there is a major push to enhance Europe's resilience, security, and autonomy with regards to sustainable access to raw materials[46]. As mining is one of the key economic drivers in the Arctic[47] it provides important employment opportunities in the Arctic regions. On the other hand, metals and minerals extraction leads to a range of environmental impacts, which not only affect ecosystems, but also indigenous livelihoods and other local uses of natural resources[48] such as tourism, fishing, and reindeer herding. This has led to increasing protests by, amongst others, nature conservation organisations, indigenous people, and fisheries representatives against new mining activities.

[44] EU communication COM (2020) 474 final
[45] Arrobas et al., 2017
[46] EU communication COM (2020) 102 final
[47] Tolvanen et al., 2018
[48] OECD (2019)

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The European Green Deal[49] is a European strategy to transform the EU into a more sustainable, environmentally friendly and climate neutral economy by encouraging more efficient use of resources, circular economy, restoring biodiversity and cutting pollution. However, the aim for climate neutrality in the Green Deal requires a transition to clean energy which necessitates more mineral resources than fossil fuel-based energy. The large increase in demand for minerals such as lithium, nickel, cobalt, manganese, graphite, copper and rare earth elements[50] (IEA) puts pressure on the mineral supply chain, although a recent report by KU Leuven[51] concluded that 45-77% of the mineral and metals requirements could be met in the future by local recycling by investing in new technologies.

There are 3 main stages in the life cycle of the mining industry: 1. the planning stage, 2. the operational stage, and 3. the post-closure / rehabilitation stage. The environmental impacts occur mainly in stage 2 and 3. In this report we will focus only on the impacts of mining on the natural environment and the resulting effect of these impacts on other activities and natural resource uses in the area; global drivers and socio-economic aspects are discussed in reports from WPs 1 and 3. Mining in the Arctic impacts both the marine and the terrestrial ecosystems, including wildlife health and behaviour, with the type of impacts depending on the location of the mine and the type of natural resource being mined. Major environmental impacts of mining are related to the disposal of mine tailings, either as submarine tailings in fjords or as land-based tailings. This is related to the sheer volumes of material and the area needed for their deposition, the toxicity and reactivity of the material, chemicals used during the processing, and the stability of the deposited tailings.

A review[52] published in 2018 on mining in the Arctic environment included a discussion of the environmental impacts on the terrestrial and marine ecosystems.

ArcticHubs includes 8 mining hubs in 4 countries: Finland (hub 4 Kittilä), Sweden (6. Malå/Kristineberg and 8. Gällivare), Norway (9. Kautokeino-Kvalsund, 10. Varanger, 11. Svalbard, 12. Egersund) and Russia (16. Khibiny), and 1 learning hub in Italy (21. Germanasca). Varangerfjord and Egersund in Norway are co-located with both fish farming and tourism hubs. Khibiny, Kittilä and Svalbard are all co-located with tourism hubs, and Kautokeino-Kvalsund in Norway, Kristineberg/Malå and Gällivare in Sweden are co-located with indigenous hubs. Both Swedish mining hubs are also co-located with forestry hubs. The mineral resources that are extracted by the mining hubs include both metals (copper, iron, gold, titanium) energy minerals (coal) and industrial minerals (talc). The studied mines are in different stages of the mining life cycle: from 1. exploration and planning, 2. operational to 3. post-closure.

[49] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[50] IEA (2022)
[51] Gregoir & van Acker, 2022
[52] Tolvanen et al., 2018

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Table 15. Mining hubs, status, and co-location

Hub[1]	4.	6.	8.	9.	10.	11.	12.	16.	21.
Status[2]	O	O/P	O/P	P	C/P	C	O/P		
Time	2006-2037	1940-	1968-2029	30 years					7-8 years
Employment	480		770	150	400		250		80
Minerals	Au	Cu Zn Au Ag	Fe	Cu	Fe	coal	Ti		
Co-location[3]	T	FI	FI	I	TA	T	TA	T	T

1. Hubs: 4. Kittilä 6. Malå/Kristineberg 8. Gällivare 9. Kautokeino-Kvalsund 10. Varanger 11. Svalbard 12. Egersund 16. Khibiny 20. Alagna 21. Germanasca
2. Status: O: operational; P: planning; C: closed.
3. Co-location: T: tourism; F: forestry; A: fish farming; I: indigenous

The main environmental impacts from mining are related to the deposition of mine tailings, either on land on in the sea, the storage or release of mine wastewater, the development of mine infrastructure, and mine activities such as traffic.

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Gregoir and van Acker, 2022. Metals for Clean Energy: Pathways to solving Europe's raw materials challenge. KU Leuven: pp 116. https://eurometaux.eu/media/jmxf2qm0/metals-for-clean-energy.pdf

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

Salokannel V, Tuulentie S & Similä J (2018). Mining in the Arctic environment – A review from ecological, socioeconomic and legal perspectives. *Journal of Environmental Management* 233: 832-844. https://doi.org/10.1016/j.jenvman.2018.11.124

Tolvanen A, Eilu P, Juutinen A, Kangas K, Kivinen M, Markovaara-Koivisto M, Naskali A, IEA (2022). The Role of Critical Minerals in Clean Energy Transitions. World Energy Outlook Special Report, revised edition. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

6.4.1.Varangerfjord

Varangerfjord is located in the far northeastern part of Norway, near the Russian border. It is a centre in the Barents region with ice-free ports and year round access to the Barents Sea. The main towns along the Varangerfjord are Vadsø on the northern coast and Kirkenes, which is located between Langfjorden to the west and Bøkfjorden to the east, two side fjords along the southern coast of Varangerfjord. The main industries in the Varangerfjord region are fishing, both fish farming and traditional fisheries by the sea Sámi community, tourism, in particular fishing and cruise ship tourism, and mining.

Kirkenes has a long history of mining of iron ore. The Sydvaranger mine (Sydvaranger, 2022) (see also figure 57) is located just south of Kirkenes at 69.6° N and 30° E and was in operation from 1910-1997. In this period, 200 million tonnes iron ore was extracted and the mine was the biggest mine in Norway. The mine was state-owned from 1945-1997. After 1997, the mine was sold to the Australian company Northern Iron, who upgraded and operated the mine from 2009-2015 and extracted 20 million tonnes iron ore of which 8 million tonnes high quality iron concentrate was sold to Europé, Middle-East and China. In 2016, the mine was bought by the Norwegian Tschudi group, who updated updated the geological knowledge of the resources, mining plans for sustainable use and environmental permits and operational licensing. The mine was bought by the American Tacora Resources in 2019 and they have plans to re-open the mine, but the mine is not currently in operation (see also figure 56). Sydvaranger mine produces high quality magnetite with a high iron content. The mining operations are partially in an open pit mine and partially underground, but the plans for the future include mostly underground operation. Sydvaranger mine covers an area of about 15 km^2, which includes the main open pit mine of ca 2 km^2, multiple waste rock piles, production facilities and mine infrastructures.

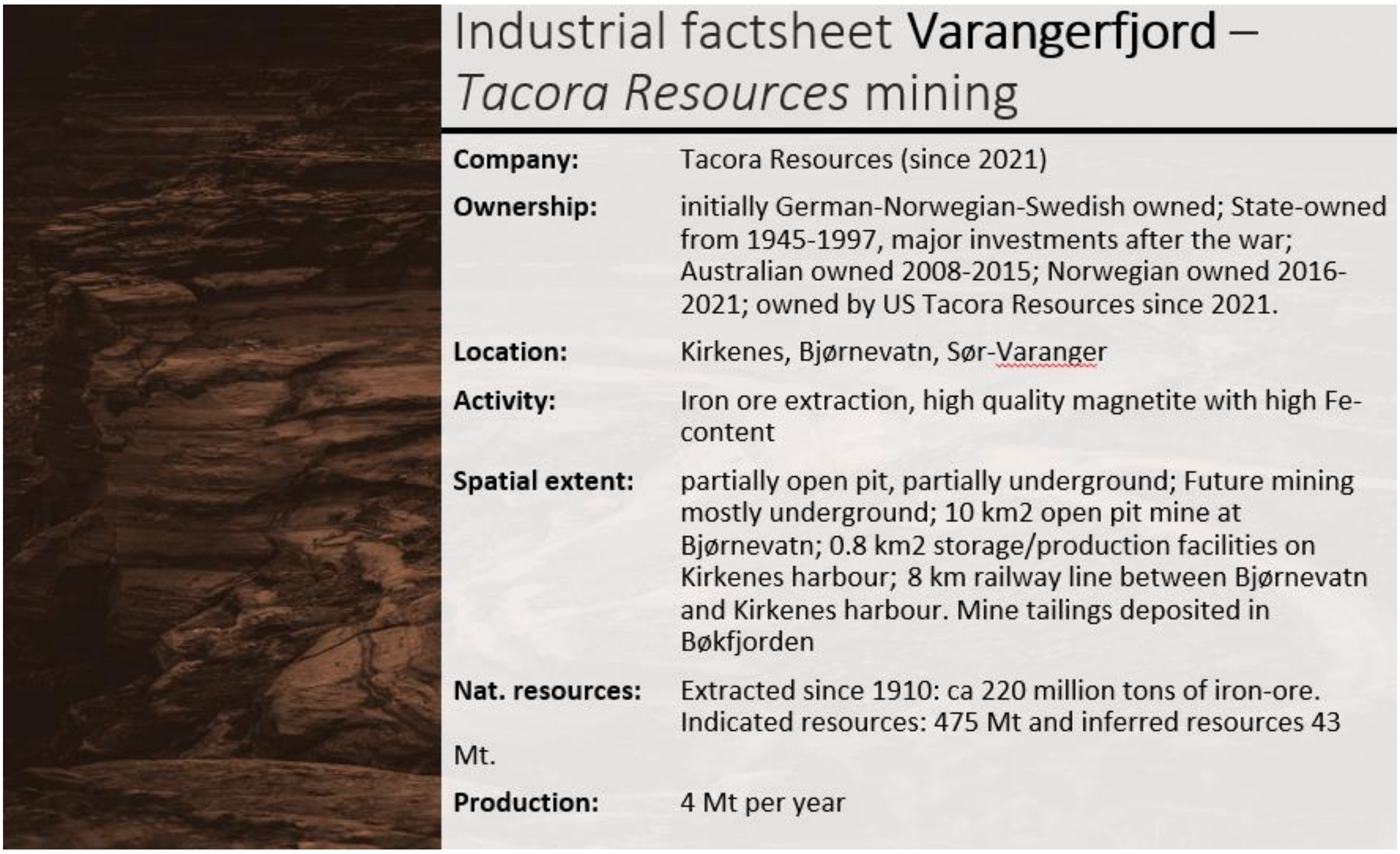

Figure 56. Industrial factsheet Varangerfjord

In addition, there is a railway line from the main mine site to production and storage facilities in Kirkenes and substantial submarine tailings deposits in Langfjorden and Bøkfjorden. Mine tailings were deposited in Langfjorden between 1910 and 1976, but the quantity of this is unknown (Simonsen, 2017). From 1976, the mine tailings were deposited in Bøkfjorden; between 1976 and 1997, ca 56 million tonnes of tailings were deposited at an average rate of roughly 2.5 million tonnes per year and ca 639 tonnes total of flotation chemicals absorbed in the tailings (Berge, 2009). In 1989, this covered an area of about 26 km^2, over an distance of up to 13 km from Kirkenes. The bottom fauna was affected up to 7 km away from Kirkenes (Skei & Rygg, 1989). Investigation into the state of the fjord bottom prior to renewed mine operation showed that the bottom fauna recovered significantly in the 10 years after the mine closed and the deposition stopped (Skaare et al., 2007). In the operational period between 2009-2015, a total of ca 24 million tonnes of mine tailings were deposited plus up to 300

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tonnes of flocculation chemicals. Although the majority of the tailings were deposited within 7 km from Kirkenes, some of the tailings have spread throughout Bøkfjorden as result of ocean currents and much of Bøkfjorden has been affected to some extent. Neidenfjorden/Bøkfjorden, of which the latter has been used to deposit submarine mine tailings since 1976, was designated a National Salmon Fjord (NSF) to protect the wild salmon populations (St.prp.nr.32 (2006-2007)). This is meant to protect the wild salmon population in this area against by identifying and removing any threats to the population.

The main environmental impacts of the Sydvaranger mine are related to the spreading of the submarine mine tailings and their effect on fish and bottom fauna populations and health, and contamination from the main mine site in terms of contaminated surface waters run-off and dust.

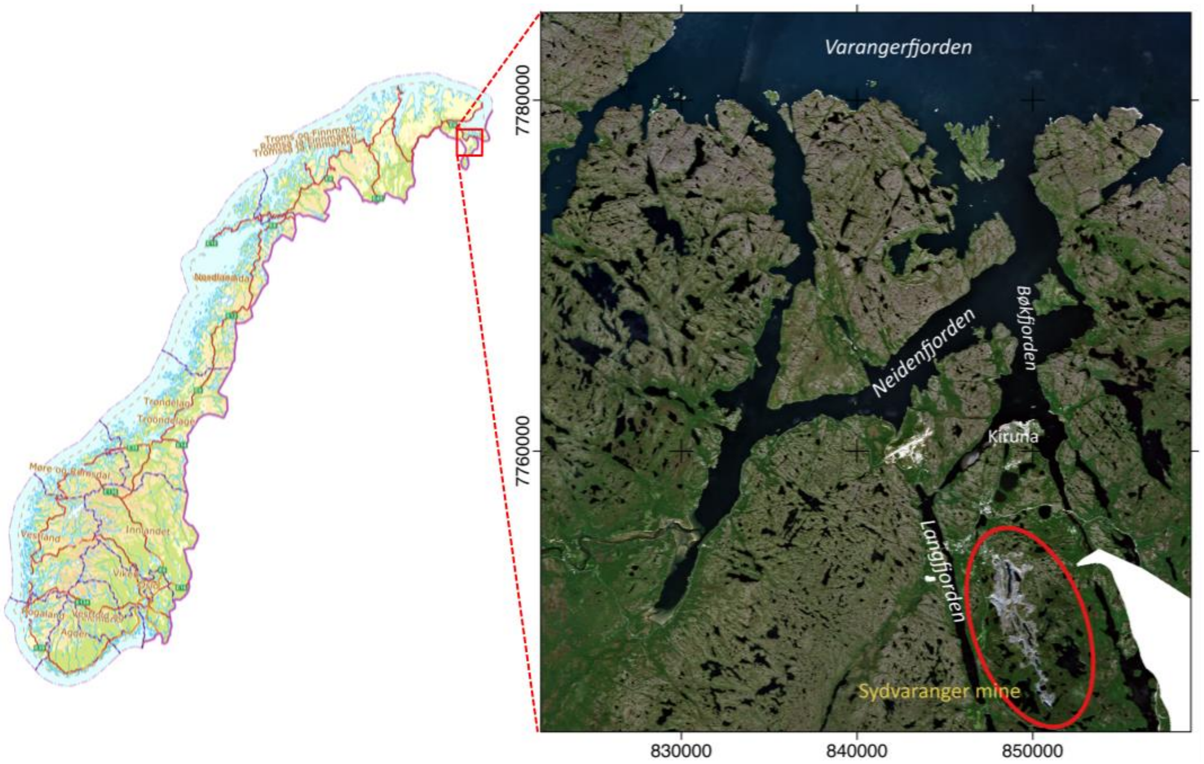

Figure 57. Sentinel-2 satellite image giving an overview of the area around the Sydvaranger mine (Nibio, 2022)

6.4.1.1. State of the Art / Environmental background

The landscape in the Varangerfjord area is a glacial landscape and classified as open fjord landscape with spread housing along the coast and undulating mountain (up to ca 200 m high) landscape dominated by sparsely vegetated mountain tops (mountain wetlands, heathland, mountain grassland) with many lakes and birch and pine forests in the valleys. According to the CORINE landcover maps

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from 2018, the area is dominated by moors and heathland (code 322), sparsely vegetated areas (333) and bare rocks (332), with broad-leaved forests (311) and agriculture (243) along the coast. Apart from a minor extension of the mining area, no changes have been mapped between 2000-2018[53]. The geology is dominated by Precambrian gneisses and the bedrock for the mine mainly consists of quartz, feldspar and amphibole with magnetite mineralisation. The climate in the region is subarctic, with cold winters and warm summers, and an average annual precipitation of 450 mm (Salomonsen et al., 2011).

Bøkfjorden (figure 57) is a ca 20 km long side fjord in the southeastern part of Varangerfjord; the ca 20 km long and narrow, 200-600 m wide, Langfjorden joins Bøkfjorden at Kirkenes. Bøkfjorden varies in depth from 9-250 m, shallow near Kirkenes and deepening towards Varangerfjord, and is separated from Varangerfjord by a sill with a depth of ca 100m, which restricts the water exchange to some extent and acts as a barrier for sediment transport out of Bøkfjorden (Berge et al., 2012; Ladstein, 2018). Bøkfjorden has large tidal differences.

The mine tailings that were deposited in Langfjorden and Bøkfjorden contained quartz, feldspar, magnetite and amphibole, and the toxic flocculation chemical Magnafloc. The tailings are very fine-grained of which more than half with a particle size of less than 630 nm (Trannum et al., 2018). The planned reopening of the Sydvaranger mine will include open pit mining in the existing industrial area. There are several new waste rock piles of 100-120 m over the current terrain planned within this area. In addition, the plan also includes further deposition of mine tailings in Bøkfjorden. The mining activity does not affect reindeer herding as there is limited activity in this area and there are currently no conflicts with reindeer herders near the Sydvaranger mine (Wråkberg, 2019).

The harbour at Kirkenes is heavily polluted with copper, PAH (Polycyclic Aromatic Hydrocarbons) compounds and TBT (Tributylin) from the shipyard. This pollution is local and decreases away from the shipyard (Berge et al., 2012).

6.4.1.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Norwegian area of Varangerfjord.

A. Habitat and landscape

The main impact of Sydvaranger mine on the terrestrial habitats and landscape is related to the extent of the mine site with an open pit mine and extensive waste rock piles (spoil heaps), and the submarine

[53] http://kilden.nibio.no; http://www.naturbase.no

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mine tailings. As mentioned in a previous section, the Sydvaranger mine covers an area of about 15 km^2, which is characterised by a large open pit mine, numerous waste rock piles and connecting roads, In this area, the original habitats are destroyed and the landscape strongly modified. The planned new mining operations will modify the mine area further with new waste rock piles of up to 120 m high, but the mine area will not be extended[54]. The ore is transported by railway to Kirkenes, ca 15 km away, mainly through built-up areas.

Another major impact of the Sydvaranger mine is on the submarine habitats and landscape: mine tailings have been deposited in Langfjorden and Bøkfjorden for many years. Similar to land deposits, the direct impact of the submarine mine tailings is physical smothering of the seabed and benthic organisms, which changes the bathymetry and bottom sediment characteristics (Skei et al., 1995; Ladstein, 2018). Although the bulk of the mine tailings remained in the deeper part of the fjord where they were deposited, some of the tailings were spread up to 13 km away from the source (Skei et al., 1995); recent investigations of the seafloor topography showed an erosional channel along which the sediments were spread northwards (Ladstein, 2018). The mine tailings are very fine-grained and the smallest grain sizes can remain suspended in the water column for long distances; Berge et al. (2012) found turbidity values higher than background values up to 10 km away from the discharge point. Suspended particles can potentially attach onto fish eggs, making them heavier so that they might sink; there is, however, no data if this ioccurs in Bøkfjorden (Bienfait et al., 2020).

B. Changes in biodiversity

The physical smothering of the seabed by the deposition of mine tailings affects the benthic populations. Programs to monitor the impact of submarine mine tailings during the mining operations from 1976-1997 found that an area of 26 km^2, up to 13 km from the disposal site, showed a reduction in fauna diversity (Skei & Rygg, 1989). A follow-up investigation in 2007, after the mine had been closed for 10 years, found that the seabed was being recolonised: there was an increase in organic content and biological activity in the top layer of the sediments, with bioturbation improving the oxygenation of the sediments (Skaare et al., 2007). The benthic fauna diversity and density increased towards Varangerfjord. The authors concluded that the predation of the king crab may have a stronger impact on the benthic fauna than the submarine mine tailings.

The deposition of the mine tailings is likely to have an effect on spawning areas. A report by Christensen et al. (2014) reported low concentrations of cod eggs, suggesting that no spawning occured in Bøkfjorden. However, this investigation was done while the mine was still in operation and there is no data on fish eggs before or after the deposition of the mine tailings (Bienfait et al., 2020). Similarly, there is no data on cod populations from before or during the mining operations. There is limited data

[54] Sydvaranger Eiendom AS: Søknad om driftskonsesjon, 2018

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on the impact on salmon in Bøkfjorden, but it was found that salmon in Sandneselva, which have to migrate through Langfjorden, which was used for the deposition of mine tailings prior to 1976 near Kirkenes and is heavily altered, have a higher mortality and different behaviour than those in Neidenfjorden and Bøkfjorden (Bienfait et al., 2020).

C. Pollution

The main pollution is related to the submarine mine that contain both metals and the flocculation chemical Magnafloc. Ecotoxicological laboratory studies show low toxicity of the mine tailings for several species including marine algae *Skeletonema costatum,* lugworm *arenicola marine*, copepod *Tisbe battagliai* and turbot *Scopthalmus maximum* (Berge et al., 2012, 2014), although they do show significant mortality to amphipod *Corophium* sp. (Brooks et al., 2019). Leaching studies indicate weak leaching of Magnafloc in seawater. In general, the laboratory studies indicate that the impact on the marine environment is not expected to be significant in terms of toxicity (Brooks et al., 2019). Bienfait et al. (2020), however, argues that further studies and extensive monitoring are necessary.

Other concerns relating to marine pollution includes the discharge of plastic particles and nanoparticles with the mine tailings or through run-off. These could impact the health and reproduction of aquatic organisms (Bienfait et al., 2020).

Surface run-off from the waste rock deposits in the mining area may contain heavy metals, but no data on this has been found. Additional impacts include noise from the mining operations and transport and air pollution from dust from transport and explosions. This could impact nearby recreational and built up areas, but no data is available.

6.4.1.3. Conflicts

There are no conflicts with the reindeer herding district (Wråkberg, 2019). There is a formal agreement between Sydvaranger Eiendom and the reindeer herding district in which the waste rock deposits in the mining area are accepted and arrangements are made for further dialogue for the placement of waste rock deposits within the concession area[55].

6.4.1.4. Mitigation

Compensation to the reindeer herding district for loss of grazing land was agreed during prior mining operations and will need to be formalised with the new company[56].

[55] Det Kongelige Nærings- og Fiskeridepartement, 19.3.2019: Om klage på vedtak om tildeling av driftskonsesjon til Sydvaranger Eiendom AS for Sydvaranger gruveområde.
[56] Saksframlegg Sør-Varanger Kommune 28.12.2016

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As part of the operating licence, the Directorate of Mining recommends that mitigation actions that need to be investigated include the possibility to deposit waste rock in quarries or parts of the mine that are no longer in use, and investigate alternative uses for the waste rock.

6.4.1.5. Ambitions

Often, public reporting and similar company information can provide information about ambitions and the company's self-perception. According to their homepage, Sydvaranger's production facilities are located adjacent to the towns of Kirkenes and Bjørnevatn and the Sydvaranger resource consists of several magnetite iron deposits with indicated resources of 475 Mt and inferred resources of 43 Mt. The mine operated from 1910 to 1997 with over 200 million tonnes of ore unearthed. Sydvaranger was the largest mine in Norway for most of this period.

- Sydvaranger website 17.6.21: http://www.sydvarangergruve.no/historie

In January 2021 Sydvaranger was merged with Tacora Resources Inc, a global iron ore mining and mineral processing company focused on the acquisition, development and operation of iron ore reserves.

- Sale of Sydvaranger to US-based mining company Tacora Resources Inc, January 2021: https://www.highnorthnews.com/en/tschudi-sells-sydvaranger-american-mining-company

Newspaper article, in Norwegian, no further information:

- Sandvik, K., 2010. Kan ikke sammenlignes. Fiskeribladet Fiskaren, 28-06-2010. (Unfortunately, there is no access to the article, no web link and the newspaper use pay wall.)

6.4.1.6. Perception

No specific data was found

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6.4.2. Svalbard

Svalbard is a Norwegian archipelago in the high Arctic, situated between 74° – 81° N and 10° – 35° E, and is surrounded by the Barents Sea, the Arctic Ocean and the Greenland Sea. The main island in the archipelago is Spitsbergen, which has 2 main settlements: the Norwegian town Longyearbyen and the Russian town Barentsburg. Svalbard has a population of about 2500 in 2022[57] and the three main industries on Svalbard are tourism, coal mining and research.

[57] Statistics Norway: https://www.ssb.no/en/befolkning/folketall/statistikk/befolkningen-pa-svalbard

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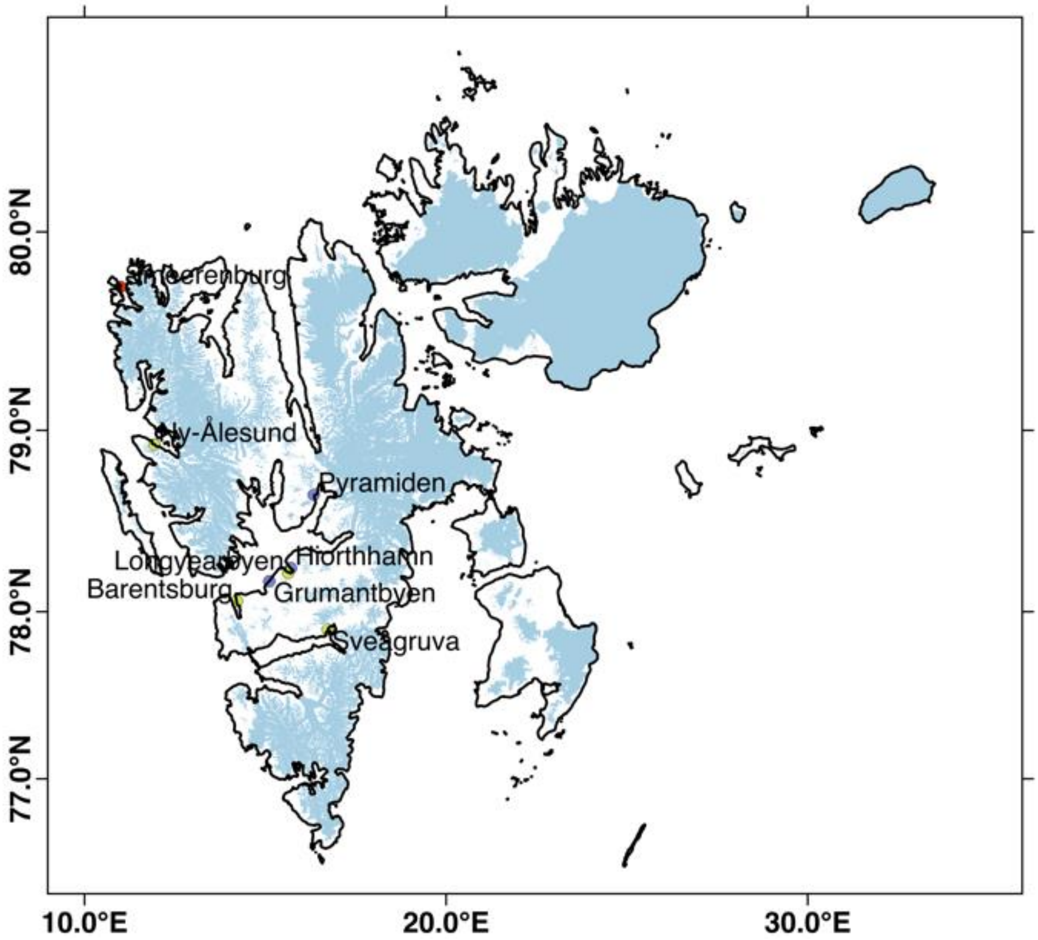

Figure 58. Map of Svalbard archipelago with coal mining locations.

The early (17th-19th century) history of Svalbard is dominated by hunting for whales and walrus and Arctic exploration by groups with different nationalities (English, Dutch, Danish, French and Russian). Coal mining started in the late 19th century and became the dominant activity on Svalbard for most of the 20th century. However, in the last 20 years, Svalbard has been experiencing a rapid and multifaceted change both in climate, industry and economic development. Coal mining has declined and is no longer the main activity, while tourism and research have increased, with tourism currently being the dominant economic activity in Svalbard (Arlov, 2020; Kotasková, 2022).

The coal mining history started when the first coal was excavated in Svalbard in 1899 and a 'coal rush' with more than a hundred groups from different nations exploring and mining for coal occurred between 1900-1920. In 1916 and 1917, several Norwegian coal mining companies started up, including Store Norske Spitsbergen Kulkompani (Store Norske) [58], and Norway became the dominant nation with

[58] https://www.snsk.no/

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commercial activities in Svalbard. This dominant economic position contributed to the development of the Svalbard Treaty, which was signed in 1920 and came into force in 1925, when Norway was formally granted sovereignty over Svalbard (Arlov, 2020).

The main areas where coal mining has taken place: 1. Adventdalen near Longyearbyen, 2. Barentsburg and Grumantbyen in Isfjorden, 3. Pyramiden in Billedfjorden, 4. Svea in van Mijenfjorden and 5. Ny Ålesund in Kongsfjorden. Only 2 coal mines in currently still in operation on Svalbard: 1. gruve 7 which is operated by the Norwegian company Store Norske and is located in Adventdalen near Longyearbyen. Gruve 7 is planned to be closed in 2025; 2. And a coal mine in the Russian Barentsburg operated by the Russian company Trust Arktikugol. Previous coal mines include several mines in Svea, which were in operation between 1916-2016 by Store Norske, Ny Ålesund (1917-1963), operated by the Norwegian Kings Bay Kul Company, and mines in Pyramiden (1940-1998) and Grumantdalen (1931-1961) operated by Trust Arktikugol. The coal mines in Svea are currently being restored back to nature with all infrastructure being removed. The coal production in the Norwegian coal mines was between 0.25-0.5 million tonnes prior to the year 2000, increased rapidly to over 4 million tonnes in 2007 and reduced again to 0.7 million tonnes in 2016. After the main mine in Svea closed, the production from the remaining mine gruve 7 in Adventdalen has been between 90000-150000 tonnes per year (SSB, 2017; SNSK, 2013). The coal production in the Russian coal mine in Barentsburg was reduced from about 485000 tonnes in 1994 to 117000 tonnes in 2019 (SSB, 2020). Figure 59 shortly summarizes the two currently operating mining companies while table 16 presents also previously active mining companies in Svalbard.

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Figure 59. Industrial factsheet Svalbard

Table 16. Summary of the mining activities on Svalbard

	Gruve 7	Barentsburg	Svea (Svea Nord) - closed	Pyramiden – closed
Location	Adventdalen	Barentsburg	Van Mijenfjorden	
Company	Store Norske	Trust Arktikugol	Store Norske	Trust Arktikugol
Activity period	1976-2025		1999-2016 Other mines in Svea since 1916.	
Employment	2021: 47		2021: 33 employees working with the restoration of Svea	

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Production	27000 tonnes for local power station, 85000 tonnes clean coal for metallurgic and chemical industry in Europe. In 2021: 121000 tonn	Reduced from 485000 tonnes in 1994 to 117000 tonnes in 2019.	No production	No production

~~6.4.1.7.~~6.4.2.1. State of the art / environmental background

The Svalbard archipelago is a high Arctic environment, characterised by short summers and long winters with extensive snow cover and large areas with permafrost. About 50% of the land is covered by glaciers and the seas to the north and east of Svalbard are covered by sea ice for more than half the year. Climate change affects Svalbard stronger than most other regions and Svalbard is experiencing permafrost thaw, melting of glaciers, reduction of sea ice and a lengthening of the growing season. Svalbard is mountainous; arctic tundra ecosystems are found in valleys and along the coast at lower elevations. The main coal mines are located around the towns Longyearbyen and Barentsburg, and localities Svea and Pyramiden. The landcover around the coal mines is dominated by arctic tundra. The coal is mined in underground coal mines, but the mine tailings were deposited in piles near the mine entrances. The long history of coal mining has thus resulted in numerous mine tailings, which, as a result of weathering and oxidation processes release acid water and heavy metals. This acid mine drainage has a strong but local effect on the surrounding vegetation.

About 65% of Svalbard is protected as national parks or special protection areas. The main mining areas around Longyearbyen, Barentsburg and at Pyramiden are not part of a protected area.

Mining activities are regulated under the Svalbard Environmental Protection Act[59], which was developed to preserve the environment in Svalbard, including landscape, flora, fauna and cultural heritage. The Governor of Svalbard is responsible for the management of the environmental protection.

~~6.4.1.8.~~6.4.2.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in Svalbard

[59] Svalbard Environmental Protection Act, Act of 15 June 2001 No. 79 Relating to the Protection of the Environment in Svalbard (https://www.regjeringen.no/en/dokumenter/svalbard-environmental-protection-act/id173945/)

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A. Habitat and landscape

The main impacts on habitat and landscape are from the construction of infrastructure and the deposition of mining waste. The construction of waste dumps, roads, buildings, coal transport lines, mining entrances, harbours, airfields, etc. occupy quite a number of square kilometres at each mining hub. The change in land use from natural to industrial has reduced the original habitat and population sizes of numerous species.

B. Changes in biodiversity

A few species are considered threatened by mining activities. This includes the very rare plant *Carex bigelowii ssp. arctisibirica*, which is known from a few localities at Svalbard (IUCN category: CR). Most individuals have been seen near Hotellneset close to Longyearbyen Airport. This was an important harbour for the coal mining industry. The road to the former mines in Bjørndalen cuts through the area. The main part of the original population was with certainty destroyed during the construction of the airport (Norsk rødliste for arter 2015). *Arctodupontia scleroclada* is in IUCN category EN. A large part of its population in Ny-Ålesund is destroyed by buildings and road constructions. *Juncus leucochlamys* (IUCN: EN) is no longer present in Longyeardalen due to destruction of natural tundra. Four populations of *Luzula wahlenbergii* (IUCN: NT) from Longyeardalen have also been destroyed by human infrastructure. Known populations of *Coptidium pallasii* (IUCN: NT) from the Longyearbyen area were also destroyed.

All polar bears approaching the vicinity of the coal mining village Ny-Ålesund were shot, according to a previous inhabitant. Kids could go skating and skiing mid-winter far away from the village, only with the moon as light source, without any fear for polar bears. Historically, it is highly likely that reindeer and ptarmigan were hunted for food by mining communities on Svalbard. The noise from the mining industry scare off animals, while infrastructure may hamper traditional migration routes. Coal ships disturb marine wildlife, especially through engine noise.

C. Pollution

The main pollution related to coal mining in Svalbard is the result of leaching and the spreading of dust from mine tailings. Oxidizing, sulfidic coal-mining tailings generate heat within the piles, maintaining non-freezing temperatures year-round within the piles. Consequently, weathering processes continue year-round and heavy metals are leached from the tailings. Contaminants are generally flush-released in spring when the outer layer on the pile thaws, causing acid mine drainage (AMD). As a result of the drainage of acidic waters rich in heavy metals from the mine tailings, the soil pH is often below 4. This affects the vegetation in the seepage tracks where plant abundance is very low and plant health very

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poor. The weathering products Al, Mn and Fe induce the largest negative impact on vegetation (Elberling et al., 2007; Askaer et al., 2008; Wojtuń et al., 2013, 2018, 2019; Kłos et al. 2017). In Svalbard regions far from any active coal mines, such as Hornsund in southern Spitsbergen, accumulation of heavy metals in plants is primarily caused by long-distance transport from industrialized regions in Europe and Asia, or from marine metal ions brought to land as sea aerosols by strong winds. Also lakes close to coal mining hubs are contaminated (Rose et al., 2004).

Coal dust (elemental carbon – EC) from open coal stockpiles is dispersed by wind and in winter accumulates on snow leading to lower snow albedo, as evidenced by Aamaas et al. (2011). However, the local contribution to the total contribution of EC pollution is only between 2 and 10 %. The remaining 90-98 % is caused by long-range transport by winds. High Ni concentrations in a moss, a lichen and two vascular plants from a gradient near Longyearbyen are assumed to be a function of wind-blown coal particles from the mining industry. Soils around Longyearbyen contain high concentrations of Cd, Co, Cu, Ni, Pb and Zn, which is also considered to be a result of coal dust accumulation (Kłos et al. 2015, 2017; Wojtuń et al. 2019).

Plants take up heavy metals from soil. The small bird snow bunting is a herbivore and insectivore. Elevated tissue concentrations of toxic elements found in populations in Adventdalen is assumed to be caused by dispersal of coal from the coal mining industry taken up by plants and insects and later accumulated in the bird. Al, Co, Se and Zn were in higher concentrations in snow bunting from Adventdalen. It is not yet known whether these levels are detrimental for the bird (Sørhus, 2017). Spontaneous iron overload has repeatedly been reported from liver tissues of Svalbard reindeer. It was caused by high uptake of dietary iron from iron-rich forage plants (Borch-Iohnsen & Nilssen, 1987; Borch-Iohnsen & Thorstensen, 2009; Fossøy et al., 2018). It is not yet concluded that this is related to coal dust. It is more likely that it is caused by naturally high Fe concentrations in Svalbard bedrocks and soil (Pacyna et al., 2018). Wegrzyn et al. (2018) hypothesize that high metal concentration in some samples of reindeer faeces may be due to dust from the coal mining industry. A comparison of reindeer from Adventdalen (coal industry-affected) with reindeer from Kapp Linné (not near any coal mining) by Røed (2018) clearly shows contrasting element levels between the locations. Most of these differences have natural causes (e.g. sea aerosols and precipitation rates). However, the concentration of Cd was closely linked to distance from coal power plant.

The burning of coal extracted on Svalbard, and all activities related to the extraction, including shipping, heavy vehicles and air-borne transport of employees, lead to substantial emissions of CO_2 and other greenhouse gases to the atmosphere.

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~~6.4.1.9.~~6.4.2.3. Conflicts

There is no data available about potential conflicts

~~6.4.1.10.~~6.4.2.4. Mitigation

There is no data available about mitigation processes

~~6.4.1.11.~~6.4.2.5. Ambitions

~~6.4.1.12.~~6.4.2.6. Perceptions

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~~6.4.2.~~6.4.3. Egersund

Magma Geopark[60] is a 2320 km^2 area in southwestern Norway which includes 5 municipalities. Magma Geopark is part of a network of more than 160 UNESCO Global Geoparks and has a geology of major international importance. In addition, sustainable development plays an important role in the area. The area has more than 300 years of mining history and about 100 abandoned and 8 active larger and smaller mines (Titania, Rekefjord east and west, Hellvik (3 mines), Egersund Granite and Espedal gravel. One of the Magma Geopark municipalities, Sokndal, has the highest level of employment in the mining industry of all Norway, compared to the number of inhabitants.

Magma geopark, also known as the Rogaland anorthosite province, consists of anorthositic and noritic intrusions that were deposited between 920-930 million years ago. The area contains large ore deposits containing phosphorus apatite, vanadium rich magnetite, ilmenite and possibly nickel. The ilmenite ore in Sokndal is one of the largest in the world. Anorthosite has a variety of industrial applications. Anorthosite massifs are known to host important ore deposits, such as ilmenite, and are in many cases excellent sources for high-quality rock aggregate and also for dimension stone. The exploitation of anorthosite for industrial mineral products is growing, and the potential for future production of aluminium and other important constituents from anorthosites is considered to be quite considerable. The active mines are extracting sand and gravel, aggregates, dimension stones and the ore mineral ilmenite. The abandoned mines were extracting feldspar, quartz, molybdenum, wolframite, mica and ilmenite.

The largest active mine is Titania AS, located in Tellenes in the municipality Sokndal, which extracts ilmenite for the pigment market, with planned extraction for next 100 years. The Titania mine is owned by the American company Kronos World Wide Inc[61] and employs 220-250 man years. The mine produces about 800000 tonnes ilmenite concentrate and 20000 tonnes magnetite annually. The mine started in 1960 and is operated as an open pit mine; open pit mining is planned to continue to 2070. The mine is one of the largest titanium mines in Europe with a spatial extent of about 1.5 km^2. Waste production includes 2-3 million tonnes of mine tailings per year, which is deposited in a land deposit with a capacity of 65 million m^3, host rock, which is deposited in a land deposit for host rock with a capacity of 1000 million m^3. Future deposits may be as sea deposits or backfilling.

60 http://www.magmageopark.no
61 https://www.kronosww.com

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Industrial factsheet **Egersund**– *Titania AS* mining

Company:	Titania AS
Ownership:	Kronos World Wide Inc, American
Location:	Tellenes, Sokndal municipality
Activity:	Plans for open pit production of ilmenite and magnetite until 2070; License to deposit tailings on land until2026. After that a reapply for new licence necessary
Spatial extent:	1.5 km2
Nat. resources:	anorthosite, ilmenite ore (reserves of 400 million tons ilmenite, with 18% titanium oxide in the ore)
Production:	around 800,000 - 850,000 tons ilmenite concentrate and 20,000 tons magnetite average annual production, some sulphus
Employment:	220–250-man years

Figure 60. Industrial factsheet Egersund (mining)

Titania has to remove a large amount of waste host rock (anorthosite) to reach the ilmenite ore. This waste rock is deposited in and around the mine. The mine also produces tailings from the separation process which is currently deposited on land. Until 1993, tailings from Titania were deposited in submarine mine tailings in Jøssingfjord (1960-1983) and Dyngadjupet (2,2 tons of tailings, 1984-1993). In 1989/1990, the company was ordered by the government to build a landfill for tailings, against advice from subject matter experts. Titania has tried to find a market to sell anorthosite rock and find potential uses for their tailings, but so far without success.

The landscape in Dalane area (Eigersund, Sokndal, Lund and Bjerkreim municipalities) is distinctive with rounded mountains tops and hills, often almost bare, with numerous, strongly branched waterways and relatively large lakes. The landscape appears barren which is due to the bedrock. In the south, it consists of feldspar-rich igneous rocks, which when weathered gives a very coarse soil. In the north and east, the valleys are wider in places with larger quaternary deposits and a more lush landscape. Areas of fertile soil with agriculture and sheep pastures are often consistent with increased concentration of apatite (phosphorus bearing minerals) in the bedrock. The whole landscape continues all the way to the largely unprotected coast. The heights are modest along the coast in the south, while in the northern areas there are heights of over 900 meters above sea level. The highest hilltop is

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Skykula on the border between Eigersund and Bjerkreim and Vinjekula on the border between Bjerkreim and Gjesdal with 906 and 907 meters above sea level, respectively. There are large sheep pastures in the heaths. Lund municipality has the largest nature protection area (Førland/Sletthei and Tverrådalen), and there are some smaller nature protection areas scattered around in the hub area (Vasshusvika, Drangsdalen, Lingborgvatnet, Eptvatnet,Svåholmane, Tedneholmen, Tingelsæte, Skåland, Mjålsjuvet, Fokksteinane, Eikebakka, Årstad, Rekedal and Nesvåg). None of the protection areas are immediate to mining activity.

~~6.4.2.1.~~6.4.3.1. State of the Art / Environmental background

The Magma Geopark area is characterised by rocky mountains, lakes and agricultural areas. The area contains a large variety of species of national importance from birds to plants, some of which are endangered. The Titania ilmenite mine is located in the mountains at an altitude of about 300 m and covers an area of ca 7 km^2, which includes the open pit mine of ca 1.5 km^2, several waste rock deposits and a tailings dam of ca 1 km^2. The tailings dam for the land deposit was 60-70 m high in 2006 and was increased to around 100 m later on to make space for the tailings. Prior to 1993, the tailings were deposited as submarine mine tailings deposits in Jøssingfjord and Dyngadjupet to the west of the mine. Jøssingfjorden was filled with an up to 55 m meter thick deposit of mine tailings, reducing the maximum depth from 85 m to 30 m; Jøssingfjorden is protected from ocean currents by a narrow fjord entrance and a shallow sill. The basin of Dyngadjupet is more exposed to ocean current and was filled from a maximum depth of 172 m to 130-140 m (Schaanning et al., 2019).

The tailings that are deposited in the land deposit still contain significant quantities of Ni and Cu. Between 2008-2015, it was estimated that typically 800 tonnes of Ni and 400 tonnes of Cu were deposited annually. As rainwater seeps through the deposit, some of the Ni and Cu is leached out and discharged in Jøssingfjord. Mine tailings that contain metal sulphides are more geochemically stable when deposited under water without exposure to oxygen (Schaanning et al., 2019).

~~6.4.2.2.~~6.4.3.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in Egersund

A. Habitat and landscape

The submarine tailings deposits cover the original fjord bottom with a 40-50 m thick layer of mine tailings and have destroyed the original bottom topography and habitat. However, recolonisation of old tailings deposits started within a year after the deposition stopped, and 20 years later, faunal

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communities have returned and benthic communities are classified as good to very good. The restitution of the area is, however, slowed down because of the on-going discharge of particles into Jøssingfjorden (Olsgard & Hasle, 1993; Schaanning et al., 2019).

Similarly on land, where the open pit mine, waste rock piles and land tailings deposit have destroyed the original landscape. In addition, mine access roads contribute to habitat fractionation.

B. Changes in biodiversity

As mentioned in the previous section, the deposition of mine tailings in Jøssingfjorden and Dyngadjupet had significant impact on the benthic fauna populations and, therefore, marine biodiversity on the fjord bottom. The deposition rate varied across the deposit from several meters a year near the discharge location to 1 mm a year 2-3 kilometers away. The reduction in fauna diversity varied with the deposition rate and fauna populations recovered within a year after deposition stopped (Olsgard & Hasle, 1993).

C. Pollution

After around 20 years of experience of operations from this landfill, there is sufficient material on which to make a decision on the consequences of continuing to deposit tailings in a landfill. The landfill has over time caused major environmental issues, and the issues will continue to grow even if deposition of tailings were to stop now. One of the problems with the landfill is that the choice was made to use a permeable dam. As a consequence of this, parts of the tailings have access to air and are exposed to weathering. This means that rainwater and groundwater will continue to seep through/ flow through the tailings perpetually and cause mobilization of minerals and chemicals used in the separation process of the ore. According to the government's pollution standard (SFT standard, now replaced by a new standard) the sediments were in 2007 mapped with class 3 nickel contamination (severe pollution) and moderate copper contamination. It's been reported that the tailings contain around 12% iron, 0.03% nickel, 0.016% copper and 0.1% sulfur. The concentrations of sulfide minerals are relatively low, but sulfide minerals can contain many heavy metals, such as nickel, copper, cobalt, zinc. The iron in the tailings will oxidize over time and create large amounts of iron precipitates (iron hydroxides). Despite the low concentration of heavy metals, the overall environmental impact may become significant due to the large amounts of tailings deposited. Mobilized nickel seeping into the surrounding area was the first reported metal pollution. Already in 2006, the limit for allowed release of nickel to Jøssingfjord was exceeded. Titania has implemented mitigating actions by adding lime (which increases pH) directly to the watercourse downstream from the disposal site, and the watercourse is used as a purification plant, where mud settles in basins.

Dust from Titania's tailings landfill is an ongoing issue in surrounding areas. Measurements of the dust have shown that there is no risk to people's health, but some may experience nasal and throat irritation

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when the dust is visible. The dust is a nuisance for people living near the mine and Sokndal municipality has ordered Titania to do what they can to reduce their emissions of dust. In august 2021 Titania reported that they have had few complaints about dust emissions so far this year showing that their measures have had a positive effect on reducing dust emissions. In the spring of 2021 they installed an irrigation system along Dam 1 that is used in combination with irrigation from a tractor. The irrigation system does not, however, cover the entire area of 1.2 km^2 as parts of the landfill are inaccessible for heavy vehicles. As such, during periods of arid conditions, the tailings become dry and dust becomes an issue.

Titania has annual emissions of 8,300 ton CO_2 equivalents.

There is an ongoing national debate between researchers, government and environmental organisations on the environmental impact of deposition of tailings in fjords / on the seafloor, and whether tailings should be deposited on land or on the seafloor. In January 2019, the Norwegian Environment Agency published their decision on whether deposition of tailings on the seafloor should be prohibited or not. They concluded against prohibiting this and argued that all mines and tailings depositions must be evaluated independently to find the best alternative with the lowest environmental impact. Recent research (PhD finished in 2019, research program NYKOS[62] finished in 2019) shows that deposition of tailings on the seafloor overall has less negative impact on the environment compared to landfill. Seawater has high pH (alkaline, pH above 8) and low oxidation potential due to low temperature. Metals will under such conditions become less mobile and have lower bioavailability compared to conditions on land. The environmental impact should only become significant if the minerals are dissolved and the metals become bioavailable. On the seafloor, only the first few centimetres of the top layer of the tailings are in contact with the seawater and chemical reactions between the tailings and the seawater occurs mainly by diffusion. Below the top layer, the pore water is reducing (redox condition), which is a condition where several minerals are more stable and many metals (e.g. Ni, Cu, Zn, Cd, Co) are less soluble than under oxidizing conditions. The chemicals used in the processing of the ore, in the case of Titania, will not react with the seawater and seep out of the deposit. While the environmental impact of tailings deposition on the seafloor is temporary, the environmental impact of the tailings deposited on land will be significant perpetually. Still, more research is needed to fully understand the environmental impact of tailings deposition on the seafloor (Trannum & Schaanning, 2017; Trannum et al., 2018).

[62] NYKOS - New knowledge on Sea Disposal: https://www.sintef.no/projectweb/nykos/

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In 2017, the university of Bergen and the Norwegian Institute of Marine Research started to conduct surveys on the seafloor in the Jøssingfjord to assess the extent of environmental impact from discharge by Titania. Their findings showed oxygen at the surface and live organisms, but only a few millimeters into the sediments, the concentration of oxygen was too low for organisms to survive. They were expecting a better biological state of the sediments as the seafloor was declared as "healthy" a few years back.

More extensive research conducted by NIVA and DNV-GL around 2017-2019 showed that the tailings deposition on the seafloor in Jøssingfjord and Dyngadjupet hasn't caused significant damage to the seafloor fauna and that a normal seafloor fauna was established shortly after the deposition was completed. Even though the fauna still shows weak signs of impact, the biodiversity is classified as "good", according to the criteria given by the Norwegian Water Act (Vannforskriften). This classification is not a complete description of the situation as it does not include the effect of environmental pollutants. The metal content of the tailings is still high enough to cause acute toxic effects on organisms in the area, despite a rich biodiversity. Because of this, the ecological condition is classified as moderate (class III). The researchers detected a gradient between the open and deep areas of the ocean near Dyngadjupet where conditions were classified as "very good", to "good" conditions in the more shallow areas in the Jøssingfjord. This correlated with increasing concentrations of copper and fine grained materials in the more shallow areas. The increased concentrations are likely due to seepage water from the landfill, which Titania has been releasing into the Jøssingfjord since tailings deposition on land commenced in 1994. To reduce the impact on creeks, rivers and lakes below the landfill, some of the seepage water is recycled to be used by the processing facility before it becomes part of the discharge to the Jøssingfjord. Overall, the discharge from the tailings on the seafloor has been minimal compared to discharge from the landfill.

~~6.4.2.3.~~6.4.3.3. Conflicts

The mining industry is facing increased critics from the tourism industry and local residents.

~~6.4.2.4.~~6.4.3.4. Mitigation

There is no data available about mitigation

~~6.4.2.5.~~6.4.3.5. Ambitions

Company information can provide information about ambitions and the company's self-perception.

KRONOS is a global company. According to their home page, KRONOS is a leading global producer and marketer of value-added titanium dioxide pigments, or TiO_2, a base industrial product used in a wide

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range of applications. “While we are proud of our progress, we never stop striving for improvement. We continue to focus on maximizing energy efficiency, minimizing waste, reducing our carbon footprint, and caring for our employees and communities.

- Company website Titania: https://kronostio2.com/en/manufacturing-facilities/hauge-norway
- https://snl.no/Titania_AS (lexical information only in Norwegian)

Norge Mining has a clear vision; to operate the most ecologically, socially and sustainable mine for Critical Raw Materials vanadium, phosphate and titanium. In this way, we want to create a lasting impact by contributing to a more sustainable future that global citizens are clamouring for. Considerate mining is at the core of our business model – in collaboration and constant communication with local neighbourhoods. Using innovation and technology, we aim to minimise any environmental impact. What’s more, some of the minerals we are sourcing will greatly contribute to a more sustainable global future.

- Company website Norge Mining: https://norgemining.com/

Larvik Granite is a traditional Norwegian quarry owner, but we are also a modern, international company focused on the future and represent a new breed of stone producers. Driven by our customer focus and commitment to quality, we strive to set new standards based on the traditions of the past and close cooperation with our customers. We value our employees highly and focus on making Larvik Granite a safe, dynamic and positive working environment.

- Company website Egersund Granite: https://larvik-granite.no/

According to their home page, Rekefjord Stone is a cornerstone business in the Municipality of Sokndal, where quarrying has been a key local industry for over 100 years. The company provides Europe with high-quality stone for the construction of infrastructure and buildings.

- Company website Rekefjord Stone: https://rekefjordstoneas.no/

~~6.4.2.6.~~6.4.3.6. Perceptions

Newspaper articles informs about perception of the company from different angels and can inform abut trends and ambitions. The newspaper articles are accessible, some are partially behind pay walls. The articles are in Norwegian and will only be given a general comment. The main topics are economic ups and downs of Titania for 20 years, their effect on the regional labour market and last, but not least the environmental consequences of dumping mining sludge on the seabed.

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Newspaper and media articles covering various aspects of Titania AS activity:

- September 2021: https://www.aftenbladet.no/lokalt/i/Wj6GPK/vi-kjenner-det-i-magen-tankene-gaar-til-filmen-boelgen-og-skredet-i-g
- August 2021: https://www.nrk.no/rogaland/titania-as-er-glad-i-sterk-dollar-1.15607427
- January 2021: https://www.aftenbladet.no/lokalt/i/R9myG2/paa-tellenes-kan-det-bygges-batterifabrikk-uten-de-kjente-konfliktene
- February 2020: https://www.at.no/anlegg/482490
- February 2019: https://www.nrk.no/rogaland/finsk-fabrikkbrann-gir-norsk-storpermittering-1.14434346
- August 2019: https://www.aftenbladet.no/lokalt/i/BRmA1E/titania-i-gang-etter-4-maaneders-stenging-naa-kan-det-bare-gaa-oppover
- February 2019: https://www.aftenbladet.no/lokalt/i/p6qMv1/200-permitteres-fra-titania
- April 2019: https://www.at.no/anlegg/468171
- July 2018: https://www.nrk.no/urix/vurderer-brudd-pa-sanksjonsregime-1.14118665
- December 2018: https://www.nrk.no/rogaland/slutter-i-titania-1.14332493
- 2017: https://www.nrk.no/rogaland/urovekkende-funn-pa-bunnen-av-jossingfjorden-1.13532071
- 2017: https://www.nrk.no/rogaland/titania-vurderer-havdeponi-for-gruveavfall-1.13552134
- 2017: https://www.nrk.no/rogaland/urovekkende-funn-pa-bunnen-av-jossingfjorden-1.13532071
- 2017: https://www.aftenbladet.no/lokalt/i/dKoqB/gruveslam-fra-titania-kan-igjen-ende-i-havet
- 2017: https://www.aftenbladet.no/lokalt/i/gMV4J/se-det-enorme-deponiet-til-titania-hvor-skal-de-gjoere-av-gruveslammet
- 2017: https://www.aftenbladet.no/lokalt/i/dV51w/hav-eller-land-hvor-boer-titania-deponere-gruveslam-i-framtiden
- 2013: https://www.aftenbladet.no/okonomi/i/8jj1A/titania-tjente-raatt-paa-raavaremangel
- 2002: https://www.aftenbladet.no/okonomi/i/2qzdq/ilmenitt-i-100-aar

Then there is a group of articles covering various aspects of mining industry in Norway and the Egersund region. The full article is hidden behind pay wall.

- August 2021: https://www.aftenbladet.no/lokalt/i/V9zkld/er-det-bare-kvinner-som-jobber-med-bergverk
- August 2021: https://www.aftenbladet.no/lokalt/i/kR2kRk/e39-her-borer-norge-mining-midt-i-den-gamle-r1-traseen
- June 2021: https://www.aftenbladet.no/lokalt/i/kR2mr9/aud-torunn-tronerud-en-saann-boremaskin-har-jeg-ved-hytta
- May 2021: https://www.aftenbladet.no/lokalt/i/kR7lpk/skisse-viser-800-meter-bred-gruve-i-dalane-slik-vil-partiene-forvalte
- March 2021: https://finansavisen.no/nyheter/ravarer/2021/03/02/7632242/global-betydning-sier-norge-mining-sjef-john-vergopoulos-om-nye-analyser-av-mineralforekomst-utenfor-egersund

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- March 2021: https://www.aftenbladet.no/lokalt/i/0K3QJg/tidligere-frp-statsraad-jobber-for-gruvedrift-i-dalane-om-fem-aar
- March 2021: https://www.aftenbladet.no/lokalt/i/JJvE1P/regjeringen-vil-ikke-ha-statlig-gruvedrift-i-rogaland
- January 2021: https://www.aftenbladet.no/lokalt/i/R9mE3W/prosjekt-i-verdensklasse-men-hvorfor-er-det-saa-stille-fra-oslo
- January 2021: https://www.aftenbladet.no/meninger/debatt/i/yR8J6A/norsk-mining-kan-tjene-millioner-mens-andre-mister-hus-og-hytter
- September 2020: https://www.nrk.no/rogaland/mineraler-for-hundrevis-av-milliarder-under-bakken-1.15133192
- 2017: https://www.aftenbladet.no/lokalt/i/lOlzL/han-gjoer-gull-ut-av-graastein

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Trannum HC, Næss R & Borgersen G (2018). Overvåking av marin bløtbunnsfauna for Titania A/S i 2018. *NIVA-rapport 7291-2018*: pp 45. https://brage.bibsys.no/xmlui/handle/11250/2565675

Trannum HC & Schaanning MT (2017). Mesokosmos-forsøk med avgang fra Titania – effekt på bløtbunnsfauna. *NIVA rapport 7223-2017*: pp 18. https://www.sintef.no/globalassets/project/nykos/pdf/niva-rapport-titania_7223-2017.pdf

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~~6.4.3.~~6.4.4. Germanasca Valley

The character of the Germanasca Valley Hub in the Western Alps is both linked to the mining resources and to the history of the Waldenses (religious group born in 1173 in Lyon, France with the conversion of merchant Waldo, founder of the movement) marked by persecution and the fight for their own identity. The Hub illustrates a long-term interaction between the local population and mining companies in the case of mines of both industrial and cultural/educational/tourism interest.

The area in question is located at the western edge of the Dora Maira Massif near the contact with the overlying Mesozoic Piedmontese Zone, which is a composite system of oceanic units here formed by the calcschists of the Cottian Alps. The Dora Maira Massif (review and references in Sandrone et al., 1990) is a continental unit consisting of an upper complex formed by pre-Carboniferous metasediments and minor marbles and metabasites, and a lower complex composed of probably Permian-Carboniferous graphite bearing metasediments. Both complexes contain meta-granitoids of granitic to tonalitic composition, which are mainly regarded as Late-Variscan (Bussy and Cadoppi, 1996). Dora Maira massif suffered two main metamorphic event in Alpine age. The first developed under eclogite facies conditions, while the second is characterized by a widespread retrogression under greenschists conditions. Talc can be attributed to the alpine mmf in eclogitic facies starting from an adequate composition (clays rich in Mg-sepiolite).

After centuries of intense mining, an ambitious project for rediscovery of the abandoned talc mines led to the birth of the " EcoMuseum of Mining " in 1993. Later a new Geoscience educational project "ScopriAlpi" (DiscoverAlps) was built for showing the magnificent internal geological structure of the Alps, within a new proposed UNESCO Global Geopark. In the meanwhile, IMERYS TALC ITALY (see figure 61), a multinational company, is still managing the talc mining activity in the Chisone and Germanasca valleys in the province of Turin. The talc mine in the Germanasca valley is an underground mine; some of the produced tailings are used to refill the underground tunnels that are finished. The company produces about 32,000 t of talc and 21,000 t of aggregates annually and it has a workforce of more than 80 employees. The local mining activity involves the whole Germanasca valley, since the talc extracted from the Rodoretto mine in the municipality of Prali undergoes its first screening in the sorting station before it is transported to the Malanaggio facility in the Porte municipality, where it is crushed, dried or decontaminated, milled and packaged according to its end use and the customers' needs.

Imerys Talc Italy has been present in the region through its facility and its mines for more than a century. This presence is generally perceived positively by the local communities. There is a relationship of constant collaboration that is strengthened through support of local activities and initiatives, aiming especially at volunteer associations and students in the valley's schools. The

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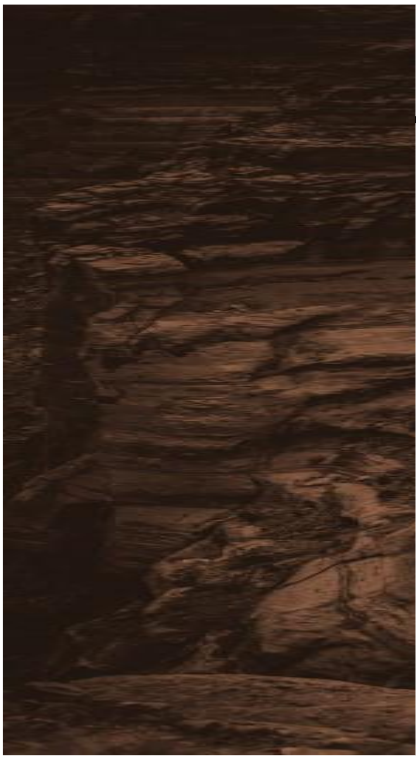
company's strong connection to the area is also shown by its collaboration with Scopriminiera and ScopriAlpi ecomuseum.



Industrial factsheet **Val Germanasca**– *Imerys Talc Italy S.p.A.* mining

Company:	Imerys Talc Italy S.p.A. (from 2011 – in progress). Before Imerys the Talc exploitation was in charge of Rio Tinto Group and of Soc.Talco-Grafite Val Chisone.
Ownership:	Multinational
Location:	Germanasca valley: Rodoretto Mine (municipality of Prali); Malanaggio dressing plant (municipality of Porte)
Activity:	Underground talc mine. Operation method: "underhand cut and fill".
Spatial extent:	No data available
Nat. resources:	Reserves estimated 265.000 tons and resources estimated 570.000 tons of talc ore to be excavated in 7-8 years. Geological exploration in progress for additional resources.
Production:	28.000 tons average talc annually (before: Up to 36.000 tons annually)
Employment:	80 man-years (mine + dressing plant + administration)

Figure 61. Industrial factsheet Germanasca

~~6.4.3.1.~~6.4.4.1. State of the Art / Environmental background

Val Germanasca is an alpine valley belonging to the Cottian Alps sector and extends for about 200 km^2 in the Cottian Alps (Piedmont, NW Italy). The valley is a branch towards the SW of the wider Chisone Valley, which it joins at Perosa Argentina, in the lower valley. Val Germanasca is crossed by the Germanasca stream, the right tributary of the Chisone stream. The territory is mainly mountainous and extends between altitudes of about 3,000 meters, corresponding to the highest peaks of the valley (Bric Ghininvert and Gran Queiron) and the 600 meters of Perosa Argentina, where the valley closes and the Germanasca stream flows into the Chisone stream. The morphological characteristics of the landscape are essentially constrained by the lithological constitution and the structural arrangement of the slopes. In correspondence with the rocks belonging to the crystalline massif of Dora Maira, erosion has led to the formation of deep valley incisions. The mountains appear, in particular on the east-facing slopes, characterized by westward attitude, with very steep slopes and rocky walls of hundreds of meters. Towards the upper Val Germanasca, where more erodible rocks outcrops such as the complex of calcschists, the slopes become less steep and the valley is more open.

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Val Germanasca has a very humid and rainy climate, which in the winter months frequently reaches temperatures below freezing. This led to the development of thick vegetation. The flora, mainly composed of alpine species, is a dominant feature of the area. The broad-leaved woods are numerous and dense. Conifers can only be found in the upper part of the valley, which however disappear at 2,000 meters to give way to the grassy surface.

The provincial road n. 169, which runs parallel to the Germanasca stream, ensures quick access to it, which can be reached in about an hour and a half from the Piedmontese capital of Turin. The valley is also crossed by a large number of secondary roads that allow adequate access to the side valleys of Salza, Massello and Conca Cialancia. There are also numerous paths and dirt roads, which testify to the widespread anthropization of the valley, which occurred above all in the past. The main inhabited centers, in addition to Perosa Argentina, are Pomaretto, Perrero and Prali, all distributed along the main axis of the valley. From an economic point of view, the Valley was characterized by widespread mining, which in the past ensured good job security. Currently the valley has assumed a predominantly tourist vocation, centered on the ski facilities present in the municipality of Prali. Traditionally, the Val Germanasca is part of the Waldensian Valleys, where the absolute majority of the population follows the Waldensian cult, which is linked to Pietro Valdo, persecuted as a heretic in the Middle Ages.

In the past, the talc deposits of the Piedmontese Germanasca and Chisone valleys have had great importance, both for the purity of the extracted material and for the economic role played in the last century. Since the mid-1700s, talc, under the name of "craie de Briancon" was known throughout Europe as a tailor stone. However, industrial exploitation can only be talked about starting from the second half of the nineteenth century. In Val Germanasca the talc was extracted in the municipalities of Prali, Salza and Perrero, in Val Chisone in those of Roure, Fenestrelle Usseaux and Pragelato. The main extraction pole naturally became Val Germanasca, where numerous mining sites were opened. In 1907 the Talco e Grafite Val Chisone Company was established in Pinerolo, becoming the only enterprise for the extraction of talc in the Pinerolo valleys. In the 1930s, with the progressive exhaustion of the mines at high altitude, excavations began on the levels Gianfranco (1377 m), Gianna (1212 m), Paola (1265 m), Vittoria (1179 m) and San Pietro (1140 m) in what it would become the Fontane - Crosetto mining complex. After the war the mines of Val Germanasca had about 600 employees, but starting from the 1960s the phase of decline of mining began. The mining activity from 1967 was concentrated in the mines of the Fontane - Crosetto complex with an annual production of about 40,000 tons. In 1990 the Societè Internationale de Talc de Luzenac, then Rio Tinto Minerals-Luzenac Val Chisone, took over the business from the Talco e Grafite Company. The deposits of the Gianna / Paola mining complex were declared depleted in 1995 and those of Crosetto in 2002. In 1995 the new Rodoretto section was opened in Pomeifrè. A two-kilometer-long tunnel, with a diameter of five meters, allows the trucks to reach the cultivation fronts directly, while about twenty miners (mostly Polish) guarantee an annual production of about 30,000 tons of high purity talc.

~~6.4.3.2.~~6.4.4.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Italian Germanasca valley.

A. Habitat and landscape

Although a proportion of the produced tailings are now used to backfill underground tunnels, older waste deposits exist on the mountain slopes and in streams and have modified the original topography and landscape. These older waste deposits have been rehabilitated. Mining infrastructure, including buildings and roads, have changed the land use and contributed to habitat fractionation. Mining activities have changed the water table which would have an impact on the local vegetation. This has been mitigated by the creation of a water storage system.

B. Changes in biodiversity

Wildlife disturbance by traffic along the roads is seasonally high. In addition, habitat fractionation as result of the mining infrastructure and mining activities is likely to have an effect on wildlife behaviour.

C. Pollution

As most of the mining activity is underground, air and surface pollution from dust is not a major issue around the talc mine. Much of the mine tailings are used for backfilling of the underground tunnels and pollution from waste deposits is therefore limited. The main air pollution related to the mine activities is due to CO_2 emissions from vehicles.

~~6.4.3.3.~~6.4.4.3. Conflicts

There is no data about conflicts available

~~6.4.3.4.~~6.4.4.4. Mitigation

There is no data available about mitigation

~~6.4.3.5.~~6.4.4.5. Ambitions

No data has been found regarding ambitions (except small databases).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

~~6.4.3.6.~~6.4.4.6. Perceptions

No more specific data has been found regarding perceptions.

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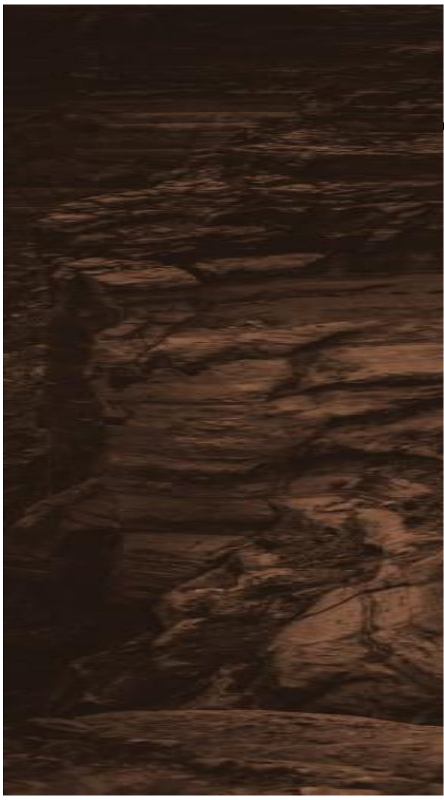
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

~~6.4.4.~~6.4.5. Kittilae

The Kittilä mine is located in Central Lapland, in northern Finland, about 170 km north of the Arctic Circle and the town of Rovaniemi. It is the biggest private employer in the Kittilä municipality with 480 employees and 300 - 400 contractor personnel. The Suurikuusikko deposit is one of the largest known gold deposits in Finland and the Kittilä Mine is currently the largest operating gold mine in Europe producing about 4500 kg of gold every year[63]. The Canadian mining company, Agnico Eagle Finland Oy, started the construction of the mine in 2006, the gold extraction commenced in 2008 with open pit mining and the mine achieved commercial production in 2009. The underground mining started 2010 and since open pit mining at Kittilä was terminated in 2012, the mine is now only operating underground, with a mine lifetime estimated through 2037. Agnico Eagle is constantly doing mineral exploration in the area to find new deposits. Some facts about Agnico Eagle are additionally presented in figure 62.



Industrial factsheet **Kittilae**–
Agnico Eagle mining

Company:	Agnico Eagle Mines limited
Ownership:	Canadian
Location:	Central Lapland, Northern Finland, about 170 km north of the Arctic Circle and the town of Rovaniemi
Activity:	Largest operating gold mine in Europe
Spatial extent	No data available
Nat. resources:	gold
Production:	4500 kg gold every year
Employment:	The biggest private employer in Kittilä municipality with 480 employees and 300-400 contractor personnel
Duration:	Estimated mine lifetime until 2037. Agnico Eagle is constantly continuing mineral exploration in the area to find new deposit

Figure 62. Industrial factsheet Kittilae (mining)

[63] https://agnicoeagle.fi

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

In Finland, the Kittilä gold mine is often referred to as a good example of mining operations as there have not been any major conflicts with other livelihoods. The use underground mining instead of open pit and the use of electric vehicles reduce noise, dust and emissions. The mine collaborates with local communities, supports local activities and provides a compensation to reindeer herders for loss of migration routes and grazing areas (Solbär & Keskitalo, 2017).

The Kittilä municipality is sparsely populated, the nearest village being about 1 km to the east of the mine, but the nearest residential houses are located about half a kilometre from the mine site. The principal land uses near the mine site are reindeer herding, forestry, and some agriculture. The Suurikuusikko deposit is located in the Loukinen River catchment which drains to the Ounasjoki River near Levi fell. The mining site is located in the lower reaches of the Seurujoki River catchment which drains further to the Loukinen River. The catchment area of the Seurujoki River is ca. 307 km^2 (Malinen, 2016). The closest nature protection areas are the Natura 2000 protection areas Loukisen latvasuot (FI1300605) and Ounasjoki river (FI1301318); the Urho Kekkonen national park is about 75 km to the northeast.

~~6.4.4.1.~~6.4.5.1. State of the Art / Environmental background

The Kittilä gold mine is located in the Seurojoki river catchment area, which is dominated by northern boreal forests and peatlands with minor agricultural land. The mine area is surrounded by a natural wetland area with 1–2 m thick peat deposits. In some places, there are quaternary, low-permeable sandy and gravelly till deposits. The area is classified as sub-Arctic and the annual mean temperature is − 1 °C. The area is typically covered by snow from October to May. The annual mean precipitation is about 500–600 mm and evaporation 200–300 mm (Turunen et al., 2020). The mining area consists of both open pit mines and underground mines, waste rocks dumps, ore processing and water treatment facilities, general infrastructure (roads and buildings), tailings ponds and several treatment peatlands. Treatment peatlands are natural peatland areas near the mining area that are used to further clean excess mine waste water before it drains in the river system (Yaraghi et al., 2020). The geology in the area is characterised by the Central Lapland Greenstone Belt, which consists of Late Proterozoic mafic volcanic and sedimentary rocks. The bedrock is rich in arsenopyrite, which is associated with the gold mineralisation. As a result, the soils and ground and surface waters have naturally high concentrations of arsenic (As), antimony (Sb) and zinc (Zn) (Yaraghi et al., 2020).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

~~6.4.4.2.~~6.4.5.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Finish municipality of Kittilae.

A. Habitat and landscape

The landscape is locally strongly affected by the construction of the mine infrastructure: the mine covers an area of about 15 km^2 where the original landscape is now replaced by mining infrastructure, such as buildings, ore processing facilities and roads, 2 open pit mines, waste rock dumps, tailings ponds and treatment peatlands. The change of land use from natural forests and peatlands to industrial use does not only have an impact on the landscape, but also on habitat and wildlife behaviour. The Kittilä mine is located in the Reindeer Herding Area in northern Finland and the land use change has impacted the natural migration routes and grazing areas of the reindeer (Solbär & Keskitalo, 2017). The change in land use also caused the loss of threatened peatland habitats, including *Carex heleonastes (lettosara)*.

Part of the treatment of mine waste waters is done through the use of treatment peatlands, using the ability of peatlands to retain toxic heavy metals from polluted waters to help purify the waste water before further discharge into the river systems (Malinen, 2016; Turunen et al., 2020). This leads to an accumulation of heavy metals in the peatlands over time (Baciu et al., 2018), which is likely to affect the peatland habitat quality and ecosystem services, such as food supply for reindeer.

B. Changes in biodiversity

Monitoring programs of the ecological status of the nearby rivers have shown no significant impact on fish fauna or benthos communities, but changes were identified in the diatom communities in the Seurujoki and Loukinen rivers in the first years after the start of the mine. No further changes were identified after these first years, indicating that that the ecological state of the diatoms have balanced to the current state (Baciu et al., 2018).

As mentioned in the previous section, the change in land use has impacted the natural migration routes of reindeer. In addition, an increase in traffic because of the mine operations has led to more collisions with reindeer and other wildlife (Solbär & Keskitalo, 2017).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

C. Pollution

The mine waste water from ore processing and mine drainage contain nitrogen compounds from explosives, antimony, arsenic and metals originating from the ore, as well as fine solid matter and sulphate. The higher sulphate content in the mine drainage water increased the electric conductivity about tenfold compared to natural waters. After the change from open pit to underground operations the amount of solid matter in the drainage waters increased (Malinen 2016). There is a clear impact on the river water quality of the Seurujoki river as result of discharge of mine waste water and drainage waters. This is characterised by elevated metal and metalloid concentrations, especially As and Sb, as well as distinct ion composition in comparison with natural waters (Turunen et al., 2020). Studies by Yaraghi et al. (2020) also showed a clear increase in the concentrations of nitrogen, sulphate and Sb downstream from the mining area. Although the ecological state of the Seurujoki and Loukinen rivers are still considered mostly good, changes in benthos diversity and abundance have been identified. Sulphate, Sb and Ni were shown as the potentially most harmful elements in the mine waste waters that could pose a risk for aquatic ecosystems (Malinen, 2016). Monitoring programs to monitor the load from the Kittilä gold mine drainage waters on the environment are in place as part of the environmental permit.

The use of natural peatlands to treat mine waste waters leads to an accumulation of toxic heavy metals in the peatland, which will decrease the effectiveness of the treatment peatlands over time. The lifetime of treatment peatlands is therefore limited and accumulation can lead to concentrations exceeding guideline values for contaminated soils. Over time there is a risk that the peatlands will become a source of contamination for the adjacent river systems (Malinen, 2016; Yaraghi et al., 2020).

Groundwater is an important component in Arctic rivers, particularly during low-flow conditions. Groundwater monitoring has shown that groundwater in the mining area has increased concentrations of contaminants indicating that mining activities have a clear impact on groundwater quality, although the measured concentrations are still below the maximum permissible concentrations of drinking water. The decrease in quality is restricted to the mining area as groundwater monitoring outside the active mine area show no change in quality (Yaraghi et al., 2020).

~~6.4.4.3.~~6.4.5.3. Conflicts

There are no data available about conflicts

~~6.4.4.4.~~6.4.5.4. Mitigation

There are no data available about mitigation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

~~6.4.4.5.~~6.4.5.5. Ambitions

Company information can provide information about ambitions and the company's self-perception.

According to their homepage Agnico Eagle Finland Oy is a subsidiary of Canadian gold-mining company Agnico Eagle Mines Limited. It owns the Kittila mine and engages actively in mineral exploration in Finland and other Nordic countries. Acquired from Riddarhyttan Resources AB in November 2005, the Kittila mine was Agnico Eagle's first operation outside of Canada. The company provides its shareholders with excellent long term value, while also creating jobs and promoting community well-being wherever we operate, both for the regions and their individual residents.

- Website Agnico Eagle: https://agnicoeagle.fi

~~6.4.4.6.~~6.4.5.6. Perceptions

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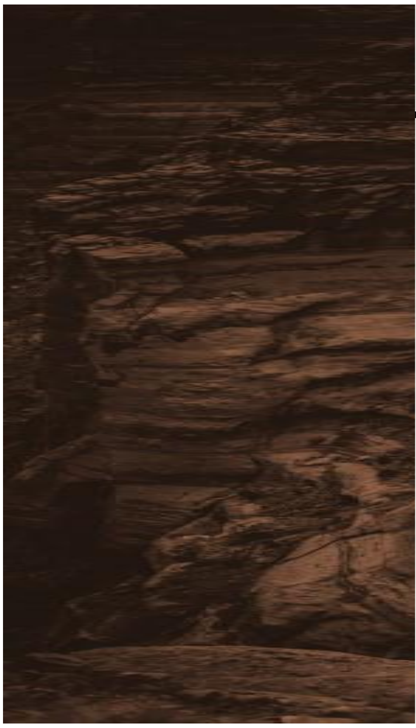
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

~~6.4.5.~~6.4.6. Malå/Kristineberg

Malå town and municipality is located in the county of Västerbotten. The population of the municipality is around 3,000 with 2,000 residing in the town. The size of the municipality is 1,727 km^2 making the population density 2 p/km^2. The Malå hub represents a complex land-use situation where mining, forestry, wind power developments, and infrastructure projects all overlap with the land use needs of Sami reindeer husbandry. Malå is identified as a mining, forestry and indigenous hub. From the forest industry perspective, we have defined the hub by the Setra sawmill located in the town of Malå and its timber procurement area. From the indigenous perspective the Malå hub is defined by Malå forest Reindeer herding community (RHC), covering an area of 7,713 km^2. The western area is used as year around grazing lands and are located in Malå, Sorsele and Lycksele municipalities. Winter grazing lands go all the way to the coast of Bay of Bothnia. The RHC has 100 members and 11 reindeer herding companies. The maximum number of reindeer are set to 4,500. From the mining perspective the hub is defined by the Kristineberg mine with an estimated impact radius of 14km (Figure 65).

Mining and prospecting have a long history in the area. Skelefteåfältet is a sulphide mineral ore rich area discovered in the 1920s and the first mine started in 1924. Since then 28 mines have been operating in the area. Today, there are five active mines, Kristineberg, Petiknäs, Renström, Maurliden and Kankberg. The mining and smelting company Boliden AB (see figure 63 below) owns all mines.



Industrial factsheet **Kristineberg** ~~–~~
Boliden AB mining

Company:	Boliden AB
Ownership:	Swedish mining company and metal producer, operating mine in Sweden, Ireland and Canada as well as smelters in Sweden, Finland and Norway. It was founded in 1931 .
Location:	Located approximately 100 km west of the Boliden Area Operations (“BAO”) Process Plant in Boliden.
Activity:	Produces from polymetallic mineralization of Volcanogenic Hosted Massive Sulfide (VHMS) type; Happens mainly by cut and fill methods
Spatial extent:	Activity is currently taking place in the L-Zone and M-Zone; Mineralization at various levels between900 m and 1250 m depth.
Nat. resources:	Cu and Zn are the main mined metals at The Kristineberg Mine, with Au, Ag and Pb credits
Production:	Around 750,000 tons annually: Largest by volume contributor to the BAO Process Plant
Employment:	No data available

resources-and-reserves-kristineberg -2018-12-31.pdf (boliden.com)

Boliden – company – Store norske leksikon (snl.no)

Figure 63. Industrial factsheet Kristineberg (mining)

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 The same area is part of Malå RHC and has over time led to losses of grazing land from direct impacts from the mines, as well as impacts related roads and mining associated traffic. Malå RHC considers lands in and around the mines Kristineberg, Storliden, Maurliden and Kankberg completely lost. Herder's observations as well as GPS data all indicate reindeer avoidance of areas around the mines. The recent closing of the Maurliden mine offers promising opportunities for restoration of lost grazing lands. On the other hand, the old, closed mines of Näsbergfältet, Rakkejaur and Adakfältet are not yet restored, and are still considered lost grazing lands.

The main mining project and the focus mine in the hub is the Kristineberg mine operated by Boliden AB and established in 1940.

Figure 64. Kristineberg mining site showing the industrial area and the dam. Immediately south of the mining area is the small town of Kristineberg

The mine is located close to the small town of Kristineberg (Figure 64), approximately 16 km SW of the town Malå. The mine is a 1,350 m deep underground mine containing zinc, copper, silver and gold. Prior to the development of the underground mine, the mine operated four small open pit mines. All tailings facilities, apart from one settling pond are closed and have been rehabilitated. The current mining area with mining infrastructure (buildings, roads, settling pond) covers an area of about three

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km². The Rävliden expansion of the mine is currently considered. The mine produced about 520,000 tonnes of mineral ore in 2020. An environmental impact assessment was completed in 2012 and forms the basis for the current environmental permit (Eriksson & Rönnblom-Pärson, 2012). The permit is in accordance with Swedish national environmental legislation and European Union mining regulations (Boliden 2021b). One of the required monitoring programs is the discharge of mine waste water into the river systems (Boliden, 2020).

According to the Boliden summary report (2021b), the Kristineberg mine produces ore from polymetallic mineralization of Volcanogenic Hosted Massive Sulphide type. The mineralization have been explored to a depth of 1,400 m, along a three km plunge between 900 m and 1,250 m depth and takes place mainly by cut and fill methods. The production capacity of the mine is 750,000 tonnes per year making the Kristineberg mine the largest tonnage contributor to the Boliden Area Operations process plant. The expansion mine Rävliden 5 km west of the Kristineberg mine was added to the mine's Mineral Resources in 2015. In 2020, the mine produced 541kt of mineralised material grading 0.6g/t of gold, 45g/t of silver, 0.52% of copper, 5.73% of zink, and 0.34% lead. Since operating started in the 1940 the mine has produced 32.6 Mt of mineralised material in total, with average grades of 1.2g/t gold, 37.8g/t silver, 1% Copper and 3.8% zink.

A considerable additional impact of the actual mining operations, is that all ore is transported by truck to the processing plant at Rönnskärsverken on the coast. The Kristineberg mine is connected to Boliden and Skellefteå to the west by highways 370 and 95. A local all-weather sealed road links the main Malå 370 highway to Kristineberg. Total driving distance between the BAO Processing Plant and the Kristineberg mine is approximately 95 km. This complex land-use situation calls for innovative participatory tools to provide an effective and inclusive dialogue in search of solutions.

~~6.4.5.1.~~6.4.6.1. State of the Art / Environmental background

The establishment of most of the new Swedish mines are planned in the northern part of country, where there are environments with high natural and cultural values, where outdoor recreation is part of the local life style and where there is a long tradition of reindeer husbandry by the Sami people (Ministry of Enterprise and Innovation 2013).

The area around the Kristineberg hub consist of a mosaic of coniferous forests, wetlands and waterbodies of different sizes.

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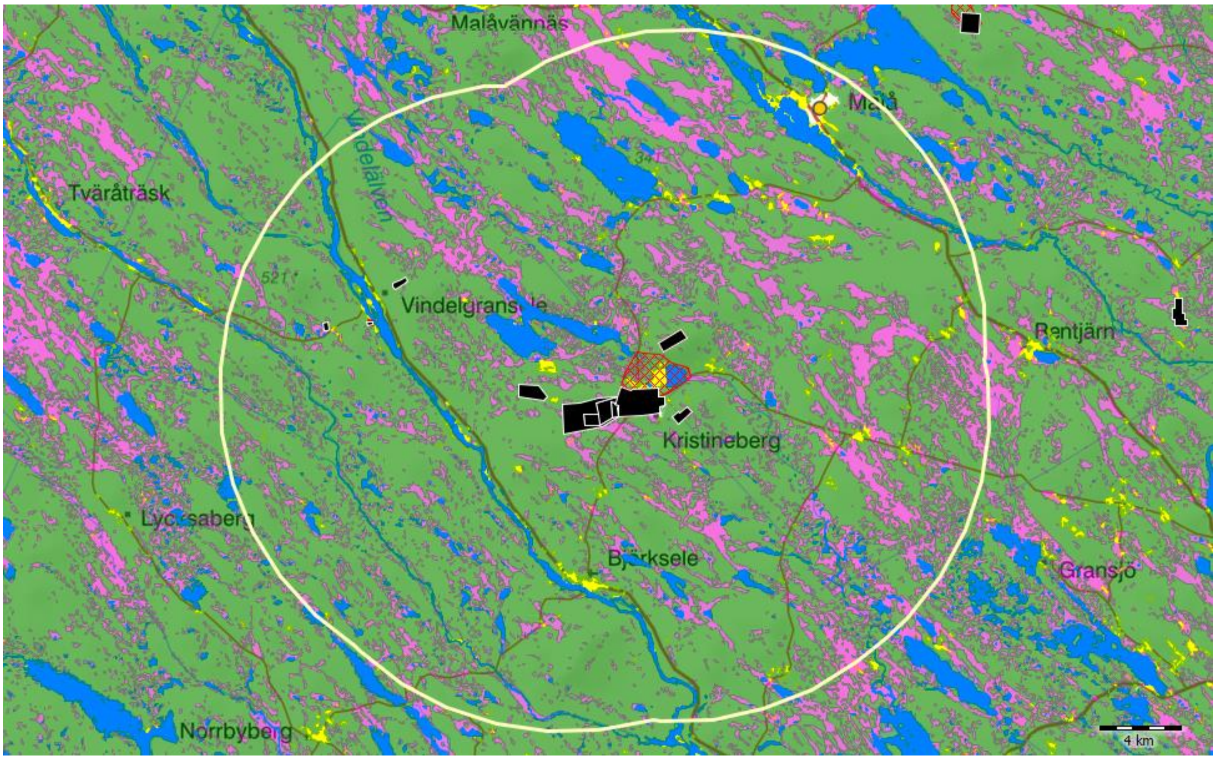

Figure 65. The Kristineberg mining hub. Mining permits are shown in black and the industrial site as a red grid and together form the centre of the hub. A yellow line marks the extension of the hub. Forests are shown in green, wetlands in pink, water in blue and agricultural land inyellow

Minor areas are used for agricultural purposes and includes smaller settlements. The area is mainly used for commercial forestry, reindeer herding and outdoor activities such as hunting and fishing. There are three Nature 2000 reserves with different forest types within about 5 km of the mine (Boliden 2020). Discharge waters from the mining area, including the settling pond drain into the small stream Vormbäcken, which is a tributary to the Vindel River. The latter is a nationally protected river and classed as a Nature 2000 area (Boliden 2021b). The discharge water contains small amounts of zinc, cadmium, copper, arsenic and nitrogen, but the impact on the chemical and biological water quality of the rivers is considered small and newer techniques to further purify the waters prior to discharge are being investigated (Gulkova 2018, Boliden 2020).

~~6.4.5.2.~~6.4.6.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Swedish municipality of Malå.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869580.

A. Habitat and landscape

The change in land use from forests and wetlands to industrial mining results in a direct loss of habitats and also reduced landscape connectivity. The small town of Kristineberg was built to house the work force and adds to the lost habitat area. Kristineberg reached a population peak in the 50s, but then went into decline and over the years many houses has been moved or demolished. In 2015 less than 200 people lived in Kristineberg. However, after Boliden AB announced new investments in the Kristineberg mine, there are signs of potential growth of the town again (SVT 2022). The total impact of the town and mine affects wildlife populations and behaviour, including reindeer migration. In addition to the main mine site and infrastructure, all ore from the Kristineberg mine is transported by truck to the processing plant at Rönnskärsverken on the coast. It is estimated that every day 40-50 trucks are entering and leaving the mining site (Boliden 2021), leading to significant traffic. This creates a barrier effect, which enhances habitat fractionation and limits animal movements. In addition, the truck traffic transporting has increased the risk for wildlife collisions. Further mining related infrastructure developments related to the expansion of the mine will likely intensify the impacts (Boliden 2020).

There are two major waste materials produced during mining, waste rock and tailings (SGU 2022). Waste rock is rock material that must be removed to reach the ore. Waste rock, including large rocks as well as fine materials, are deposited in direct proximity of the mine to avoid transportation costs. Tailings (mineral processing sand) are a waste product from mineral processing where the valuable minerals are separated from their ores. The tailings are mixed with water and the mix, called slurry, is pumped to a constructed dam close to the mine, where the tailings are allowed to sediment (SGU 2022).

The Kristineberg mine reported a total production of 38.15 tonnes of hazardous material in 2021 (SEPA 2022).

According to Boliden AB the noise and vibration disturbances from the mining activities are in accordance with the environmental terms (Boliden 2020).

B. Changes in biodiversity

The effect of mines on the surrounding ecosystems, particulary wild life is not fully understood. A review on the response of reindeer/caribou by Skarin and Åhman (2014) reported a zone of avoidance up to 14 km from mines. However, the reported results are highly dependent on the contextual situation. We have decided to use the higher number recognizing the importance of reindeer as an indicator species for green infrastructure. A 14 km impact zone will also include infrastructure dependent on the mine such as population areas, transportation etc.

C. Pollution

Mining activities cause major incidences of dusting especially during dry periods. Areas adjacent to mines used during the snow free seasons can have significant problems with dusting. A layer of dust will reduce the photosynthetic processes of vegetation (Hassen 2016). Dust on snow on wintering areas reduce the reindeer's ability to smell lichen through the snow cover.

The water used in the mineral processing originates from surrounding lakes or streams. However, a large proportion of the water is recycled or consist of collected rain water.

A major negative impact on the natural environment from mining, in particular mining of metal ores, is related to run-off from mining areas. Even bedrock from the mine deposited in waste rock piles or used in the construction of mine infrastructure, such as roads, often contains elevated levels of sulphate or heavy metals, or nitrogen derived from explosives. Surface run-off transports the contamination into the water systems and increased nitrogen levels may lead to eutrophication (Hassen 2016).

Information on discharge of metals and other compounds to recipients (surrounding natural water) are collected and published by the Svenska miljörapporteringsportalen and discharge information is publicly available at the Swedish Environmental Protection Agency (SEPA 2022). The general trend is that the discharge of metals has decreased over time due to stricter legislation and more efficient industry processes (SGU 2022). The data reported from the Kristineberg mine in 2021 (SEPA 2022) are listed in table 17.

Table 17. Compounds released into the water from the Kristineberg mine 2021.

Pollutant	Released into the water (kg)
As	2.67
Cd	2.32
Cu	16.35
Hg	0.03
N-tot	10,694
Pb	0.77
Zn	223.9

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There are no report on the emissions into the air in the SEPA database. However, in a recent report Boliden AB reports that there are emissions of CO_2, NO_2 and SO_2 from the industrial site. These emissions mainly originate from the diesel engines involved in the loading and transportation processes. Other sources are the heating of the mine air in the winter and heating of some facilities using fossil fuels. Blasting is also a source of gas emission (Boliden 2020).

~~6.4.5.3.~~6.4.6.3. Conflicts

There is currently no data about conflicts available

~~6.4.5.4.~~6.4.6.4. Mitigation

There is currently no data about mitigation available

~~6.4.5.5.~~6.4.6.5. Ambitions

Only databases common for all Swedish hubs available.

~~6.4.5.6.~~6.4.6.6. Perceptions

Only databases common for all Swedish hubs available.

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Skarin, A. and Åhman, B. (2014). Do human activity and infrastructure disturb domesticated reindeer? The need for the reindeer's perspective. Polar Biology, 1–14. https://doi.org/10.1007/s0030001414995

SVT 2022. https://www.svt.se/nyheter/lokalt/vasterbotten/efter-50-ar-av-rivningar-nu-byggs-nytt-i-kriberg

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~~6.4.6.~~6.4.7. Gällivare

The Gällivare hub area defined by the municipality boundaries is dominated by the mining industry. Gällivare is also defined as an indigenous and forestry hub. There are 10,500 people living in the town of Gällivare and 17,500 living in the municipality. With a municipality size of 16,800 km^2 the population density is 1 p/km^2. Gällivare is also part of the traditional lands of Sami people and the town of Gällivare is the meeting point of the four reindeer herding communities of Gällivare, Girjas, Baste Čearru, and Unna Tjerusj.

Two major mines are located in or near the town of Gällivare also making the area a hub for mining activities. The Malmberget iron mine operated by LKAB is located directly in the north end of Gällivare (Figure 66).

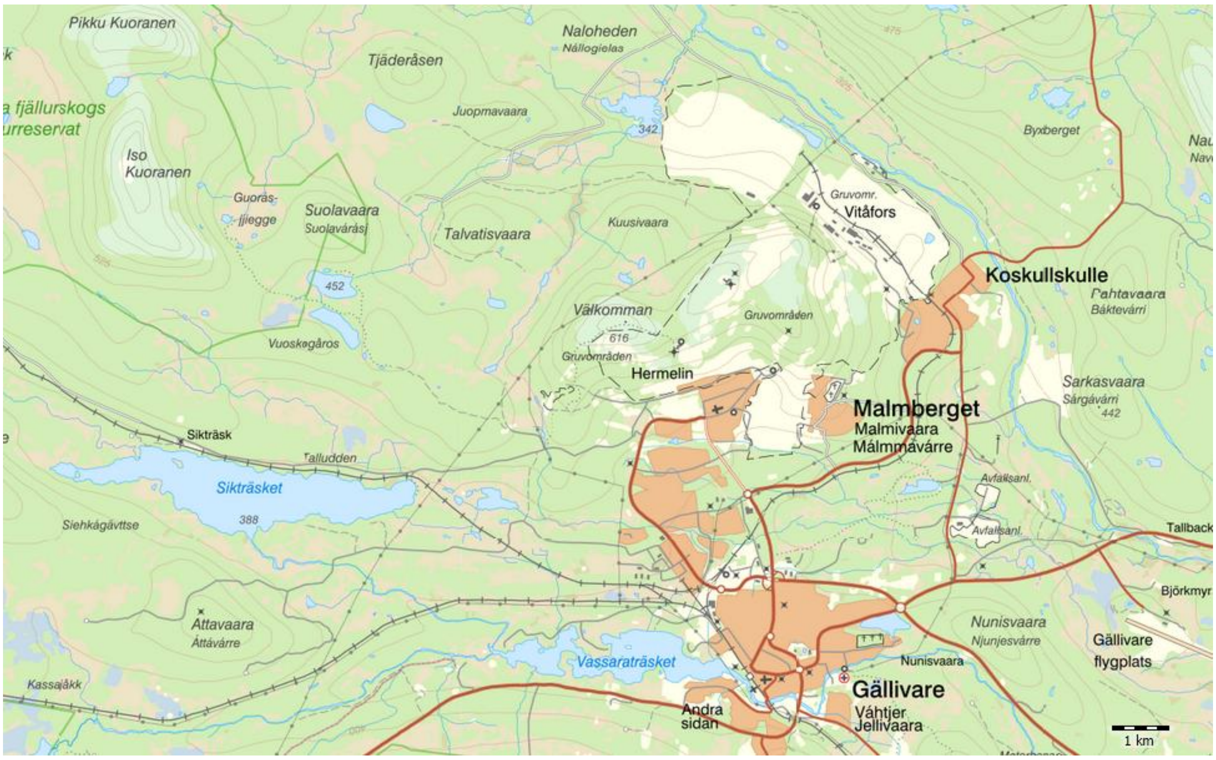

Figure 66. The Malmberget mine north of Gällivare. The mining area is shown in light yellow (Gruvomr./gruvområden in Swedish).

Malmberget has been in operation since the 1700s and lay the grounds for the establishment of Gällivare as a town on lands, until then primarily used by the Sami. Currently, this mine is expanding into urban area (LKAB 2022). Whole neighborhoods are being torn down and residents are forced to relocate. Part of the future plans for the Malmberget mine include the major establishment of the HYBRIT and the first fossil free steel production system in the world. A demonstration site for fossil

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free production of direct reduced iron (sponge iron) will be established in Gällivare at the LKAB mining site Malmberget. The plant should be completed in 2026 and produce 1.3 million tonnes of direct reduced iron. By 2030 the production should be increased to 2.7 million tonnes per year. To provide energy for the project, Vattenfall AB will construct the world’s largest site for production of hydrogen gas also in Gällivare. The site is located within the lands of Baste Čearru. Much additional press and documentation exists for this project. Further south in Norra Svartbyn near Boden but also on the lands of Gällivare RHC the The Swedish company H2GS AB (a project named H2 Green Steel) plans to establish another steel plant based in hydrogen gas with plans to start production in 2024. On the south side of Gällivare, Boliden AB operates the Aitik mine and processing plant, established in 1968 (Figure 67).

Figure 67. The Aitik mine south east of Gällivare. The mining area are shown in light yellow and immediately on the right is the tailings dam (slamdamm).

Today, mining is carried out in two open pits (Aitik and Salmijärvi) and the ore is processed in an adjacent advanced and effective equipment enrichment plants for crushing and sorting minerals. This efficiency of the plant has made it possible to also explore adjacent mining sites. From processing plant the metal concentrate is transported on railway to Boliden Mineral AB’s smelter, Rönnskärsverken, in

Skelleftehamn where final products of copper, gold and silver are produced. The industrial factsheet for Gaellivare (figure 68) sums up some facts about the leading mining companies in the area.

Industrial factsheet Gaellivare – *LKAB* and *Boliden AB mining*

Company:	LKAB
Ownership:	Swedish (state-owned)
Location:	LKAB is Europe's largest iron ore producer. Its core product is mined in Malmberg (Gaellivare) and Kiruna. It is shipped out to the rest of the world from Narvik and Luleå.
Production:	LKAB mines 80% of all iron ore in the EU
Employment expected:	4500 employees in total (no data about Malmberg)

Company:	Boliden AB
Ownership:	Swedish mining company and metal producer
Location:	The Aitik mine is located south-east of Gällivare and is the largest open pit copper mine in Europe covering an area of approximately 50 km^2
Production:	Mainly copper, but also gold and silver
Employment expected:	770 employees at Aitik mine

What we do – LKAB LKAB – Store norske leksikon (snl.no)

Figure 68. Industrial factsheet Gaellivare (mining)

The Aitik mine has grown into the largest open pit copper mine in Europe covering an area of approximately 50 km^2. The mining area also includes the open pit mine Salmijärvi, waste rock and overburden dumps, maintenance and office facilites, a concentrator plant, a large tailings magazine, and a rail transport terminal (Boliden 2021a). The Aitik mine is mainly producing copper, but also gold and silver. The Aitik mine employs 770 people and many more are employed in jobs related to the mine. Aitik is expected to be in operation until 2029 but a number of expansions of the existing mine are planned and proposed which is expected to prolong operations with the Liikavaara expansion being first in line. This proposal calls for an open pit mine with the copper ore being transported to the near Aitik processing plant. To secure this project Boliden AB purchased properties in the two villages of Sakajärvi and Liikavaara. The mine will have significant additional impact on reindeer husbandry in Gällivare RHC in terms of additional habitat loss and increased fragmentation of grazing lands. Several

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EIS-reports and court documents exist for the project. An additional proposed expansion of the overall Aitik operation include the underground Nautanen mine located within the lands of Baste Čearru.

The Gällivare area is part of the traditional lands of Sami people in the greater Sapmi land area. Gällivare RHC is a forest sameby covering 8,321 km^2 spanning from the town of Gällivare in the north to the islands and coastline of the Bay of Bothnia in the south. Gällivare is part of the Lule Sami area. The highest allowed number of reindeer in winter is set to 7,000. There are 35 active reindeer companies in the RHC. The RHC is loosely divided into a number of different groups. The Nordvall, or the Purnu, group is managed as its own group and use the area around the Aitik mine during the entire grazing year (Figure 69). The Europa highway E10 that runs through the wintering area of Gällivare RHC and the railway line forming the western boundary of the RHC lead to significant reindeer mortalities.

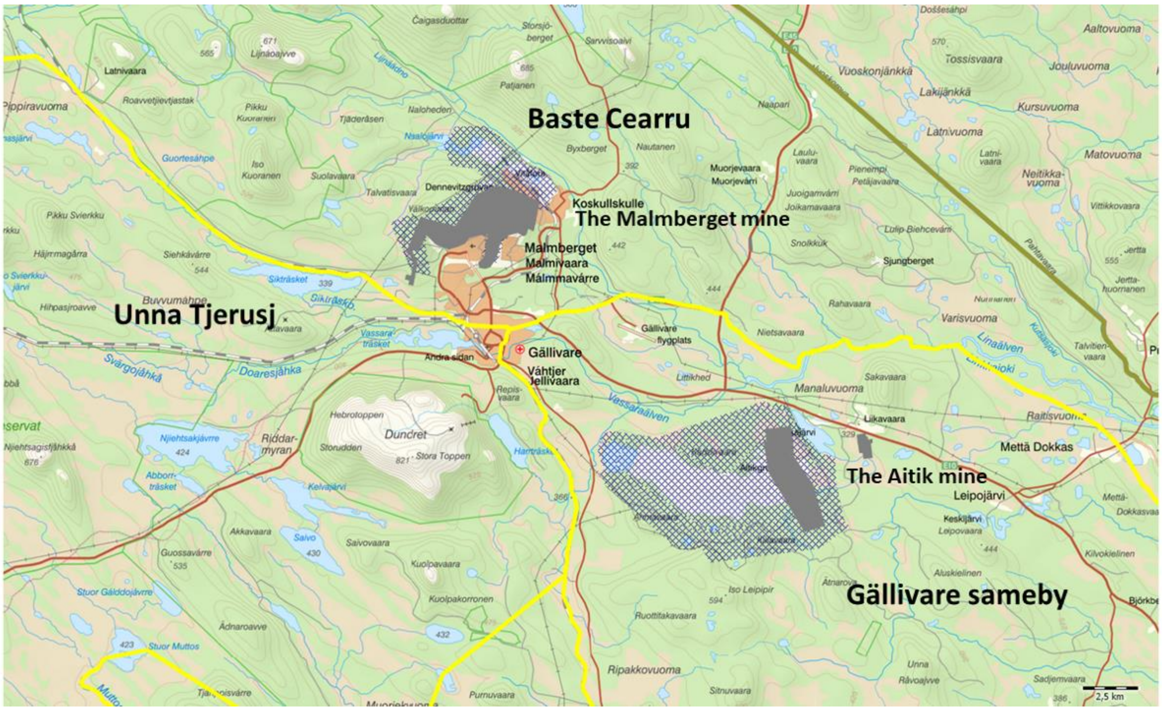

Figure 69. The town of Gällivare is located between the LKAB operated mine Malmberget and the Boliden AB operated mine Aitik. Gällivare is also the meeting point of the three RHCs Gällivare, Baste Čearru, Unna Tjerusj

Prior to the mining époque, all areas were traditional grazing lands for reindeer. Today the RHCs attempts to use all areas around the mines as pastures for reindeer during all grazing seasons.

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~~6.4.6.1.~~6.4.7.1. State of the Art / Environmental background

The area around the Malmberget and Aitik mines mainly consist of a mosaic of coniferous forests, wetlands and waterbodies of different sizes, but also include smaller mountainous regions above the tree limit as well as alpine birch forests (Figure 70). The forests often include areas with high natural conservation values and the surface waters are to a large extent declared as Nature 2000 areas due to their high conservation values (Boliden 2021a).

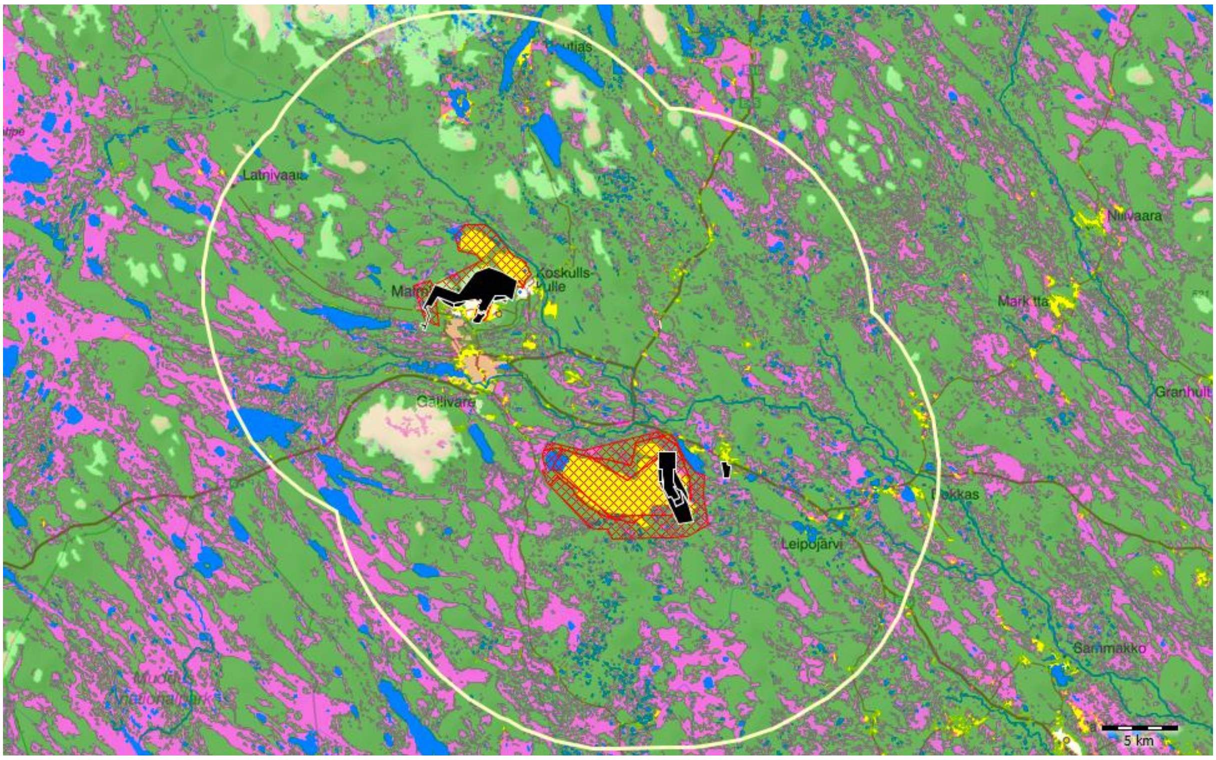

Figure 70. The Gällivare hub. Mining permits are shown in black and the industrial site as a red grid and together form the centre of the hub. A yellow line marks the extension of the hub. Forests are shown in green, wetlands in pink, water in blue and agricultural land in yellow

The hub aree consist of the major population concentrations of Gällivare and Malmberget as well as several smaller towns and villages. There are also some agricultural areas in the hub. The area are mainly used for commercial forestry, reindeer herding and outdoor activities such as hunting, fishing, berry picking and recreation (Boliden 2021a).

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~~6.4.6.2.~~6.4.7.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Swedish municipality of Gällivare.

A. Habitat and landscape

The change in land use from forests and wetlands to industrial mining results in a direct loss of habitats and also reduced landscape connectivity. Both the Malmberget mine and the Aitik mine take up considerable areas where the original natural environment has been completely destroyed. This in turn affects wildlife populations and behaviour, including reindeer migration, and has resulted in a loss of reindeer grazing land. Both the main mining areas and related road infrastructures create a barrier effect which enhances habitat fractionation and limits animal movements. In addition, the significant truck traffic transporting has increased the risk for wildlife collisions. Further mining related infrastructure developments related to the expansion of the mine will likely intensify the impacts.

There are two major waste materials produced during mining, waste rock and tailings. The Malmberget mine reported a production of 332 tonnes of hazardous material and 8,988 tonnes of non-hazardous material in total 2021. The Aitik mine reported a production of 1,592 tonnes of hazardous material in total 2021, of which 672 tonnes were recycled. The same year the mine also reported a production of 9,251 tonnes of non-hazardous material of which 4,317 tonnes were recycled.

Vibration measurements and air shock measurements are continuously performed around Aitik. The measurement results are within the current limit value.

B. Changes in biodiversity

Mining activities cause incidences of dusting especially during dry periods; in particular the open pit mine Aitik has major incidences of dusting. This is a problem also reported in the local media (NSD 2018). The area to the south of the Aitik mine, which is used for reindeer grazing during snow free seasons, suffers specific periods with problems with dusting. The area to the north of the Aitik mine is used for winter grazing and dust on snow reduces the reindeer's ability to smell lichen through the snow cover. A layer of dust will also reduce the photosynthetic processes of vegetation (Hassen, 2016). Boliden AB has measured dust levels from the industrial site and concluded that the levels are within the limits stated in the permit (Boliden 2018). However, they noted higher dust levels east of the mine, which is expected given that the wind direction is predominantly west to east.

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C. Pollution

In 2021 the Malmberget mine reported CO_2 emissions of 104,466 tonnes of which 63% originated from a fossil source. The same year the Aitik mine reported CO_2 emissions of 76,756 tonnes, all of which originated from a fossil source. In 2021 the Aitik mine also reported CO emissions of 371 tonnes (SEPA 2022). Other emissions reported in 2021 from the Malmberget mine are listed in table 18.

Table 18. Reported emissions into the air from the Malmberget mine in 2021. The Aitik mine only reported emissions of 25,334 kg of NOx (nitrogen oxides) from that year

Pollutant	Emission into the air (kg)
As	10.5
Cd	1.09
Cl2, unorg-HCl	14,357
Cr	188.95
Cu	21.06
DX-ITEQ	0.00024
F2, unorg-HF	11,204
Hg	15.41
NH3	1,249
Ni	124.24
NOx	1,937,898
Pb	25.5
PM10	86,190

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SOx	200,913
Zn	193

In 2021 the Malmberget mine reported 86,190 kg of emitted dust particles. No data were reported from the Aitik mine (SEPA 2022).

The reported amount of metals and other compunds released into the water 2021 are listed in table 19 and 20 for Malmberget and Aitik respectively.

Table 19. Reported compounds released into the water from the Malmberget mine in 2021

Pollutant	Released into the water (kg)
As	12
F-tot	9,989
Ni	82.3
N-tot	314,652
P-tot	411
Zn	15.4

Table 20. Reported compounds released into the water from the Aitik mine in 2021

Pollutant	Released into the water (kg)
As	3
BOD7	36,363
Cd	0.15

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Cl-tot	535,140
Cr	0.75
Cu	17
Hg	0.007
NH4-N	4,544
Ni	14
N-tot	61,397
Pb	0.27
P-tot	25
TOC	28,489
Zn	203

~~6.4.6.3.~~6.4.7.3. Conflicts

There are currently no specific data about conflicts available

~~6.4.6.4.~~6.4.7.4. Mitigation

There is currently no data about mitigation available

~~6.4.6.5.~~6.4.7.5. Ambitions

Only databases common for all Swedish hubs available.

~~6.4.6.6.~~6.4.7.6. Perceptions

Only databases common for all Swedish hubs available.

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Skarin, A. and Åhman, B. (2014). Do human activity and infrastructure disturb domesticated reindeer? The need for the reindeer's perspective. Polar Biology, 1–14. https://doi.org/10.1007/s0030001414995

SVT 2022. https://www.svt.se/nyheter/lokalt/vasterbotten/efter-50-ar-av-rivningar-nu-byggs-nytt-i-kriberg

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~~6.4.7.~~6.4.8. Kvalsund-Kautokeino

The former Kvalsund municipality has now been part of Hammerfest municipality since 2020 and is located around the fjords Repparfjorden and Kvalsundet, 20-30 km south of Hammerfest (figure 71). Kvalsund is a traditional sea Sámi community where both reindeer husbandry and traditional fishing are important. Kvalsund has a need for more local employment opportunities as young people are leaving the area (Nygaard et al., 2017).

The mountains around Repparfjorden hold some of the largest known copper deposits in Norway, including the Ulveryggen and Nussir deposits (Vieth Rør, 2018). The Ulveryggen copper deposit was mined by the company Folldal Verk AS in several open pits between 1972 and 1978. During the operation of the mine, the mine tailings were deposited as a series of cone-shaped mounds in the inner part of Repparfjorden; the original shape still remained after 40 years (Andersson et al., 2018).

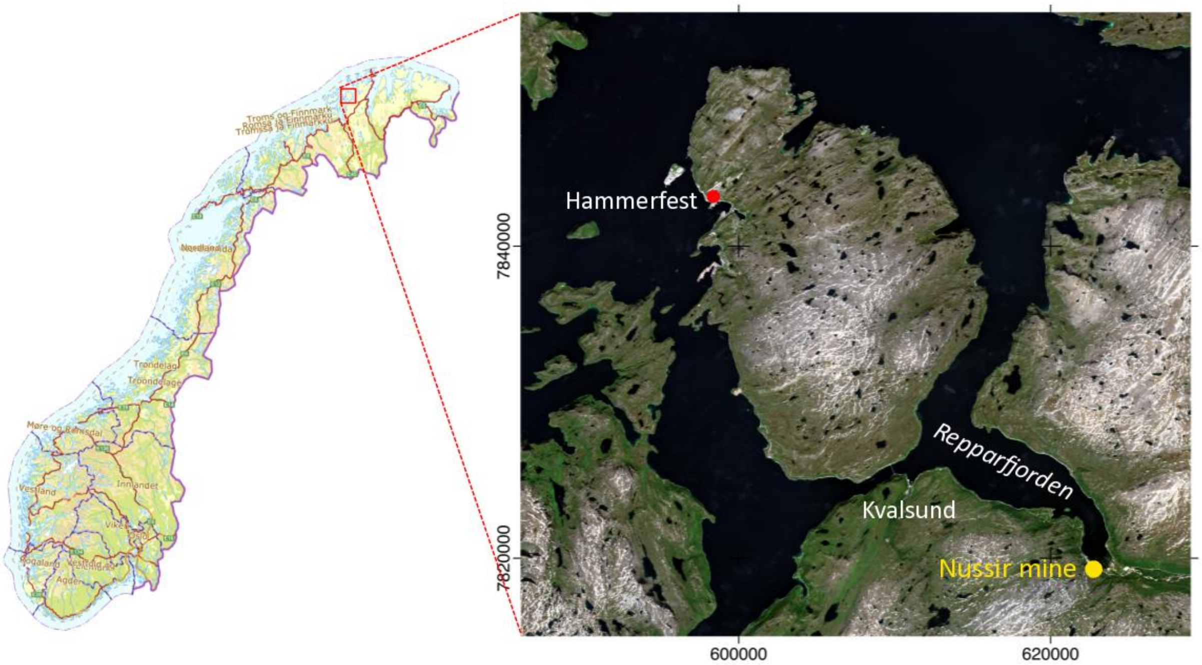

Figure 71. Sentinel-2 satellite image giving an overview of the area around the planned Nussir mine. Norway map on the left from http://kilden.nibio.no

The Norwegian (with international investors) company Nussir ASA[64] has been planning to open a new copper mine at the location of the original mine since 2005 and mine both Ulveryggen and Nussir deposits. The expected lifetime of the new mine is 25-30 years with expected employment of 150 man-years. The total amount of copper ore reserves in the Ulveryggen and Nussir deposits is estimated to

[64] https://nussir.no/

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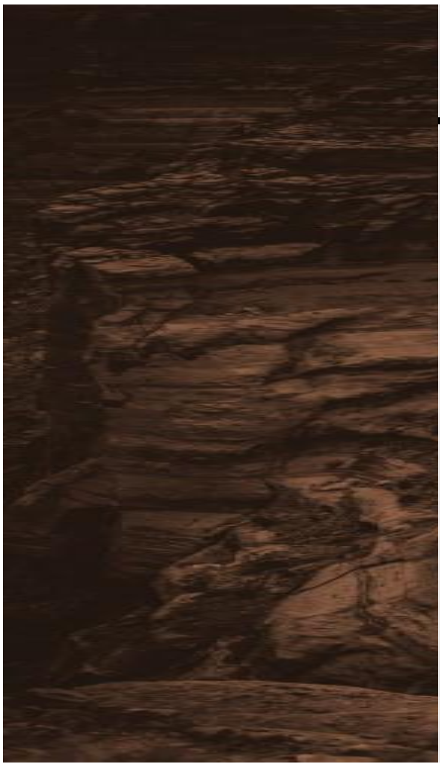
be 25 million tonnes, which can produce ca 185000 tonnes copper and additional gold and silver. Expected production is 25000 tonnes per year Cu equivalent. Nussir has tailings permit to deposit 2 million tonnes of tailings per year, up to 25 million m^3 tailings in total in a submarine deposit in Repparfjorden[65]. The permit allows up to 500000 m^3 of host rock to be deposited on land[66]. The total mining area in the zoning plan covers 63 km^2, of which 25 km^2 on land and 36 km^2 in Repparfjorden. The mine is planned as an underground mine utilising existing infrastructure, but some new infrastructure, including new harbour facilities will be constructed. The mine is also planned to be a fully electric, zero emissions mine. Nussir received an operating license from the Government in 2019, supported by the local council, but conflicts with Sámi organisations, environmental NGOs and other user groups over the impact on reindeer husbandry and the use of submarine mine tailings have so far blocked the start-up of the mining operations.



Industrial factsheet **Kautokeino** – *Nussir mining*

Company:	Nussir ASA
Ownership:	Regional/local
Location:	Repparfjord, Hammerfest kommune
Activity:	Planned copper mining with gold and silver as by-products, mostly underground, with sea tailings in Repparfjord
Spatial extent	Spatial extent: total 37.6 km2, of which ca 16.6 km2 on land and 21 km2 in Repparfjord
Nat. resources:	expected 80 million tons copper ore, 25 million m3 rock excavated over 25-30 years, 550000 m3 per year
Production:	20000 tpa average annual CuEq production
Employment:	150 man-years

Figure 72. Industrial factsheet Kautokeino (mining)

[65] Det Kongelige Nærings-og Fiskeridepartement 14.02.2019: Vedtak om driftskonsesjon for Nussir og Ulveryggen kobberforekomst. Tiltakshaver: Nussir ASA.
66 Miljødirektoratet, 15.01.2016. Oversendelse av tillatelse til virksomhet etter forurensningsloven - Nussir ASA. Miljødirektoratet 2016/398.

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Kautokeino is the Sámi “capital” of Norway with 95 % of its population indigenous Sámi, being one of only two municipalities where the Sámi people are in majority. Reindeer herding is the main industry as well as a strong public sector with several Sámi institutions. The trekking patterns to the coast and other municipalities implies that land use changes in these areas touch Sámi reindeer herding. Kvalsund is used as spring, summer and autumn pastures for reindeer husbandry, some of them with winter pastures in Kautokeino. The planned mining operations are located in the reindeer herding district 22 Fiettar, who use the area for spring, summer and autumn grazing from May to October, as well as calving. In addition, reindeer district 20 Fálá uses the area to migrate to their summer grazing land on Kvaløya (Eira et al., 2020).

~~6.4.7.1.~~6.4.8.1. State of the Art / Environmental background

The landscape in the Kvalsund area is a glacial landscape and classified as open fjord landscape with spread housing along the coast and hilly mountain landscape dominated by rocky outcrops and sparse vegetation (mountain wetlands, heathland, mountain grassland) higher up. According to the CORINE landcover maps from 2018, the area is dominated by moors and heathland (code 322), sparsely vegetated areas (333) and bare rocks (332), with broad-leaved forests (311) and agriculture (243) along the coast. No changes have been mapped between 2000-2018[67]. Repparfjorden is about 12 km long and 1.5 to 4 km wide. The Repparfjord river flows via a delta into Repparfjorden in the southeastern end of the fjord. The climate in the region is subarctic, with an average summer and winter temperature in the area of 10°C and -5°C, respectively, and the fjord is mostly ice-free (Pedersen et al., 2018).

Repparfjorden and Repparfjord river are designated National Salmon Fjord and National Salmon River and are of great importance for the wild salmon population[68] (Urke et al., 2011). Repparfjorden is also a spawning ground for cod (van Meeren & Fosså, 2017). The inner part of Repparfjorden and the delta from Repparfjordelva are one of the most important localities for migratory birds in Hammerfest municipality and are therefore important areas for biodiversity. This area includes various nature types such as fresh water, brackish water, mudflats, glacial/fluvial gravel deposits, birch forest, grasslands and open coastal heathland. The area is used by many bird species, including a number of threatened species, and the delta is home to a small colony of harbour seals. In addition, otters, a threatened

[67] http://kilden.nibio.no; http://www.naturbase.no

[68] https://www.regjeringen.no/contentassets/0cd46706c4544870a2579212d980726e/no/pdfs/stp200620070032000dddpdfs.pdf

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species, are reported from several localities in Repparfjorden and lakes in the surrounding mountains[69].

The geology is characterised by Paleoproterozoic greenstone belt consisting of mafic volcanic rocks and carbonate-siliciclastic rocks, including dolomites. The region contains several Cu deposits both in the volcanic and the carbonate-siliciclastic rocks. The main Cu sulphides in Nussir and Ulveryggen are chalcopyrite and bornite, which contain low amounts of potentially toxic elements, reducing the threat to the environment. The Ulverygen deposit is low in carbonate which limits the formation of soluble Cu-carbonates. The Nussir deposit, however, is hosted by dolomites, which may lead to a higher solubility of copper in certain conditions (Mun et al., 2020).

As mentioned in the previous section, the Nussir area and surrounding areas are used as calving grounds and spring to autumn grazing areas by the 22 Fiettar reindeer herding district, and as migration routes by the 20 Fálá reindeer herding district. One of the migration routes crosses the planned mining area and existing mining roads near the coast.

~~6.4.7.2.~~6.4.8.2. Environmental impacts

The following environmental impacts are based on the mining industry operating in the Norwegian hub of Kvalsund municipality of Gällivare.

A. Habitat and landscape

The main impacts from the mining activities on habitat and landscape will be from the submarine mine tailings in Repparfjorden, infrastructure development on land, in particular the development of new harbour and processing facilities at Markoppneset, and the deposition of waste rock in land deposits.

The construction of new facilities at Markoppneset will have a major impact on the landscape and will include the removal of all vegetation and, therefore, the loss of habitat for a variety of plants, birds and other animals and the loss of reindeer grazing land. It will also have a visual impact for the local residents and recreational users[70]. The area was, however, already regulated as an industrial area and another company, Horisont energi[71], is planning to build an ammonia factory in the same area. Even though the mine will be underground, the construction of a new mine entrance for the Nussir ore

[69] http://www.naturbase.no ; http://artsdatabanken.no ; Hammerfest Kommune, 23.06.2020. Kommuneplanens arealdel for Hammerfest 2020-2032. Planbeskrivelse, Planens ID: 5406-20170003.

[70] Naturvernforbundet 24.11.2021: Nussir ASAs anleggsarbeid på Markoppneset

[71] https://www.horisontenergi.no/

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deposit, planned waste rock deposits and traffic will alter the landscape and impact migration routes for reindeer.

The submarine mine tailings will have a direct impact on the submarine habitat and landscape by physical smothering of the seafloor and benthic organisms, which changes the seafloor topography and bottom sediment characteristics.

B. Changes in biodiversity

The main impact of the mine on biodiversity is likely from the submarine mine tailings. In the deposition area, the benthic organisms will be smothered and it is likely that both the population abundances and species diversity will decrease significantly in the deposition area (Ramirez-Llodra et al., 2015). In the longer term, species composition may change as more tolerant species become dominant. Studies in Bøkfjorden have shown that bentic species will likely return after the discharge of mine tailings is discontinued (see Varangerfjord chapter), although potential toxic effects from the leaching of copper or chemicals could affect species on a longer term. The tailings plume with suspended fine particles can have an effect on fish populations. Some fish avoid turbid waters, changing their migration routes, and fish may ingest and potential bioaccumulate chemicals or metals dissolved in the water (Ramirez-Llodra et al., 2015). The spawning area for cod partially overlaps the area where the submarine mine tailings will be deposited. According to local fishermen, cod left the spawning area when mine tailings were deposited in Repparfjorden in the 1970's. The volume of planned mine tailings is significantly large than in the 1970's and a similar impact is expected (Fosså et al., 2011). Another concern is the effect of suspended particles on the fish eggs. A laboratory study found that a significant amount of particles attached to fish eggs that were exposed to suspended mine tailings. However, they found no or very limited effect on embryo and larval mortality and no differences on the timing of hatching or abnormalities (Reinardy et al., 2018).

As Repparfjorden and Repparfjordelva are National Salmon Fjord and River, it is important to identify the impact on salmon. Investigations have shown that young salmon migrate relatively quickly through Repparfjorden, so they will only be briefly exposed to potential contamination from the mine tailings. There is, however, no data on the behaviour of older returning salmon, which are expected to spend a longer time in the fjord (Fosså et al., 2011).

The mining activities will also have a local impact on the terrestrial biodiversity. As mentioned in the previous section, the construction of new harbour and processing facilities on Markoppneset will have a strong impact on the biodiversity in this area. In addition, traffic and the disposal of waste rock is likely to disturb both reindeer grazing as well as other animals using the area[72].

[72] Naturvernforbundet 24.11.2021: Nussir ASAs anleggsarbeid på Markoppneset

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C. Pollution

As result of the new interest in reopening the mine, several studies were carried out to investigate the long term impact of the existing submarine mine tailings (Sternal et al., 2017; Andersson et al., 2018; Pedersen et al., 2018; Reinardy et al., 2019; Mun et al., 2020). The mine tailings that were deposited between 1972 and 1978 in the inner part of Repparfjord remained in place for 40 years. The tailings are present as a 9 cm thick layer enriched in Cu, Fe, Ni, Cr and Ba, 3-9 cm below the current seafloor surface (Sternal et al., 2017; Mun et al., 2020). High concentrations of Ni and Cr are typical also for natural sediments in the area. It is shown that less than 5% of the Cu in the original mine tailings has dispersed to the outer fjord. However, the majority of the Cu in the tailings is bound to potential bioavailable fractions and may get released in the water column or taken up in benthic organisms, although the surface sediments do currently not pose a risk to the marine environment (Pedersen et al., 2018). Concentrations of Pb, Zn, As, Hg, Cd in the mine tailings are similar to those found in river sediments (Mun et al., 2020).

An ecotoxicology study investigating the effect of the process chemicals that will be discharged with the mine tailings found that the chemicals have no toxic effect on algae, but that high concentrations caused mortality of copepods *Tisbe battagliai* and polychaetes *A. Marina*. This indicates that there may be some impact on the environment when mine tailings are discharged at maximum concentration (Lillicrap et al., 2011).

In addition to chemicals and higher metal concentrations, the mine tailings could also contain microplastics. An ecotoxicological study investigating the effect of both Cu and microplastics from the mine tailings on blue mussels *Mytilus edulis* found no significant effect on Cu accumulation and no significant combined effect of Cu and microplastics. It is noted, however, that the exposure time in the study was short and that longer exposure times may give a different result (Okyere, 2020).

Noise and airpollution (dust) is considered to be a minor issue as most of the mining activities are underground and all vehicles electric. Possible pollution from land deposits, such as acid mine drainage, is also considered to be low.

~~6.4.7.3.~~6.4.8.3. Conflicts

As mentioned in the introduction, there are conflicts with the reindeer herding districts over the loss of grazing and calving land and disturbance of the reindeer. The reindeer herding districts experience increasing impacts on their livelihood through reduction and fractionation of grazing land and disturbances to the migration routes by industrial and recreational developments and activities such as windfarms, hut villages, snow scooter løypes and roads and powerlines. The combined impact of this is affecting the indigenous livelihood (Eira et al., 2020).

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Nature conservation groups including Naturvernforbundet and fishing organisations, including the Institute of Marine Research (IMR) are strongly against the use of submarine mine tailings and the new construction of facilities on Markoppneset. They are worried about the impact on fish behaviour and populations, including salmon, and the traditional fishing culture in the area (Vieth Rør, 2018).

~~6.4.7.4.~~6.4.8.4. Mitigation

Nussir ASA[73] proposed as number of mitigation measures. The mine is planned to be fully electric with zero emissions. Mining activities will take into account the presence of reindeer by reducing mining activities when reindeer are using the area for grazing or calving in spring and autumn. In the later stages of the mine, waste rock will be used for backfilling to reduce the amount of waste rock deposited in land deposits. The land deposits will be rehabilitated after closure.

~~6.4.7.5.~~6.4.8.5. Ambitions

Company information can provide information about ambitions and the company's self-perception.

According to their homepage, Nussir ASA was formed in 2005 and is registered in Hammerfest municipality in Troms and Finnmark county. The two orebodies that comprise the copper project, Nussir and Ulveryggen, are about 4 km apart from each other, located in Hammerfest municipality, adjacent to the regional road and the Repparfjord. The company's objective is to now build the most environmentally acceptable mine in the world, powered entirely by renewable energy. Nussir wants to be an active contributor to the local community and in line with the company's principles on environmental protection and social engagement, the company enabled local stakeholders to choose themselves the consultants that were to perform the Environmental and Social Impact Assessments (ESIAs). The company will continue this approach through the mine's construction and operation, using a similar committee of local stakeholders to oversee the monitoring of environmental impacts and to ensure the mine is developed in a way that, to the best extent possible, has a net positive impact on the local community.

- Nussir website: https://nussir.no/

~~6.4.7.6.~~6.4.8.6. Perceptions

Case assessment documents, in Norwegian:

- Assessment of complaints against operating license by the Ministry of Trade, Industry and Fisheries: Klage over Nærings- og fiskeridepartementets vedtak 14. Februar 2019 om tildeling

[73] https://nussir.no/

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av driftskonsesjon til Nussir for utvinning av Repparfjord kobberforekomst. Sak 19/5729, 29. november 2019. (There is no web link provided)

- Assessment of 'reguleringsplan Nussir – med konsekvensutredning' by Utviklingsvalget: Saksprotokoll: reguleringsplan Nussir – med konsekvensutredning. Arkivsak 10/53. 30-06-2011. (There is no web link provided)

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6.5. Indigenous

ArcticHubs includes 6 indigenous hubs in 4 countries: Finland, Sweden, Norway and Greenland. The indigenous hubs in Sweden and Norway are co-located with mining hubs, and in Sweden also with forestry hubs, while the indigenous hubs in Finland and Greenland are co-located with tourism hubs. The data collected for the indigenous hubs consists partly from meetings and workshops with participating reindeer herding communiteis, but also from scientific research papers investigating different types of environmental impact from local industrial activities and transport infrastructure on the indigenous lifestyle, what measures can be taken to reduce these impacts and improve co-existence of industrial activities and indigenous lifestyle, and the environmental impact of indigenous activities. Other data includes national databases which contain a wealth of historical and current information on landcover/land use and changes in the past decades, reindeer husbandry and statistical information of various activities, newspaper articles and an application for whale protection.

The indigenous hubs in Finland, Sweden and Norway are all characterized by traditional Sami reindeer herding activities. Reindeer husbandry is affected by the environmental impacts of industrial activities in the area as these activities impact the grazing lands and migration routes for the reindeer. Areas that were traditionally used become more fragmented by transport infrastructure (roads, railways, powerlines), habitats are lost as result of mining activities (e.g., large open pit mines and land deposits in Sweden), food supplies are diminished as result of forestry practices (old growth forests are replaced by more dense managed forests) (Kivinen et al. 2010, Sandström et al. 2016, Turunen et al. 2020), and reindeer are disturbed by tourist activities (e.g. snow scooters) and windmill parks (Skarin et al. 2015, 2018, 2021). The combined effect of these environmental impacts from nearby industrial activities also limits their ability to adapt to the effects of climate change. On the other hand, reindeer husbandry has an impact on the environment itself as well: overgrazing has had an impact on the Arctic vegetation, predator control affects predator populations, and there is an increase in off road motorized traffic and vehicle tracks in wilderness areas. On the side of reindeer herding activities, the indigenous hub in Finland, Inari, is characterized also on the traditional fishing. The indigenous hub in Greenland is characterized by Inuit hunting and fishing and the Inuit livelihood in generel. Here, tourism activities can disturb Arctic wildlife and traditional whale and reindeer hunting, fishing and the Inuit culture in general. Also, proposed mining activities are expected to have impacts on the Inuit hunting and fishing and Inuit culture in general.

At the same time, different mitigation efforts are in place or are being investigated to reduce environmental impacts and conflicts with indigenous hubs. These include e.g., the development of more sustainable forestry management practices (lean forestry, promoting lichen growth), rehabilitations of abandoned mining and forestry areas and a reduction of mining activities at certain seasons to reduce disturbance of reindeer. In Greenland, several relevant laws regarding resource

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utilization prescribe that local resident – Inuit - must be involved in development initiatives and that the organization of activities around the use of resources must ensure a good coexistence between the various users.

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6.5.1.Inari

The Inari hub covers the municipality of Inari, whose administrative centre is Ivalo, but it has another central village called Inari (Figure 73). Inari municipality has a population of about 7000 people of which about 2200 belong to the indigenous Sámi people. Inari village nowadays serves as an essential hub for indigenous Sámi culture in Finland with only 600 inhabitants. The village is the capital of Sámi culture, since the Sámi culture center Sajos, the Sámi Parliament's main office, Sámi church, Sámi radio, as well as the Sámi museum and the Sámi Education Institute (SAKK) are located in there. The Sámi culture is also represented well in the Skábmagovat film festival, as well as in the Ijahis Idja -music festival.Inari municipality has the biggest number of official languages in Finland: In addition to Finnish, three Sámi languages are spoken in the municipality (Northern Sámi, Skolt Sámi and Inari Sámi), and all basic services area provided in the three Sámi languages (Inari municipality, 2022). The traditional livelihoods of the Sámi people are fishing, gathering, handicrafts, hunting and reindeer herding. The economic value of the traditional livelihoods is not big, but the livelihoods are crucial to the culture (Sámediggi, 2022). Some of the Sámi make their living from these traditional livelihoods, but a big part gets their income from more modern occupations. There are about 500 reindeer herders in the municipality of Inari (Figure 74) and around 33 000 reindeer. Tourism and forestry are the most contested issues when it comes to Sámi land use, including reindeer herding.

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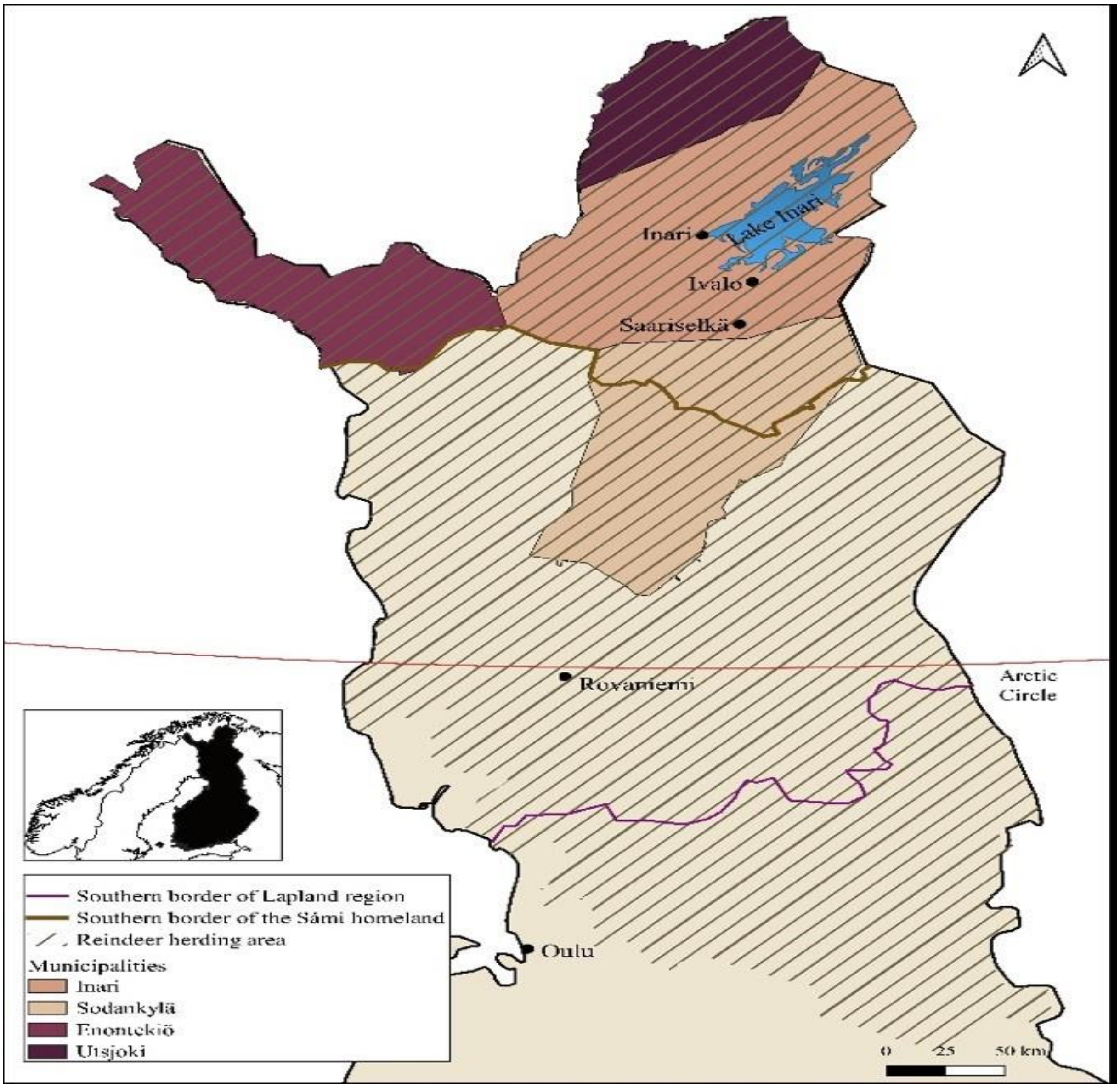

Figure 73. Map of the Inari hub and its surroundings, reindeer herding area and the Sámi homeland area (Data: Natural Earth 2022, Johanna Roto 2015, National Land Survey Finland 2022, Reindeer Herders' Association 2022. Map: Arctic Centre, University of Lapland 2022)

As well as in the reindeer herding area in total, also in Inari municipality, the amount of reindeer owners has been decreasing from the start of 1990s (Figure 74). Partly because of that, the number of reindeer has also been decreasing in the municipality (Figure 75). Among reindeer owners, the number of males has decreased more than the number of females. The number of young and middle-aged reindeer owners is considerably high. There has also been some disputes between different land uses,

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like reindeer husbandry and Sámi culture, forestry and tourism, in Inari (Saijets & Rasmus, 2017; Turunen, et al. 2020).

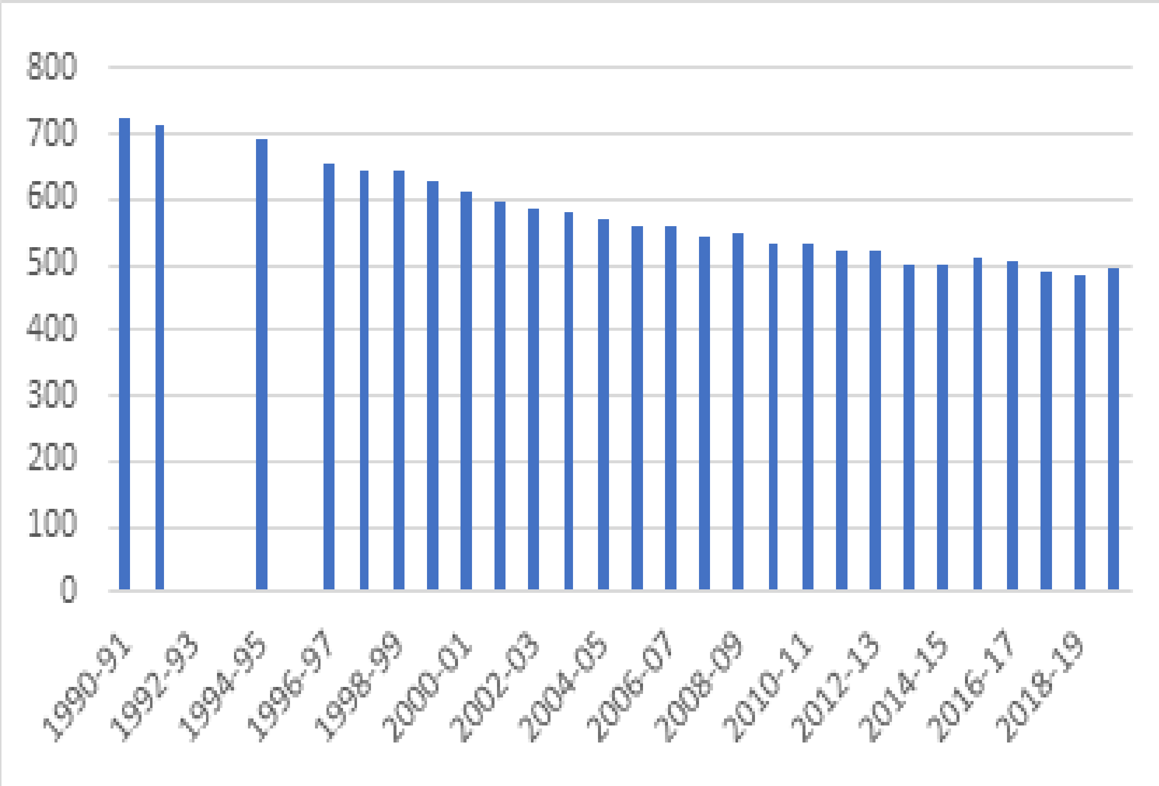

Figure 74. The number of reindeer herders in the municipality of Inari from 1990 to 2020 (Reindeer Herders' Association)

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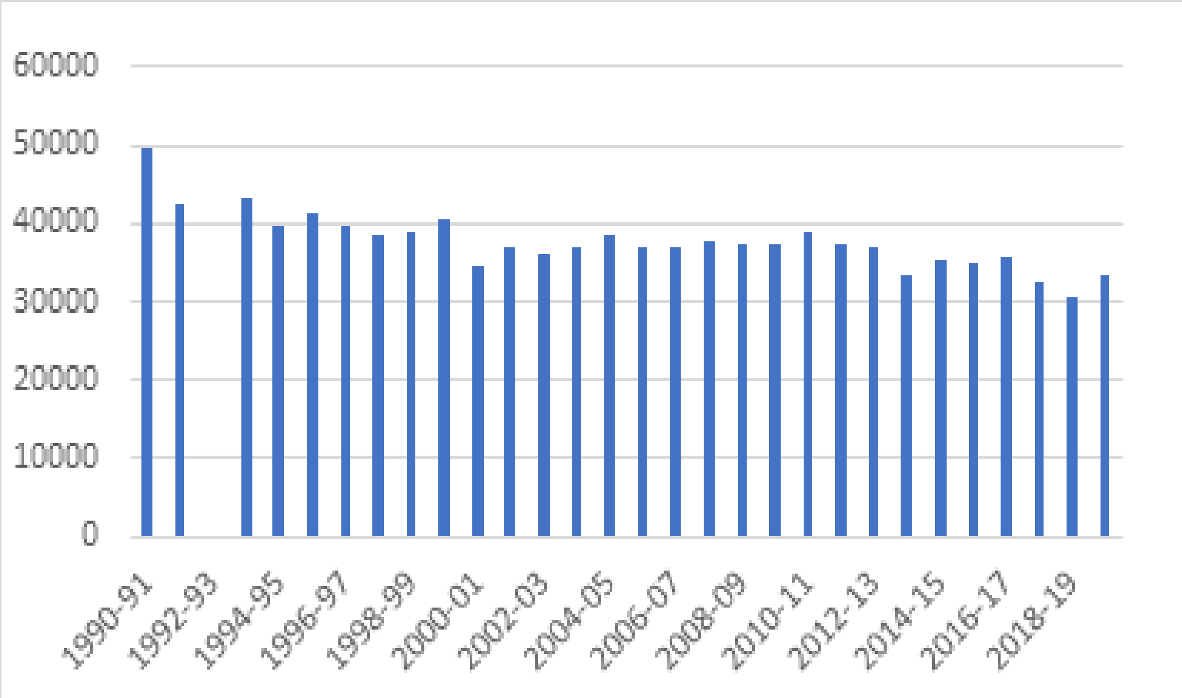

Figure 75. The number of reindeer in winter stock in the municipality of Inari from 1990 to 2020 (Reindeer Herders' Association)

Lake Inari is important economically, socially and culturally for both indigenous and local people. In recent years, the total catch in Lake Inari has been 150 000kg from which 38% commercial fishing, 38% fishing for domestic use and 24% fishing by out-of-towners. Lake Inari has long traditions in commercial fishing, which is conducted year-round, but focused on ice-free season. The catch has been annually ca 40 000 kg (Natural Resources Institute 2021). Half of the catch is whitefish; other important species include brown trout, vendice, Arctic char and lake trout, but nowadays demand also for pike, perch, grayling and burbot has increased.

From the viewpoint of fishing, water quality and fish communities of Lake Inari are threatened by climate change, natural leaching, air pollutants, gold mining, regulation of water level, one-sided fishing, community wastewater, forestry, agriculture and reindeer husbandry. The status of lake Inari has been assessed as good, and most of the lake is assessed as excellent (MAF 2021). Long-term monitoring shows however, that spring-summer temperatures have increased and also icefree period has extended (Puro-Tahvanainen et al. 2019). It is expected that fishery of lake Inari will gradually change from salmon dominated to perch dominated and further to cyprinid dominated ones due to increased temperature and production (Hayden et al 2017, MAF 2021, Turunen et al 2023). Fishermen of Lake Inari have observed increase in the abundance of spring spawn species such as perch and

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pike; sliminess of their fish traps and nets as well as weakened water quality close to the river mouths and particularly during hot summer weathers. The fishermen reported that these changes may be caused by increased nutrient loads from the community waste waters and incomplete water treatment (Puro-Tahvanainen et al. 2019, Turunen et al 2023)

(For more background information, see also chapter 5.3.6. where Inari is also introduced from a tourism perspective) and WP3 D3.2.

6.5.1.1. State of the art / Environmental background

(For information about the environmental characteristics of Inari, see chapter 5.3.6.1.)

6.5.1.2. Environmental impacts

The following environmental impacts are based on the indigenous industries that are operated in the Finnish municipality of Inari (see also Table 21).

Forestry has had negative impacts on reindeer herding in Inari for several decades (Turunen et al., 2023). Winter pastures, particularly old growth forests with lichen pastures, have been decreased and fragmented due to cuttings and soil preparation. See detailed impacts of forestry practices on reindeer herding from e.g. Kivinen et al. (2010) and Turunen et al. (2020). The pastures removed from the use of reindeer herding have greatly increased the grazing pressure on the remaining areas, and herders have been forced to feed reindeer with supplementary feeds for several generations in most of the herding districts in Inari to compensate the loss of lichen pastures. Feeding has greatly increased the expenses of reindeer herding. In addition, forestry roads have increased traffic and disturbance to reindeer herding.

The relationships between forestry and reindeer husbandry in the reindeer management area have remained poor in Inari and escalated into serious disputes from the 1980s onwards. For example, the forest conflicts in Inari municipality (Inari, Kessi and Nellim) were characterized by complex ecological, economic, social, and cultural questions (Kyllönen et al., 2006; Hyppönen et al., 2010; Saarikoski and Raitio, 2013; Jokinen, 2014). Since these conflicts many studies have been conducted for solving and improving the relations between state forestry and reindeer husbandry (Mustajoki et al., 2011; Saarikoski et al., 2013). Now, the reconciliation of reindeer husbandry and

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state forestry have improved during the past decades. In its current practice, Metsähallitus applies a more interactive and participatory approach to planning to ensure an improved prevention and governance of conflicts between the two livelihoods. According to our survey in Inari, reindeer herders are relatively satisfied with the consultation procedure in which Metsähallitus organizes consultations with herding districts (Co-operation Agreement between Reindeer Herders' Association and Metsähallitus, 2013).

Our recent study in Inari showed that there has been conflicts also in recent years with private and joint forest owners (e.g. Inarin yhteismetsä), however, because they have restricted reindeer herding on their land, for example by requiring a removal of the round up site and prohibiting supplementary feeding of reindeer (Turunen et al, 2023). Few private and joint forest owners in Inari are cutting old-growth forests, but they have difficulties in selling the timber to the forest enterprises, and they therefore sell it to the Inari municipality. Forest enterprises nowadays often require that the timber they buy is from a forest owner who follows the criteria of the FSC (Forest Stewardship Council) certification system. When FSC certification is applied, the perspectives of the herding cooperatives are better taken into account due to the consultation procedure it requires (FSC standard for Finland 2010). One of the herders interviewed predicted that rather than expanding and growing, the forestry in Inari would be gradually finished in forests owned by the state, but probably later also in forests of private and joint owners (Turunen et al 2023). The sales from forests of private and joint owners are dependent on the sales from the state land.

Herders reported also positive impacts of forestry on reindeer herding. Thinning of dense seedling stands increases the amount of light within the forest, which improves the growth of lichens. In addition, visibility is increased and the moving of the herds becomes easier. Thinning has also improved pastureland quality of previously dense forests with moss layers on the forest floor. Wood chips as a result of thinnings could be utilized by the thermal power station of Inari municipality, which would mean cheap and local energy. One of the herders also pointed out that compared to clear cutting, forestry which utilizes methods which keep the area forested, was found to be more favorable for reindeer herding (see Turunen et al 2020, Rikkonen et al 2023).

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Table 21. Environmenetal factors affecting Sami livelihoods

Environmental factors affecting Sámi livelihoods						
Environmental impact	Area affected	Impact	Duration	Impact on other activities	Mitigation	Further needs
1. Milder winters 2. earlier springs 3. more snowfall 4. hotter summers 5. ice-crust on snow 6. change in the freeze/thaw cycles	Reindeer grazing areas, lakes and swamps	1. Loss of reindeer 2. Loss of reindeer pathways 3. Reindeer work disturbed	All-year round, worst during winter	Impact on tourism, local nature, local culture	Need to change the pathways of reindeer, supplementary feeding, compensation	More research
Damage on downy birch	Fell areas	Loss of reindeer feed	Summer times during outbreaks	Impact on the ecology of the area		
Damage and loss of reindeer, especially calves	Wilderness areas and national parks	Reindeer, especially calves, being lost and injured, economical loss	All-year-round		Compensation system, hunting	More effective compensation system
Conserving nature, especially old forests	National parks and other conservation areas	Obstrucs major land-use in the areas, preserve the important winter grazing areas of reindeer, but also can increase the amount of predators which decrease the amount of reindeer and hence the income	All-year-round	Impacts positively for tourism, recreation etc., but usually negative for forestry		

Table 22. Local activities affecting the environmental factors of Sami livelihoods

Local activities affecting the environmental factors of Sámi livelihoods							
Factor	**Environmental impact**	**Area affected**	**Impact**	**Duration**	**Impact on other activities**	**Mitigation**	**Further needs**
Tourism	1. Increased land use 2. Increased pollution and littering 3. More traffic, noise and trampling by snow scooters, husky safaris etc. 4. Noise pollution	Areas near tourist villages like Inari, Saariselkä	Loss of grazing area of reindeer, reindeer are distrubed by the increasing amount of people, especially dogs and snow mobiling distrub reindeer, harder to gather reindeer because herds are spread, loss of reindeer, conflicts	All-year-round	1. Dwelling 2. Biodiversity 3. Impact on the pristine nature	Negotiations between tourism operators and reindeer herders, Moving routes of reindeer have had to be changed	Better reconsilиation between tourism and reindeer husbandry, Centralizing tourism in existing areas, less husky farms, better rules on husky tourism

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Infrastructure development – roads, buildings	Increase in roads and buildings	Areas near tourist villages like Inari, Saariselkä	Loss of grazing area of reindeer, loss of reindeer	All-year-round	Impact on the pristine nature	Centralization of tourism buildings	Mindful zoning
Forestry	1. Loss and fragmentation of old forests which are important winter pastures 2. Increased amount of forestry roads	Forestry areas	1. Decrease in the well-being of reindeer and loss of reindeer, increase the grazing pressure on the reimaining areas 2. Fragmentation of reindeer pasture land, and increased traffic which leads to distrubance and loss of reindeer	All-year-round	Impact on tourism, biodiversity and nature, recreation	Herders forced to feed reindeer with supplementary feeds, which increases the expenses, reindeer need to be kept near settlements to feed them, softer forestry methods, forbidding forestry or applying forestry certificates such as FSC and PEFC	Better reconsiliation between forestry and reindeer husbandry, more research on different forestry methods and their effects on reindeer husbandry
Mining related activities like gold mining and mineral prospecting	1. New claims mean new roads and areas taken away from reindeer herding 2. Converting gold pannning claims into larger-scale mechanical gold mining 3. Effect on the water quality	Areas near gold mining areas like Lemmenjoki Nationalpark	1. Loss and fragmentation of pasture lands, loss and disturbance of reindeer and their well-being	Summertime	Increasing concerns among reindeer herders, impact on the local nature	Prohibition of the mechanical gold mining in Lemmenjoki national park	Mining act should be reformed in a way that reindeer herders have more authority in decision making
Hunting (mainly by non-locals)	Dogs that are not used to reindeer are used in hunting disturb reindeer and spread the herds, the non-locals are ignorant and not aware of local culture and how to behave there, hunting at certain times distrub reindeer	Especially popular moose and willow grouse hunting areas	Reindeer being hurt and distrubed, dogs and traffic by ATVs disturb reindeer and makes the gathering of them more difficult, pregnant hinds are distrubed and spread in the spring, and hunting in the autumn distrubs the rutting time, hunting of willow grouse and rock ptarmigan during spring start two months before the traditional Sámi hunting with traps, the prolongation of moose hunting until January is harmful because reindeer that have settled down on their winter pastures are easily disturbed	Mainly spring and autumn times	Impacts on biodiversity: e.g. the amount of rock ptarmigans is already very low	Regulation of hunting permissions	Hunting regulations should be more clear, less hunting permissions should be sold for non-locals, dog-free hunting?, Sámi culture should be taken into account when deciding the amount of hunting permissions
Cumulative effects	All the different activities and	Whole area	Decrease and fragmentate the reindeer pasture	All-year-round		Supplementary feeding, reindeer herders needing	Research needed on the cumulative effects of

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of increased land use	land use methods together		areas, disturb reindeer, reindeer migration routes need to be changed, loss of reindeer etc.			other source of income	different land use methods on reindeer husbandry

A. <u>Habitat and landscape</u>

1. Sámi livelihoods affecting local environment							
Factor	Environmental impact	Area affected	Impact	Duration	Impact on other activities	Mitigation	Further needs
Reindeer husbandry	1. Overgrazing 2. Increase in off-road motorized traffic and vehicle tracks 3. Predator control afffects predator populations 4. Fences and rubbish left accidentaly from supplementary feeding to nature 5. Eutrophication	Reindeer herding area, including sanctuaries and wilderness areas	1. Damage on vegetation and soil 2. Damage on soil and vegetation, erosion and pollution 3. Damage on other animals: fences damage or kill grouses	All-year-round	Tourism and recreation, wilderness photography		
Fishing	1. Fishing nets and other equipment lost in the lakes 2. Gas leaks	Mainly Lake Inari	1. Damage on auqatic fauna and birds 2. Impact on water quality	All-year-round	Tourism and recreation		

Reindeer have multiple effects on boreal forest through selective grazing, trampling and fertilizing (Turunen et al, 2020). Reindeer change the composition, structure and abundance of vegetation, and they usually accelerate also below-ground processes. Winter grazing of reindeer decreases mostly the amount of terricolous lichens and epiphytic lichens (Köster et al., 2015; Akujärvi et al., 2014). In winter, snow cover protects vegetation and grazing is targeted only to that part of vegetation where reindeer have been digging. Winter grazing does not thus affect vegetation as strongly as summer grazing (Kumpula et al., 2011). During summer the biomass of summer forage plants can greatly decrease through grazing, but their regeneration is often effective (table above). Both terricolous and epiphytic lichens have decreased in the winter pastures of the reindeer management area throughout the 1900s, and especially after the 1970s (Kumpula et al., 2014). Greatly decreased proportion of lichens can be explained by other land use, particularly forestry, high reindeer densities (Kumpula et al., 2019), and increased competition of terricolous lichens with other faster growing species, such as shrubs, due to climate change (Turunen et al., 2009). The impact of reindeer husbandry on lichen pastures depends not only on reindeer densities, but also on herding practices. For example, a lack of pasture rotation exposes lichen-rich winter pastures to summertime trampling by reindeer. However, a full seasonal

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pasture rotation may be difficult to organize in a number of HDs, due to the lack of seasonal pastures or other land use (Kumpula et al., 2011, 2014, 2019).

Reindeer digging for terricolous lichens through the snow can cause direct damage or indirect frost damage to seedlings in winter pastures (see Turunen et al 2020). In addition, herding work, such as moving reindeer herds through the seedling stands e.g. to the round-up sites and supplementary winter feeding of reindeer in the seedling stands can damage seedlings. Reindeer grazing limits the growth of birches in summer pastures, because birch leaves are an important part of the summer diet of reindeer. On the other hand, the impact of reindeer summer grazing on birch can be favorable in regions where the sprouting of birch hampers the development of cultured pines. On these sites, reindeer grazing can reduce the need of clearing the seedling stands (see Turunen et al, 2020).

B. Changes in biodiversity

Digging and trampling by reindeer can have an effect on seedlings as they get exposed, predator control also affects predator populations.

C. Pollution

Supplementary feeding can cause pollution, see table.

6.5.1.3. Conflicts

See tables above

6.5.1.4. Mitigation

See tables above

6.5.1.5. Ambitions

No relevant data material

6.5.1.6. Perceptions

No relevant data material

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6.5.2.Kvalsund – Kautokeino

Kautokeino is the Sámi "capital" of Norway. 95 % of its population are indigenous Sámi, being one of only two municipalities where the Sámi people are the majority. Reindeer herding is the main industry and a strong public sector with several Sámi institutions. In East-Finnmark, which includes reindeer areas Kautokeino East, Middle and West, there were around 70 800 reindeer in total (spring herd) in 2021. Since 2016 the number has been quite stable, fluctuating between 68 900 and 71 300 (Norwegian Agriculture Agency, 2021). Besides, Kvalsund is also a traditional sea Sámi community. The area in and around the municipality plays an important role for spring, summer and autumn pastures for reindeer husbandry, but there are also some essential winter pastures in Kautokeino. Still, unemployment rates in the municipality reveal that there is a need to find alternative employment and business development.

The Sámi reindeer herding in Kautokeino-Kvalsund is increasingly affected by industrial development such as mining and other land use changes. Numerous studies across the Arctic have documented that the physical barriers and pasture fragmentation resulting from cabin resorts (such as those in Kvalsund-Repparfjord) as well as infrastructure development (e.g., roads, power lines) adversely affect the distribution and movements of reindeer (Bradshaw et al, 1997; Nellemann & Cameron, 1998; Vistnes et al, 2008; Skarin & Alam, 2018) from the 1990s and onwards.

Following the Norwegian Reindeer Herding Act (2007)[104] unlimited access to seasonal pastures is an important material basis for Sámi reindeer herders' culture and livelihoods and should be preserved. Together with other land uses and encroachments like tourism and mining, severe winter season conditions seem to be an ongoing and future threat to the reindeer husbandry (Vikhamar-Schuler et al, 2016).

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6.5.2.1. State of the art / environmental background

Environmental monitoring program in Kautokeino

The "Monitoring programme for inner parts of Finnmark County" was initiated in 1998, and field surveys were made in 2005, 2013 and 2018. The surveys in 2013 and 2018 were restricted to the southernmost parts of Finnmarksvidda, the main winter grazing area, hence omitting the more northerly established sites (Tømmervik et al. 2012). The sites span across reindeer herding districts 16, 17, 30A, 30B, 30C. In 1998, the southern facing sites had a continuous occurrence of reindeer lichen heath with an average amount of 203 g/m^2 in forest, leeward sites and on mires. At the more wind-exposed sites that were more easily available to reindeer for foraging due to little accumulation of snow, the lichen biomass was less than 50 g/m^2 in large parts of the study area. Our monitoring shows that the steadily reduced number of reindeer from 1998 to 2005 resulted in a massive increase in lichen biomass in all parts of southern Finnmarksvidda. From 2005 to 2010, we recorded a stable situation for lichen biomass in leeward sites and forests in the districts 16, 30A and 30B, whereas biomass was reduced in the districts 17 and 30C. During the same period, there was a reduction of lichen biomass at wind-exposed sites in district 30A, but an increase in district 30B (Tømmervik et al, 2011).

For the period from 2010 to 2013 we documented a reduction of lichen biomass in all parts of the grazing system, except for in District 30A where lichen biomass has been stable in leeward sites and forest and has even increased in exposed sites. The increase of lichen biomass in this District may be due to increasing snow depths in recent winters, increased use of supplementary foraging (which have reduced the need for foraging on in situ resources), and that the reindeer have spent more time on the summer grazing sites before being herded to the winter grazing sites. In District 30B, the reduction from 2010 to 2013 is particularly large on wind-exposed sites – from 635 to 261 g/m^2. The reduction is even a bit larger in the most wind-exposed plots (the centre plots at our sites), from 653 to 160 g/m^2. This shows that the grazing pressure has been high the last couple of years. We link this to increasing snow depths, which have forced reindeer to seek for forage at the most wind-exposed sites. This implies that the reindeer must seek over large areas every day to cover its nutrients requirements. In winters with much lichen biomass available, the reindeer will be able to cover its nutrient requirements within a few square meters, leading to increased survival, body weight and reproduction. When lichen biomass is as scarce as is the current situation in large parts of southern Finnmark, even relatively low reindeer densities impede increases in lichen biomass over time. As there is little of grass and other

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plants that can replace lichens in the reindeer diet in these areas, a massive reduction of grazing pressure must be implemented to allow lichens regrow to the sustainable biomass levels as seen during the period from 2005 to 2010 (Tømmervik et al, 2014). However, in the period 2013-2018, there has been an increase of lichen cover in some of the northern areas of Kautokeino and Karasjok, while the situation is stable in the southern areas (Johansen et al, 2019).

Databases:
* Naturbase (Miljødirektoratet) https://www.miljodirektoratet.no/tjenester/naturbase/
o Reindeer migration routes, grazing areas, districts
o Nature protection areas
o Snow scooter løypes
o Wind power
o Wilderness areas * Kilden – Arealinformasjon – NIBIO https://kilden.nibio.no
o Land use, land cover maps
o Forest resources
o Agricultural resources
o CORINE land cover data * Artsdatabanken https://www.artsdatabanken.no
o Vegetation types
o Landscape types
o Protected species

6.5.2.2. Environmental impacts

There are large year-to-year fluctuations in total meat production from reindeer husbandry in Kautokeino. This is due to high mortality caused by challenging winter grazing conditions, as well as loss to predators. For instance, during the winter and spring of 2020 there was a large amount of snow which resulted in a feeding crisis in most of the districts in Troms and Finnmark and Nordland counties. Due to fluctuating temperatures, there was icing and packing of hard snow in the pastures which prevented the reindeer from accessing forage (Norwegian Agriculture Agency, 2021).

A. Habitat and landscape

A long-term study has reported vegetation changes over a period of more than 40 years, estimating sizes of various vegetation classes by the use of remote-sensing techniques and ground surveys (Tømmervik et al, 2004). They reported that vegetation types dominated by bilberry (Vaccinium myrtillus), wavy hair-grass (Deschampsia fleuxuosa), the dwarf cornel (Cornus suecica), and mosses have tripled in abundance compared to 40 years ago. In contrast, lichen-dominated heaths and woodland (forests), preferred by the reindeer stocks intensively utilizing these areas of

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Finnmarksvidda, have decreased by approximately 80 % in abundance during the same period. At the same time, extent of birch forests has increased dramatically. The decline in lichen-dominated areas can be explained by intensive grazing by reindeer, especially in the period 1961–1987. Other factors, such as climate change (increased precipitation), caterpillar attacks, and long-transported air pollution (e.g., nitrogen) may also have contributed the increase of forests and other vegetation types.

* Johansen, B., and Karlsen, S.R., 2005. Monitoring vegetation changes on Finnmarksvidda, northern Norway, using Landsat MSS and Landsat TM/ETM+ satellite images. Phytocoenologia, 35: 969-984. Doi: 10.1127/0340-269X/2005/0035-0969.

3.4.3.2.2. Changes in biodiversity

The state of biodiversity in nature, as measured by the Norwegian Nature Index (2020), is considered as good (quantitatively evaluated on a scale from 0 to 1) for the Kvalsund-Kautokeino area. The only exception is the state of forests, which is moderate in most of the country, including the whole of Finnmark. A main reason for this is a general decline in abundance of old-growth forest trees (especially aspen, rowan and large willows), small rodents and several bird species. Forest state in K-K increased from 2014 to 2019 – from below moderate (0.35) to moderate (0.45) and, this improvement was concomitant with a similar improvement in most of the country. Data on state of nature from Kautokeino-Kvalsund are mostly indirect, meaning that rather few datasets are retrieved within the hub, but time series collected elsewhere are given validity on regional level.

* Eftestøl, S., Flydal, K., Tsegaye, D., and Colman, J.E., 2019. Mining activity disturbs habitat use of reindeer in Finnmark, Northern Norway. Polar Biology, 42: 1849-1858. Doi: 10.1007/s00300-019-02563-8.
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3. Pollution

Mining has taken place around Kvalsund for shorter periods on several occasions, last time in the 1970s. “Mine tailings were discharged to the inner part of the fjord, Repparfjorden. Metal speciation analysis was used to assess the historical dispersion of metals as well as their potential bioavailability from the area of the mine tailing disposal. It was revealed that the dispersion of Ba, Cr, Ni, Pb and Zn from the mine tailings has been limited. Dispersion of Cu to the outer fjord has, however, occurred; the amounts released and dispersed from the mine tailing disposal area quantified to be 2.5–10 t, less than 5% of Cu in the original mine tailings (Pedersen et al. 2017).” However, “An estimated 80–390 t of Cu still remains in the sediments of the disposal area in the inner part of the fjord (MTS and TAS), from the seafloor, with a thickness of 10–14 cm", which may contribute to future contamination (Pedersen et al 2018).

Today there are more plans on expanding the mining activity to extract copper with gold and silver as by-products from underground in the Nussir mountain area. For 10 years, Nussir ASA, a Norwegian mining company dependent on foreign investments, planned an opening of a copper mine. Such mining activity will produce waste that will end up both as land deposits (host rock) and as sea tailings in Repparfjorden, including masses contaminated with Xantat (chemical used during extraction process) (Nellemann & Vistnes, 2011; Eira et al, 2020). Nussir received an operating license from the Government in 2019, supported by the local council but plans for a sea deposit in the fjord caused protests from environmental NGOs, Sámi organizations and other user groups. Another example of industrial development in the area is a planned facility for green energy at Markoppneset not far from the Nussir mine. Locations for the mentioned industrial interests falls within the Fiettar reindeer herding district and the mountain areas are mapped as spring (including calving areas), summer and autumn foraging areas for reindeer. One of the migration routes for reindeer crosses the roads in the lower part, near the coast of the planned mining area.

In Kautokeino, the copper-gold mines in Bidjovagge (Biedjovággi) were operated during two periods from 1970–1975 and 1985–1991. The pollution from the mines were limited but some pollutants have been reported leaking into water courses[116]. The mines produced only copper concentrate during the initial period, but in the 80's and 90's a copper concentrate containing gold was produced. No impact was detected from the mine area discharges in the closest watercourse, the Sieidasjokka, which is a tributary river in the Alta/Kautokeino watercourse (Skei et al, 2019).

In 2015, Norwegian Institute for Air Research (NILU) in collaboration with Norwegian University of Science and Technology (NTNU), collected moss from 230 sites and determined the content of 53 metals in these (Steinnes et al, 2017). The purpose of the survey was to map atmospheric deposition of heavy metals in Norway. Compared with data from 2005, a decrease was observed in the deposition of vanadium and lead. For chromium, nickel, copper, zinc, arsenic, cadmium and antimony, there was no appreciable change in deposition from 2005 to 2015. For West-Finnmark, including Kautokeino and Kvalsund regions, air pollution appears to be particularly low at all monitoring times (1977-2015). In addition to atmospheric deposition of pollutants from local sources, other natural sources may contribute to observed concentrations of elements in moss: natural cyclic processes, in particular long-range atmospheric transport of substances from the marine environment, root uptake in higher plants and transfer to the moss e.g. through leaching of elements from living or dead plant material, mineral particles released to the air e.g. from wind erosion of local soil, and uptake from the ground in periods where the ground is covered with water.

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6.5.2.3. Conflicts

No more relevant data

6.5.2.4. Mitigation

No more relevant data

6.5.2.5. Ambitions

No relevant data material

6.5.2.6. Perceptions

No relevant data material

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6.5.3. Nuup Kangerlua

Nuup Kangerlua is an extension of Nuuk city – the capital of Greenland. Nuuk is home to the Government of Greenland's administration and several educational institutions. Cultural institutions such as Greenland's Culture House, National Theatre, Nationwide Radio and TV - KNR - and Nationwide Newspaper - Sermitsiaq - are placed in Nuuk. A lively business environment helps to create a dynamic and modern capital.

The landscape in the fjord area Nuup Kangerlua has a history of indigenous Inuit hunting and fishing and the traditional fishing and hunting profession remains one of the cornerstones of the Nuuk´s Greenlandic indigenous culture.

With the imminent opening of an international airport in Nuuk, the number of local tourism operators is increasing, and the range of tourism services is rapidly increasing. For example, 3 land allotments have been given to tourism camp sites at the bottom of Nuup Kangerlua and currently the municipality has prepared a proposal for a concession area for trophy hunting at the bottom of Nuup Kangerlua.

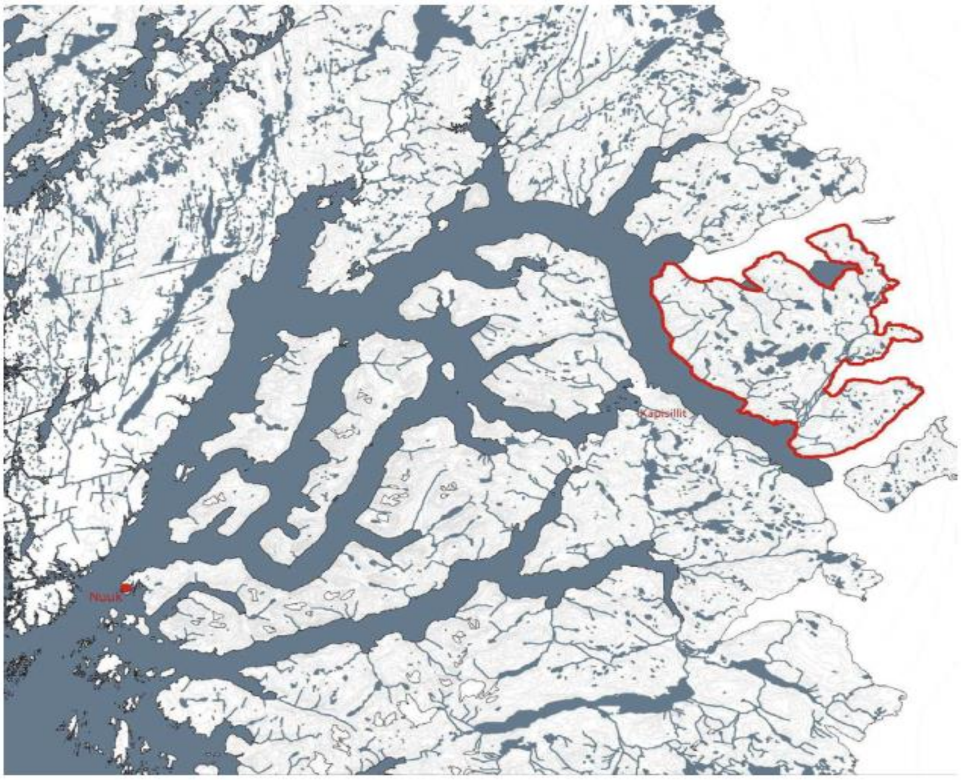

Figure 76. Town Plan Supplement 010-1 Concession Area Nunatarsuaq, Nuuk. August 2022.

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6.5.3.1. State of the art / environmental background

Today, the fjord Nuup Kangerlua is used merrily for boat trips by both tourists and locals. Inuit fishermen primarily catch halibut and cod for purchase at the local fish factory as well as reindeer hunting is carried out by both professional and recreational Inuit hunters. Hunting and fishing have been the livelihood for generations. Although, traditional hunting livelihood is decreasing. There is a local concern that this traditional livelihood handed down by generation is decreasing as younger generations go into more modernized labour. There were just 2000 professional hunting licences in 2020 in Nuuk. However, recreational hunting is increasing, with 5000 licences the same year.

Hunting is regulated by means of seasons and permissions. A general hunting license is mandatory for anyone, who wants to hunt. The general license comes in two categories: professional and recreational. In addition, a specific license is needed when hunting species limited by quota. The quota system regulates the number of animals available for hunting. Professional hunting license holders usually do not make a full living from hunting. In addition, they will often do dinghy fishing in summer and ice fishing in winter.

Seal still plays an important role. A number of whale species have hunting quota. The meat and the skin are consumed in Greenland only. Reindeer and musk ox are the most important land species. Seabird hunting is regulated by means of quota. A few species are not quota-regulated. In general, the police enforce the hunting regulations.

There is a concern that there is a domination of foreign labour and languages in existing industries, and in general less use of the Greenlandic language. Indigenous voices are calling for protection for indigenous livelihoods and culture, as well as more ownership over the industrial developments, especially the tourism industry.

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Catches of mammals and birds

	2015	2016	2017	2018	2019	2020*
			Landings in tonnes			
1 Seals	16	11	8	5	–	–
2 Whales	42	24	4	5	15	7
3 Landmammals	344	367	329	335	347	338
			Numbers of catches			
4 Birds	121,043	111,672	102,914	80,402	77,096	42,701

Source: https://bank.stat.gl/FIE003, https://bank.stat.gl/FIE002, https://bank.stat.gl/FIE004 and https://bank.stat.gl/FIEFANGST

**Preliminary figures*

1 Ringed seal, harp seal, hooded seal, bearded seal and harbour seal

2 Beluga whale, narwhale, killer whale, harbour porpoise, pilot whale, atlantic white-sided dolphin, minke whale, bowhead whale, humpback whale, fin whale and walrus.

3 Arctic hare, reindeer, musk ox, arctic fox and polar bear

4 Guillemot, eider, king eider, squaw, mallard, fulmar, theist, little auk, black-legged kitti, canada goose, barnacle goose, short nest goose and ptarmigan

Figure 77. Catches of mammals and birds. Greenland in Figures 2022. Grønlands Statistik

The numbers of families who practice the traditional livelihood with hunting and fishing is decreasing especially in Nuuk but also at nationwide. The number of recreational hunters is increasing and is more than twice as many as professional hunters. Some hunters do not train their sons to become traditional hunters and fishermen but let them take an education to get other job opportunities. However, many young men have learned hunting and fishing skills and practice hunting and fishing in their spare time. The so-called recreational or sports hunters. In that way hunting and fishing provides an important supplement to household economy and an important cultural practice is continued. In a slightly different way, but with roots in the original culture.

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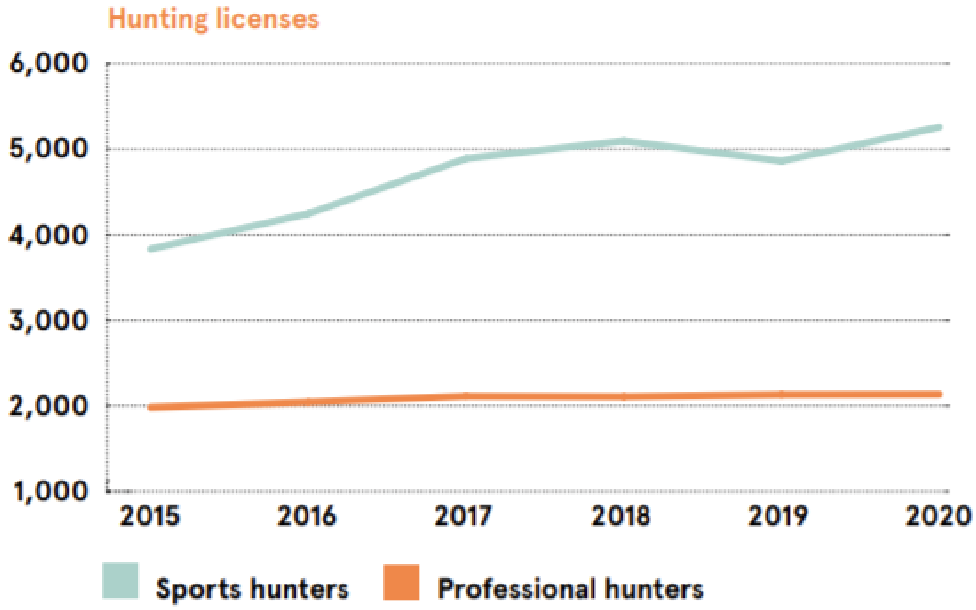

Figure 78. Hunting licenses to sports and professional hunters. greenland in Figures 2022. Grønlands Statistik

While there is an increase in tourism activities, other traditional activities are banned in the Nuup Kangerlua. A few years ago, authorities decided to ban whale hunting in Nuup Kangerlua and referred whale hunting to other locations.

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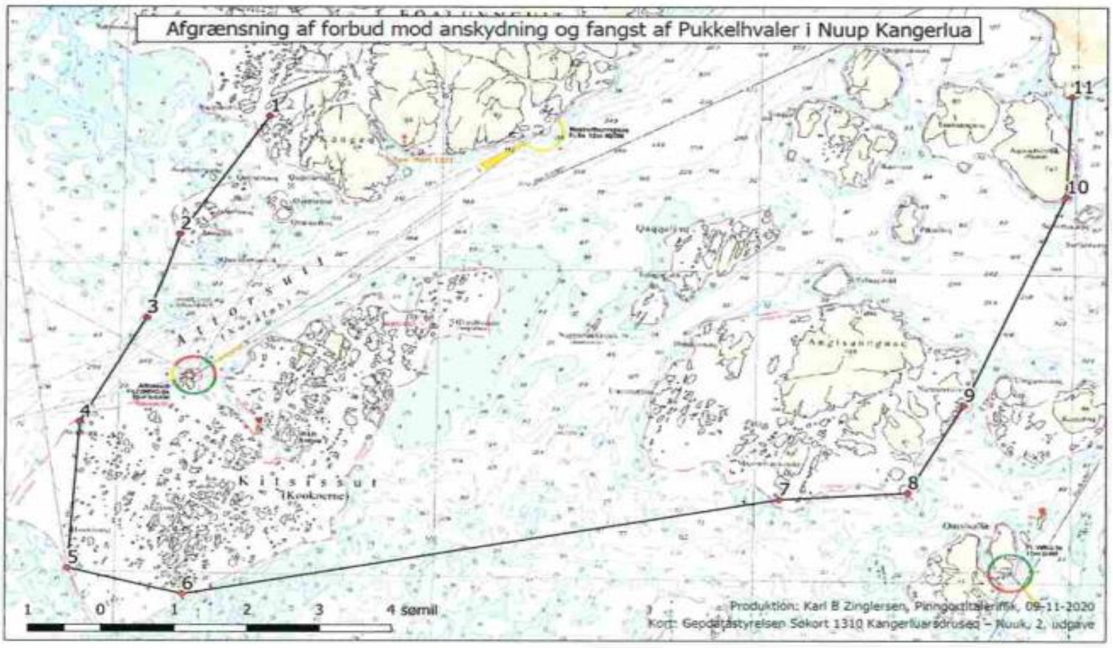

Figure 79. Delimitation of the ban on shooting and cathing hunpback whales in Nuup Kangerlua. Kommunal vedtægt for Kommuneqarfik Sermersooq om forbud mod fangst og anskydning af pukkelhvaler i Nuup Kangerlua. (2018)

The traditional Inuit hunters and fishermen may end up in a difficult situation, as new users of landscape areas and the fjord have begun to operate in areas that have only been used for traditional reindeer hunting, whale hunting and fishing.

The Land Use Act and the Trophy Hunting Concession Act take account of local Inuit hunters and fishermen and, for example, continue to give them the right to hunt in trophy hunting concession areas. But this does not change the fact that several new forms of land and fjord use are increasing and can create an experience of congestion. Conflicts can arise as different forms of use, values and connections to areas can be difficult to reconcile. The increasing level of different activity may change Nuup Kangerlua's character as a wilderness area. Nuup Kangerlua is designated as an untouched natural area – a wilderness area - in the current municipal plan.

The municipal and local tourism operators are busy developing Nuuk town and Nuup Kangerlua as a tourist destination. In our newly survey in connection to WP 3 several local Inuit appeals for more citizen involvement in development initiatives, as several legislations prescribes this. They wish more dialogue in the public hearings and more public information. This is to make nuanced proposals for the organizing and management of activities to ensure good coexistence. A more interactive and

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participatory approach may improve common understanding and openness for management of resource use to ensure good coexisting.

6.5.3.2. Environmental impacts

As the recreational hunting is increasing, a potential impact is that it is leading to more noise pollution due to more speedboat owners.

6.5.3.3. Conflicts

New forms of use of land with increase in land allotments for cottages for both local citizens and camp sites for tourism may seem two-sided. New employment and income opportunities from tourism can push traditional activities into the background which comes with a sometimes-difficult trade-off between the new tourist industry and the original hunting and fishing industry.

There are several potential conflicts in relation to indigenous whale hunting and tourism activities. Tourism actors are sceptical to whale hunting, as it can create negative experiences and reactions from tourists. As an example, in Nuuk authorities has banned whale hunting in the fjord.

There are also several new comers to this area due to tourism development, and this raises concerns locally as the new tourist actors guide in an environment and culture they do not know and they do not share the Greenlandic perspectives and do not speak the language. This conflict is also in line with the local interests to take more ownership in the tourism development. Locals demand more citizen involvement to empower their positions in a situation with intensified new global economic interests.

6.5.3.4. Mitigation

In response to the abovementioned conflicts that can arise between the tourism and indigenous industries, an approach where space is created and consideration is given to different resource users under certain conditions that ensure good coexistence, is promoted (e.g., more interactive and participatory approaches that may improve common understanding and openness for management of resource uses to ensure good coexistence).

6.5.3.5. Ambitions

No relevant data material

6.5.3.6. Perceptions

Non accessible documents regarding the application of protection of humpback whales.

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Humpback whale protection in Nuup Kangerlua, applied 2021. This is to protect permanently residing humpback whales in the Nuuk fiord. There has been a conflict between tourist operator and Greenlandic hunters over this subject. Proposal and enactment: "Forslag KV 290121 dk Hvalfredning" and "Forslag vedtaget_ Pukkelhvaler i Nuup Kangerlua er fredet _ KNR". Map of the protected area: " KV kortbilag". As well as 7 other documents comprised of articles.

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Kommunal vedtægt for Kommuneqarfik Sermersooq om forbud mod fangs tog anskydning af pukkelhvaler I Nuup-Kangerlua.2021.

FORSLAG. KOMMUNEPLANTILLÆG 010-1 KONCESSIONSOMRÅDE NUNATARSUAQ, NUUK. AUGUST 2022.

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- Siumut efter fredning: Fjorden er forvaltet til en zoologisk have. 30. Juni 2021.
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6.5.4. Gran Sameby (Gällivare, Jokkmokk and Malå)

Gran sameby is a reindeer herding community with extensive territories, a maximum of 7000 reindeer in the culled herd and approximately 50 members centred around 7 families. Gran is an amalgamation of local Ume-Sámi and the North-Sámi that were forcefully moved by the Swedish state, so that two distinct languages are spoken. In June of 2019, Vindelälven-Juhttátahkka which covers vast areas of Gran territory, received the designation as an UNESCO Biosphere Reserve. Gran is an active member on the board and has worked since 2013 on building knowledge and interaction with other Biosphere Regions and participates in projects with great and useful results. Gran has also created close bonds with the Innu First Nation in Pessamit, Manicouagan-Uapishka Biosphere Region, Quebec, Canada.

Gällivare Indigenous hub

The Gällivare municipality is part of the traditional lands of Sami people in the greater Sapmi land area. The town of Gällivare is located in Swedish central Norrbotten and can be seen as a hub for the three Sami reindeer herding communities (samebyar) Gällivare, Baste Cearru and Unna Tjerusj. The population in Gällivare municipality is 17000. The Gällivare municipality covers 8321 km2 and spans from the town of Gällivare in the north to the islands and coastline of the Bay of Bothnia in the south (Figure 80).

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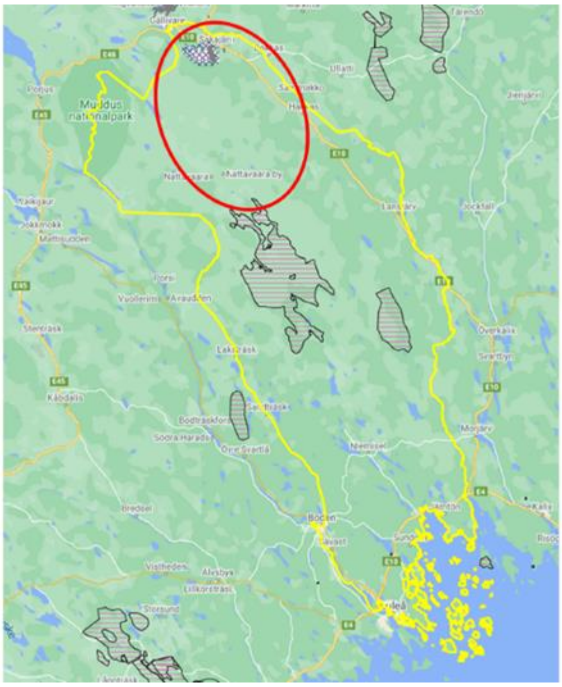

Figure 80. Gällivare sameby spans more than 200 km from Gällivare town to the coast of the Bothnia Bay. The centre is located within the red circle (References)

The area around the centre of Gällivare town is actively used for forestry, reindeer husbandry, but is also characterized by mining activity including two mines in operation by LKAB and Boliden Minerals AB (see section xxx about mining industry). Gällivare is also part of the Lule Sami area. The highest allowable number of reindeer in winter is set to 7000 individuals and in total, there are 35 active reindeer companies operating in Gällivare. In the surroundings around the center of Gällivare, most of the forest land belongs to the state-owned company Sveaskog AB, SCA AB, and to a smaller degree to other private owners. Most of the forest land is used industrially, the more specific distribution of ownership can be seen in figure 81.

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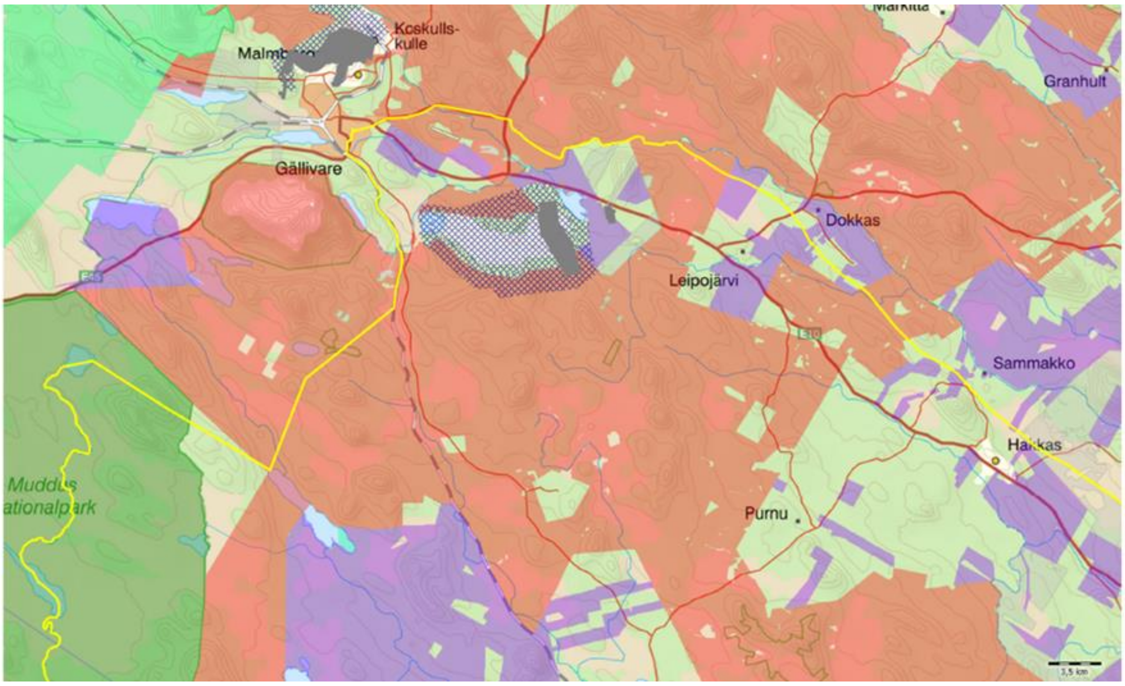

Figure 81. Land ownership for the Gällivare area. State owned Sveaskog AB (red) and SCA AB (purple) are major industrial forestland owners. Small private lands (transparent). The two mines of Malmberget operated by LKAD and Aitik operated by Boliden AB (crosshatched). The Gällivare sameby marked in yellow is furthermore loosely divided into a number of different groups. The Raatukka group is managed as its own group and makes use of the area around the Aitik mine during the entire grazing year

Jokkmokk Indigenous hub

The population of the Jokkmokk municipality is near 5000. The town of Jokkmokk is one of the most prominent centers for Sami culture and young Sami from all over Sapmi come to Jokkmokk for education. Jokkmokk is an essential meeting place for the three mountain samebyar Sirges, Jåhkågasska Tjiellde and Tuorpon which all have their winter grazing areas around Jokkmokk. In addition, the forest samebyar Slakka and Udtja also have grazing land nearby. Table 23 provides an overview of the extent of the reindeer industry in the respective samebyar around Jokkmokk in terms of people active in the industry, amounts of reindeer and numbers of active companies. The Jokkmokk samebyar have a special agreement of their common use of their winter grazing areas.

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Table 23. Overview of Samebyar around Jokkmokk including members active in reindeer hering industry, amount of reindeer and herding companies

Sameby	Number of members	Max. reindeer number	Number of reindeer companies
Sirges	385	15500	96
Jåhkågassska	100	4500	45
Tuorpon	105	9000	59
Slakka	10	1000	2
Udtja	50	2800	14

At the same time, commercial forestry is ongoing through the whole year in and around Jokkmokk. In this regard, the biggest parts of land ownership belong to Sveaskog AB, SCA AB and the National Property Board Sweden. Besides, next to smaller publicly owned land grounds, some smaller forest areas belong to private landowners. A more concrete distribution of forest land ownership can be seen in figure 82. Meanwhile, also the tourism sector is expanding in most of its form in and around Jokkmokk.

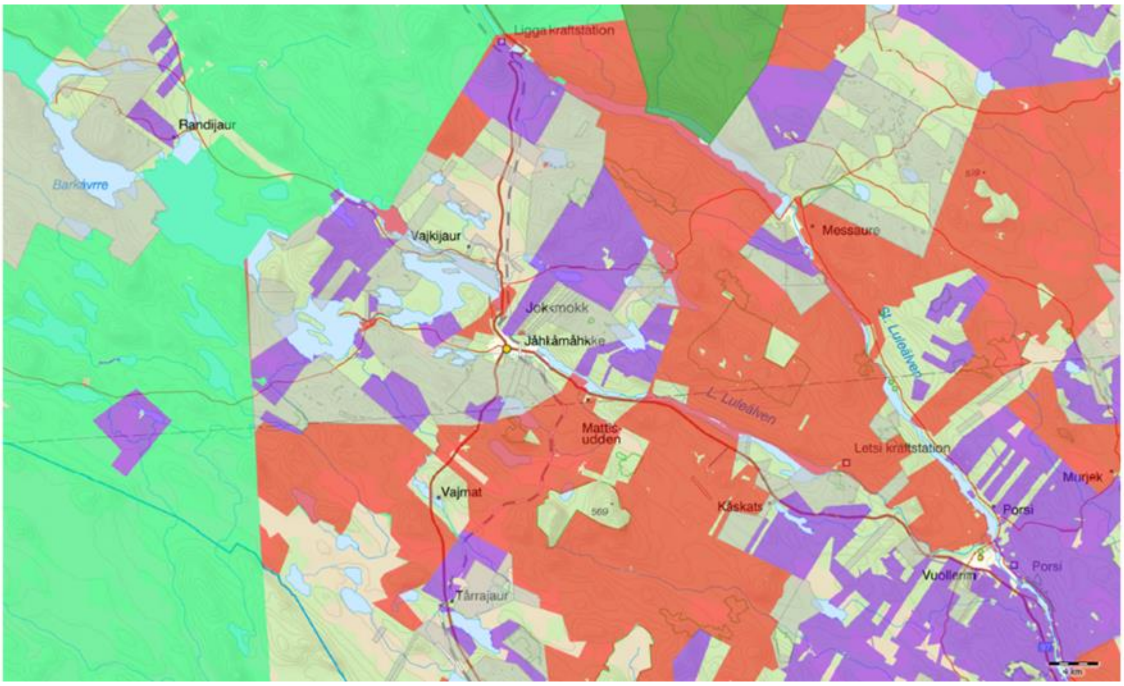

Figure 82. Land ownership in the Jokkmokk area include the state-owned forest companies Sveaskog AB (red), the National Property Board Sweden (green), SCA AB (purple), Jokkmokks forest common (gray) and small private landowners (transparent)

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Malå Indigenous hub

Malå town and municipality is located in the county of Västerbotten. The population of Malå has around 3000 people. Malå sameby which is a Sami reindeer herding community, is a forest sameby covering and area of 7713 km2. The western parts of the municipality are important grazing lands for reindeer herding all year round (åretruntmarker) and reach beyond Malå to the Sorsele and Lycksele municipalities. The winter grazing lands of reindeer expand all the way to the coast (Figure 83). The Malå sameby itself has 100 active members within the reindeer herding industry including 11 reindeer herding companies with a maximum number of reindeer of 4500 individuals in total.

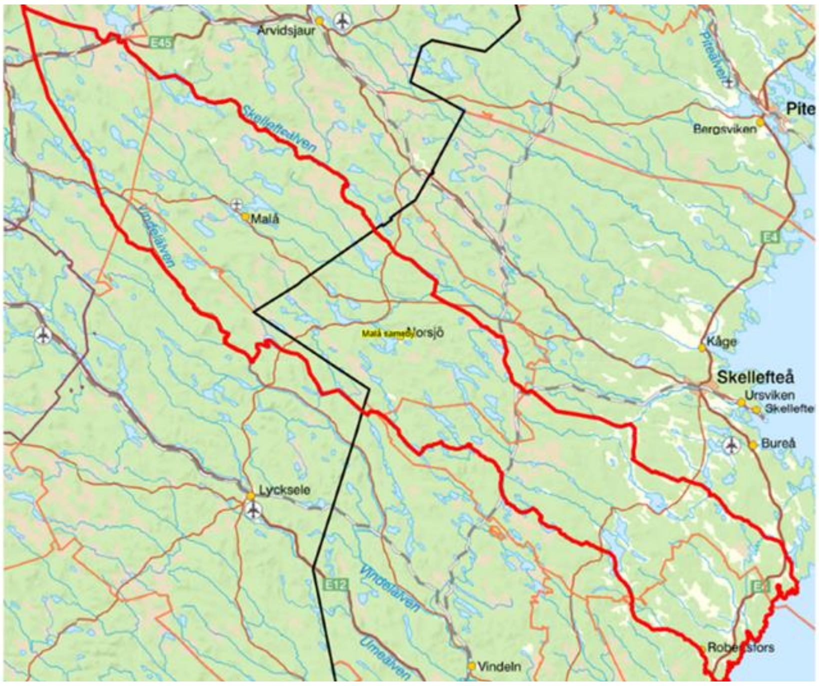

Figure 83. Malå forest sameby is located in the Swedish county of Västerbotten. West of the Lappmarksgräns (black line) grazing is allowed all year. Winter grazing lands are located east of Lappmarksgräns all the way to the coast.

As in Gällivare and Jokkmokk, forestry activities are ongoing throughout the year in Malå. Most of the surrounding forest land is owned by Sveaskog AB. In addition, land areas are owned by SCA AB and

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some smaller private owners. Figure 6 shows a more setailed distribution of landownership in and around the centre of Malå.

Moreover, Malå is characterised by the mining industry and there is a number of active and abandoned mining grounds around the Malå centre. Currently, the most active and largest mine is Kristineberg which is operated by Boliden AB (see chapter about mining industry).

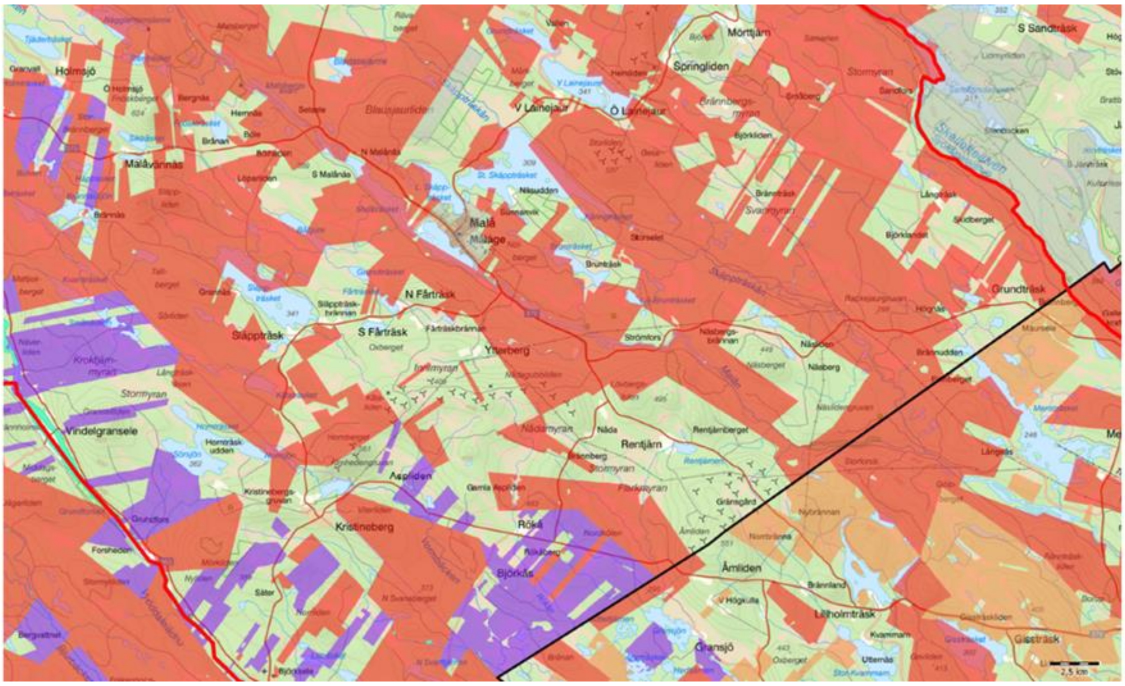

Figure 84. Land ownership for the area surrounding the town of Malå centre: State owned Sveaskog (red), SCA AB (purple) and small private forest owner (transparent).

6.5.4.1. State of the art / environmental background

(For information on the environmental background of Gällivare, Jokkmokk and Malå, please see chapter 3.1.3.1. (under the forestry and mining sections)

Indigenous Sami reindeer husbandry represents a land use system that is ultimately dependent on how other land uses are carried out, e.g. with forest areas providing lichen as a key winter resource for reindeer (Sandström et al. 2016). The reindeer husbandry system constitutes complex and unique land use form carried out by the indigenous Sami people across Sapmi, an area covering much of northern Sweden, Norway, Finland and Northwestern Russia. More than 20 other indigenous groups carry out reindeer husbandry across the Russian north and Mongolia (Oskal et al. 2009). Reindeer is recognized as a keystone species in the mountain landscape of Sweden, as well as elsewhere across

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the circumpolar range (Vors & Boyce 2009). The reindeer husbandry system can be considered the last remaining grazing system of semi-domesticated or domesticated animals that uses the native range and seasonal movements to access and use grazing resources in a similar way as its native ancestor species. By depending on continuous lands connected by migration routes for their annual long-range migrations, reindeer husbandry represents the last remaining large-ungulate migrations in the northern hemisphere (Vors & Boyce 2009).

6.5.4.2. Environmental impacts

The direct negative impacts of indigenous Sami reindeer husbandry on the natural environment can only be considered minor, and consequently there is no specific statistics describing, for example amount of gasoline used by cars, snow mobiles, trucks and helicopters. Such negative impacts are less significant when compared to the direct and indirect enviromental impacts of forestry and mining industries.

In contrast, reindeer husbandry provide a whole series of positive impacts on ecosystems and environments. An intact and well-functioning reindeer husbandry system can be seen as an indicator and a pathfinder of a healthy and well-connected ecosystem. Environments where reindeer can move and access, naturally occurring seasonal foods indicates intact natural landscapes with numerous benefits to other wildlife populations and natural systems. When the opposite is true and reindeer cannot move through landscapes, hinders and barriers to reindeer also have negative impacts on other populations natural systems.

Reindeer populations have positive impacts on biodiversity by keeping the landscape open, and as trampling and fertilization create opportunities for non-competitive species to thrive (Tunón & Sjaggo 2012). The importance positive contributions of reindeer husbandry on biodiversity is clearly manifested in the Swedish environmental goal "Magnificent mountain landscapes" where the first objective outlines the importance of "maintaining high grazing pressure to maintain the mountain landscape’s open character" (Naturvårdsverket 2019). In this environmental objective, the mountain landscapes are also identified as a Sami cultural landscape. Decreasing reindeer populations and consequent reduced grazing pressures will not only reduce biodiversity in the mountains, but also negatively affect the Sami cultural landscape and thus, the Sami culture as a whole. This highlights the link between the mountain and the forest landscapes and identifies forests as the critical bottleneck in reindeer husbandry (Kivinen et al. 2014). Consequently, if the forest landscape cannot provide for the number of reindeer needed in the mountain landscape it will have strong implications for the efforts to maintain a grazing-based cultural and natural mountain landscape and, thus, reduce biodiversity.

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Furthermore, and contrary to the goals of reindeer herders, reindeer husbandry is considered essential to maintain today's predator population targets for brown bears, lynx, wolverine and eagles. As the situation stands today, to maintain population targets for these four large carnivores depend on reindeer as a food source. Today, the agreed upon maximum of a 10% loss of reindeer to predators is far exceeded on most samebyar.

A. Habitat and landscape

Described in section before.

- Some low levels of mechanical levels in the mountains
- Supplementary feeding can lead to diseases and loss of natural behaviour of reindeers

B. 3.4.4.2.2. Changes in biodiversity

Described in section before

C. 3.4.1.2.3. Pollution

Dusting from the Aitik mine has significant negative impacts on reindeer grazing lands. We have documented long distance avoidance of summer grazing areas in Gällivare sameby south of the mining area. This is especially apparent during dry summers when dusting from the sand magazine become especially severe. During winters with prevailing westerly winds, dust on snow has been documented as far as 20 km east of the mine. Dust on snow makes it difficult for reindeer to smell the lichen through the snow. Furthermore, dirty snow hardens and is more difficult for the reindeer to dig thru.

In general terms, the impacts of other industries on reindeer husbandry in the different hubs in Sweden are quite similar. Forestry has a major impact in all hubs. Mining affects all hubs either directly as is very apparent in Gällivare and Malå samebyar or indirectly as a future threats as is the case in Jokkmokk with the proposed Gallok mine. But, threats and worries are also part of every day life in Gran sameby with proposed and ongoing permission to explore for minerals for example the Elkem mine on the border to Norway.

6.5.4.3. Conflicts

See in text above

- In some cases reindeer husbandry can limit mining expansion, tourism activities (hiking, snow mobiling, hunting), and the development of new power lines and wind mills.

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- Other land users cause overall loss of grazing land and quality of grazing land which increased habitat fragmentation and reindeer losses, but also loss of traditional and cultural landscapes and environments

6.5.4.4. Mitigation

See in text above

6.5.4.5. Ambitions

Strengthening indigenous act and develop new reindeer husbandry act.

6.5.4.6. Perceptions

No relevant material

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7. Conclusions

This delivery report, titled “Changes in the Arctic Environment as a Result of Hub Activity”, serves a compilation of data on the environmental impacts stemming from selected ArcticHub activities. It identifies economic hub activities affecting the Arctic environment and its ecosystem services, encompassing issues such as habitat fragmentation, biodiversity loss, and pollution. Drawing from a wealth of data sources, including environmental impact assessment, company reports, scientific studies, and statistical data, it represents a robust compilation provided by the task force of AH WP2 coordinated by NORCE.

By examining eighteen hubs across the Arctic, along with comparative cases elsewhere, the report sheds lights on the significant environmental shifts resulting from activities such as forestry, aquaculture, tourism, mining and indigenous practices. Furthermore, it underscores the interconnected nature of these activities and their potentials to exacerbate local conflicts. Positioned as a foundational document, this report lays the groundwork for further work packages within the ArcticHubs project.

In delving into the complexity of Arctic environmental dynamics, the report shows the need for interdisciplinary collaboration to navigate toward sustainable solutions in these vulnerable environments. Its serves a call to action, emphasizing the importance of collective efforts in addressing the multifaceted challenges posed by hub activities in the Arctic.

The findings in this report underline the intricate environmental dynamics of the Arctic, further complicated by the exacerbating effects of climate change. While acknowledging this broader context, the report zooms in on the specific impacts of hub activities, ranging from habitat fragmentation to pollution, and the arising conflicts stemming from competing interests.

Moreover, the report emphasized the heavy reliance of hub activities on natural resources within environmentally vulnerable Arctic areas. As the Arctic region is susceptible to climatic and environmental changes, these activities operate within a delicate balance. The growth and intensification of hub activities, often fueled by ambitions for expansion and heightened external interests, pose new challenges and threats to local environments.

Across multiple hubs, there is a recognized imperative for enhanced participatory dialogue among various stakeholders to foster better sustainable solutions and reduce potential conflicts in the future. Particularly significant are the findings regarding forestry and its interconnections with reindeer husbandry, highlighting the negative impact of large-scale forestry on lichen crucial for reindeers’ food supply. Mitigation strategies, such as thinning techniques and improved participatory dialogues between reindeer husbandry and forestry, are emphasized by both Finnish and Swedish hubs.

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Aquaculture activities across Actic Hubs evoke shared environmental apprehensions, especially concerning the escape of farmed fish and transmission of diseases to wild populations. This exacerbated by an increased growth of foreign investment and ownership, adding complexity to potential conflict zones with mining, indigenous interests, and traditional fishing.

Similarly, rapid tourism growth in several hubs leads to further infrastructure projects, paradoxically contributing to overcrowding and environmental pressures. These developments underscore the need for a delicate balance between economic growth and environmental preservation, especially in areas prized for their pristine natural landscapes.

Mining activities present significant environmental changes, including pollution, habitat destruction, and impacts in wildlife habitats.

Indigenous communities, predominantly in traditional reindeer husbandry find their practices intersecting with modern activities, often leading to conflicts with mining, tourism, and forestry interests. In navigating these complex challenges, fostering dialogue and understanding among stakeholders becomes imperative. As indigenous communities grapple with habitat fragmentation loss, the report emphasizes the importance of respected and integrating traditional practices into modern activities to ensure more local owenership and sustainable futures.

This report is the result of extensive collaboration among diverse hub coordinators, representing various backgrounds, disciplines, and geographical origins. Methodological reflections within the report underscore the diverse sources of data utilized, emphasizing the importance of standardizing concepts to facilitate interdisciplinary collaboration.

As a foundational document, this report lays the groundwork for further work within the ArcticHubs project. It serves as a comprehensive handbook for forthcoming ArcticHubs work packages, which will employ additional, complementary co-production methodologies in collaboration with local communities and stakeholders.

The diverse range of activities within ArcticHubs poses numerous. Each activity brings forth unique environmental concerns, underscoring the imperative for careful management and effective mitigation strategies. These hubs, often characterized by small-scale societies, serve as intense intersections of global activity, where conflicting interests and ambitions collide. Despite ambitions for growth across various activities, these expansions introduces paradoxes within the realms of environmental, economic, and societal sustainability.

Interconnected complexities effects are evident, not only within individual hub activities, but also in their interactions with one another. It is noteworthy that multiple hub activities are co-located within the same hub, amplifying the interconnectedness and escalation of environmental impacts. The

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presence of several negative feedback loops underscores the need for interdisciplinary cooperation and increased participation of local communities in politics and research.

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