CAPARDUS - Capacity-building in Arctic standardization development

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Arctic in a summary: A horizontal scan report

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CI	Classified, information as referred to in Commission Decision 2001/844/EC	

EXECUTIVE SUMMARY

The report provides an overview of the Arctic with focus on the human activities and how they are affected by climate change, economic opportunities and changing geopolitical situation. The report gives a summary of the Arctic Council working groups and the Indigenous Peoples' organisations, the main economic activities, research, infrastructure, technologies and services. All these factors are needed for sustainable development in the region, bringing broad social and economic benefits within and beyond the Arctic region. The report is complementary to the specific topics presented in the workpackages from WP1 to WP7, which have focus on studying the development of standards, guidelines and practices for environmental protection, economic development and other activities in the Arctic.

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1. Introduction

The horizontal scan report is a brief review of the main actors and their main activities, which represent the basis for sustainable development in the Arctic. The report also summarizes some key technologies and services that brings societal and economic benefit to the Arctic, both to the local communities and to external actors. The report describes general aspects of the development in the whole Arctic region, complementing the case studies in CAPARDUS which are specific for the selected Arctic communities.

The boundaries of the Arctic region are defined in different ways, depending on the context, as shown in Fig. 1.

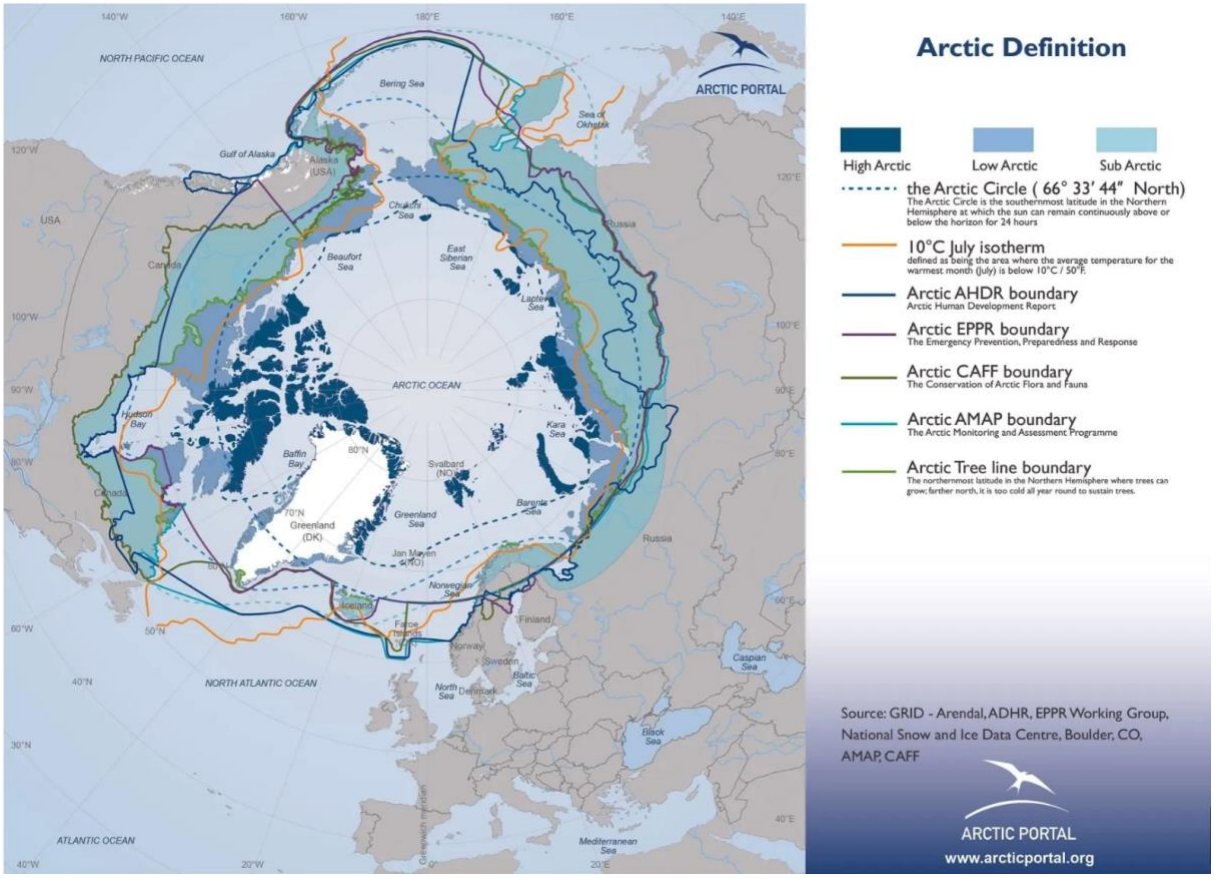


Figure 1. Map of the Arctic with different definitions of the boundary. Examples of climatological boundaries are the 10 degree C July isotherm and the Arctic tree line boundary. Four of the Arctic Council working groups have defined other boundaries.

2. The main actors in the Arctic

2.1 The Arctic Council

The Arctic Council is the leading intergovernmental forum promoting cooperation, coordination and interaction among the eight Arctic States (Canada, Denmark, Finland, Iceland, Norway, Russian Federation, Sweden and the United States of America), Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, in particular on issues of sustainable development and environmental protection in the Arctic. It was formally established in 1996 by the Ottawa Declaration.

Arctic Council also has six Indigenous Peoples' organisations as members (Fig. 2) and some non-Arctic states, along with inter-governmental, inter-parliamentary, global, regional and non-governmental organizations as observers (https://arctic-council.org).

Figure 2. Indigenous Peoples' organisations who are members of the Arctic Council

The Council's activities are primarily conducted in six Working Groups (Fig. 3) and one standalone Expert Group that cover a broad field of subjects, from climate change to emergency response, from mental health to sustainable development.

Figure 3. Arctic Council Working Groups

The ***Arctic Monitoring and Assessment Programme*** (AMAP) started in 1991, before Arctic Council was established. AMAP is mandated to monitor and assess the status of the Arctic region with respect to pollution and climate change issues. Furthermore, AMAP documents levels and trends, pathways and processes, and effects on ecosystems and humans, and propose actions to reduce associated threats for consideration by governments. AMAP also produces science-based, policy-relevant assessments and public outreach products to inform policy and decision-making processes. AMAP has established thematic data centres for atmospheric contaminants data, marine contaminants data**,** and radioactivity data (https://www.amap.no/about) . Since 1995 AMAP has produced more that 80 assessment report and technical reports.

Conservation of Arctic Flora and Fauna (CAFF) is mandated is to address the conservation of Arctic biodiversity, and to communicate its findings to the governments and residents of the Arctic, helping to promote practices which ensure the sustainability of the Arctic's living resources. It does so through various monitoring, assessment and expert group activities. CAFF's projects provide data for informed decision making to resolve challenges arising from trying to conserve the natural environment and permit regional growth (https://caff.is/) .

Protection of the Arctic Marine Environment (PAME) addresses marine policy measures in response to environmental change from both land and sea-based activities. PAME develops and coordinates

strategic plans, programs, assessments and guidelines, complementing existing legal arrangements aimed at protection of the Arctic marine environment (https://pame.is/).

Emergency prevention, Preparedness and Response (EPPR) is tasked to (1) Develop guidance and risk assessment methodologies; (2) Exchange information and best practices regarding prevention, preparedness and response to accidents and threats from unintentional releases of pollutants and radionuclides, and to natural disasters; (3) Coordinate response exercises and training; and (4) Maintain the operational guidelines for two of the legally binding agreements negotiated under the auspices of the Arctic Council, agreements on Search and Rescue (SAR) and Cooperation on Marine Oil Pollution Preparedness and Response (MOSPA). More info at https://eppr.org/ .

Arctic Contaminants Action Program (ACAP) was established as the sixth working group, mandated to work to prevent and reduce pollution and environmental risks in the Arctic. ACAP carries out demonstration projects to raise awareness and show possibilities to cut pollution in the Arctic and clean up. ACAP encourages nations to strengthen policies and take actions to reduce pollutants and mitigate associated environmental, human health and socio-economic risks. More information at https://arctic-council.org/about/working-groups/acap/home/.

Sustainable Development Working Group (SDWG). The goal of SDWG is to propose and adopt steps to be taken by the Arctic States to advance sustainable development in the Arctic. This includes opportunities to protect and enhance the environment and the economies, culture and health of indigenous peoples and Arctic communities. In 2004 the Arctic Council prepared an extensive report giving an integrated picture of the state of human development in the circumpolar Arctic. The report, entitled Arctic Human Development report, has been supplemented by a number of updated reports on the human development in the Arctic (https://oaarchive.arctic-council.org/handle/11374/51). The SDWG proposes and adopts steps to be taken by the Arctic states. This includes pursuing opportunities to protect and enhance the environment, economies, culture and health of Indigenous peoples and Arctic communities. The SDWG leads a number of projects on topics such as food innovation, digitalization of Indigenous languages, mental health and suicide prevention, waste management, sustainable energy and other activities (http://sdwg.org).

The strategic vision for the Arctic Council's Sustainable Development Working Group for the period 2017 – 2030 has defined a set of priorities and project areas to strengthen the resilience and well-being of the peoples of the Arctic and promote the three basic sustainable development pillars: ***social equity, economic development and environmental protection*** (https://oaarchive.arctic-council.org/handle/11374/1940).

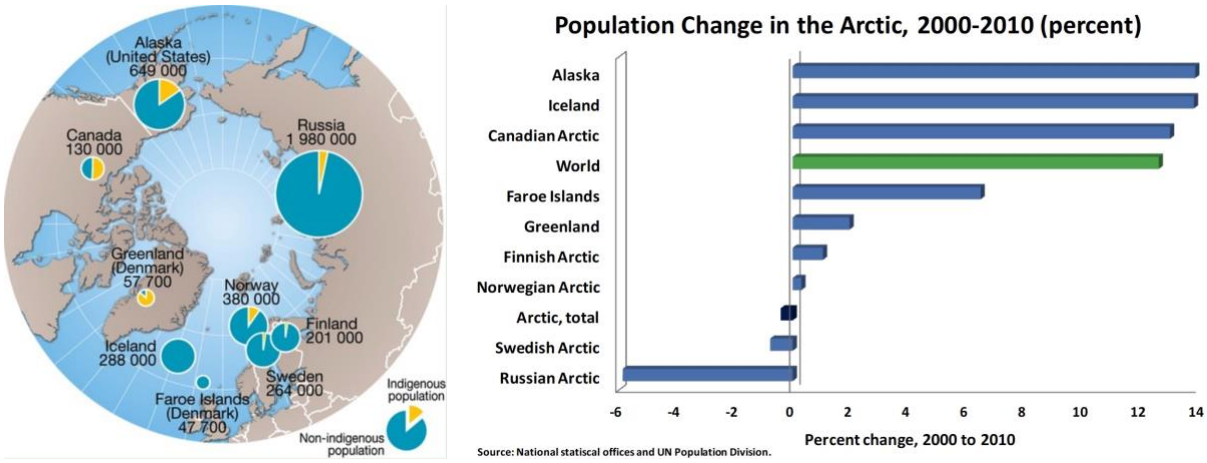
Table 1: Priorities and project areas

• Community vitality • Economic assessment • Educational opportunities • Heritage and culture • Human health • Infrastructure	• Reduction/elimination of inequalities • Science and research for sustainable development • Sustainable business involvement and development • Sustainable energy • Transportation links • Water and sanitation services

The Arctic Council has been an important organisation to promote collaboration between the members on environmental and climate issues, shipping, pollution, search and rescue, support to Indigenous People and other topics. However, after the Russian invasion in Ukraine in February 2022, the formal functions of the Arctic Council was put on hold, and collaboration activities were strongly reduced. As of May 2023, when Norway takes over the chairmanship of the council after Russia, it is not clear how the council will operate in the next two years. However, it is expected that some activities of the working groups, permanent participants and observers will be restored.

2.2 People living and working in the Arctic

The Arctic represents one of the most desolate and sparsely populated areas in the World, with few economic opportunities and in hostile climate. There are about 4 mill. inhabitants in the Arctic, and about 10 % are Indigenous People, living to a large extent of traditional livelihood such as hunting, herding, fishing or trapping. Except for Greenland and Northern Canada, indigenous peoples form a minority, though they can form the majority in local communities. In parallel with traditional livelihood, they are participants in the modern society where they adopt new technologies as they become available. The map in Fig. 4a shows the population distribution by country and Fig 4b shows the changes in population from 2000 to 2010, which increases in most regions, except in Russian and Swedish Arctic. The same trends have continued from 2010 to 2020 and are projected to continue from 2020 to 2030, according to the Arctic Human Development Report, 2014 (www.norden.org/en/publications).



a b

Figure 4. (a) Population in each of the Arctic regions divided into indigenous and non-indigenous people and (b) changes in percent from 2000 to 2010. From the Arctic Human Development Report (2014) and https://www.grida.no/resources/7154

The six Indigenous People's organizations represented in the Arctic Council are shown in Fig. 5 and described as follows.

The Aleut International Association (AIA) is a not-for-profit corporation that represents the Indigenous peoples of Aleut descent in the United States and the Russian Federation. It was created by the Aleutian Pribilof Islands Association (APIA) and the Association of the Indigenous peoples of the North of the Aleut District of the Kamchatka Region of the Russian Federation (ANSARKO). AIA is governed by a

Board of Directors comprised of four Alaskan and four Russian Aleuts under the leadership of a president. AIA was formed to address environmental and cultural concerns of the extended Aleut family whose wellbeing has been connected to the rich resources of the Bering Sea for millennia. Its mission is to promote continuity of culture and protect the resources needed to sustain it. The need to understand global processes, such as trans-boundary contaminants transport, the impacts of climate change and the effects of commercial fisheries on the ecosystem of the Bering Sea, to name a few, was an impetus in joining in the work of international fora where AIA is actively pursuing collaboration with governments, scientists and other organizations to improve the wellbeing of the Aleut peoples and their environment.

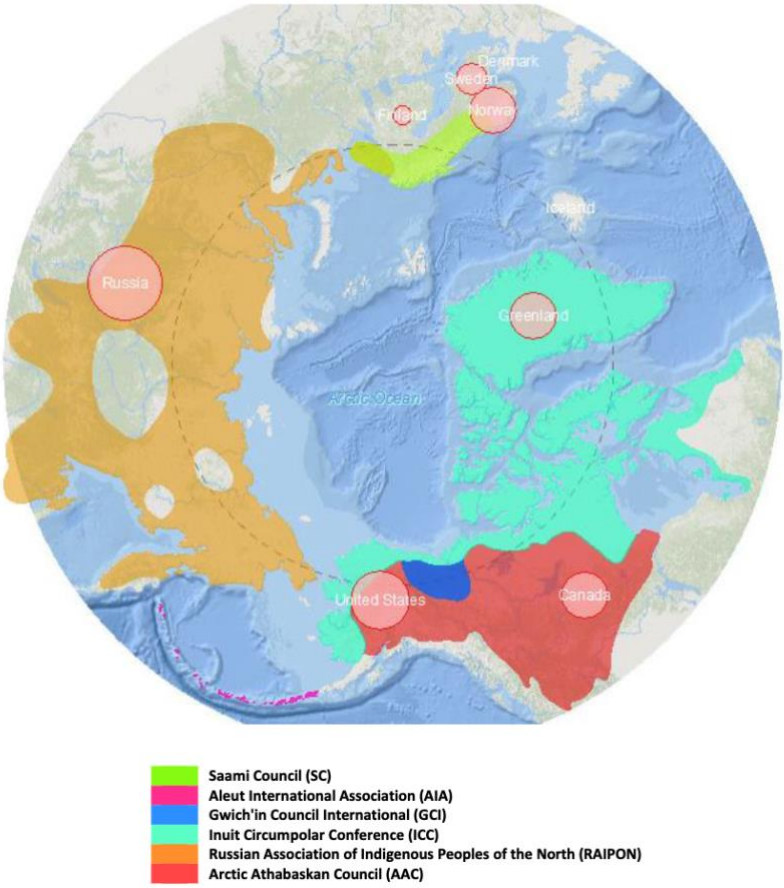


Figure 5. Area covered by the different Indigenous Peoples Organisations (Romero Manrique et al., 2018)

The Arctic Athabaskan Council (AAC) was established in 2000 to defend the rights and further the interests internationally of American and Canadian Athabaskan members. The AAC also seeks to foster a greater understanding of the shared heritage of Athabaskan peoples of Arctic North America. The Athabaskan peoples have traditionally occupied a vast geographic area of approximately 3 million square kilometers. This region has been continuously occupied by Athabaskan peoples for at least 10,000 years. The ancestors of contemporary Athabaskan peoples were semi-nomadic hunters. The staples of Athabaskan life are caribou, moose, beaver, rabbits and fish. Collectively, the Arctic Athabaskan peoples share 23 distinct languages. Peoples of Arctic Athabaskan descent represent approximately two percent of the resident population of Alaska (12,000), compared with about one-third of the Yukon Territory (10,000), the Northwest Territories and provincial norths (20,000) in Canada. Athabaskan peoples are a relatively young and growing population compared with non-Aboriginal Arctic resident groups (https://arcticathabaskancouncil.com/).

The Gwich'in Council International (GCI) is a non-profit organization that represents 9,000 Gwich'in in Alaska, United States and the Yukon and Northwest Territories in Canada. GCI's mission is to amplify the voice of the Gwich'in Nation on issues of sustainable development and the environment in international fora, predominantly the Arctic Council. GCI's membership consists of two representative bodies in Canada and one in the United States: Gwich'in Tribal Council (GTC), who represents the beneficiaries of the Gwich'in Land Claims Settlement Act in Canada's Northwest Territories; the Vuntut Gwich'in First Nation (VGFN), which is a self-governing First Nation in Old Crow, Yukon; and the Council of Athabascan Tribal Governments (CATG), for the eight Gwich'in communities in Alaska. GCI is governed by a volunteer Board of Directors, composed of four members from Canada and four from Alaska. Canada and Alaska each appoint a co-chair from its members (https://gwichincouncil.com/) .

The Inuit Circumpolar Council (ICC) was founded in 1977 and has grown into a major international non-government organization representing approximately 180,000 Inuit of Alaska, Canada, Greenland, and Chukotka (Russia). ICC has held Consultative Status II at the United Nations Economic and Social Council since 1983 and is active within the United Nations and its various subsidiary bodies. ICC consults regularly with the United Nations on a broad range of issues concerning the Arctic and Indigenous human rights. ICC was actively involved in the Arctic Environmental Protection Strategy, which later became the Arctic Council in 1996. ICC is one of the original Permanent Participants under the Arctic Council structure. ICC focuses great effort within the Arctic Council and is active in its various Working Groups, Task Forces and individual projects. ICC also participates in the Senior Arctic Officials meetings and Ministerial meetings. ICC considers the Arctic Council to be the premier international forum dealing with Arctic policy issues today (https://www.inuitcircumpolar.com/).

The Russian Association of Indigenous Peoples of the North (RAIPON) represents 40 Indigenous peoples totaling over 250,000 people living in 60 percent of the whole Russian Federation territory, including the North, Siberia and the Far East. RAIPON's goal is to protect Indigenous Peoples' human rights, defend their legal interests, assist in solving environmental, social, economic, cultural and educational issues and to promote their right to self-governance. RAIPON works with the State Duma and the Government of the Russian Federation regarding legislation related to Indigenous Peoples' issues. In addition to its status as a Permanent Participant in the Arctic Council, RAIPON participates in international structures such as the United Nations Economic and Social Council with a special consultative status and the Governing Council, and the Global Ministerial Environment Forum of the United Nations Environment Program as an observer. (https://en.raipon.info/).

The Saami Council represents the Sámi people live in Sápmi, an area that stretches across the northern parts of Finland, the Russian Federation, Norway and Sweden. There are no available statistics on how many Sámi there are, but over 100,000 is the estimate that is used most often. The majority of the Sámi population lives in Norway. There are nine total Sámi languages spoken today. The Sámi people traditionally made their living from reindeer herding, fishing, livestock farming and hunting. Since 1989, the Sámi in Norway have had their own elected assembly – the Sámediggi – which acts as a consultative body for the Norwegian government authorities (https://www.saamicouncil.net/en/home/)

The Indigenous People's organizations play a key role in the work of the Arctic Council and the Working Groups, especially the ***Sustainable Development Working Group*** (SDWG). The majority of the populations are involved in various industries or services. There are large resources in the Arctic which

have been exploited by companies related to minerals, fisheries, marine mammals, oil, gas and timber resources (Fig. 6).

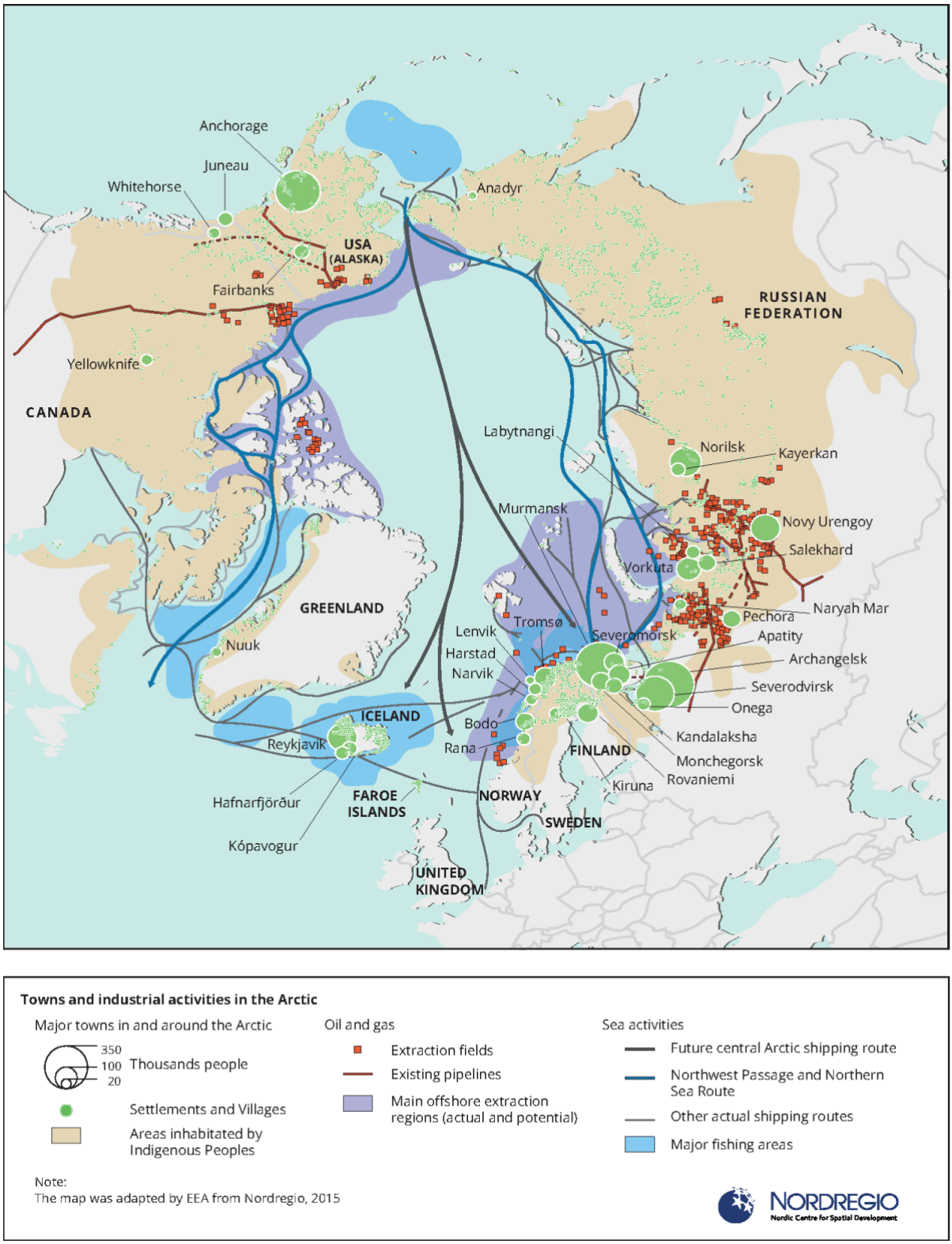


Figure 6. Map of towns and industrial activities in the Arctic. The map is adopted by EEA from Nordregio, 2015 (https://www.eea.europa.eu/data-and-maps/figures/towns-and-industrial-activities-in).

In the last few decades oil and gas exploitation has been a very profitable industry in the Arctic and it is still very important in areas such as the North Alaska slope, in the Barents Sea and in the Yamal area. The industries have generated wealth in these communities, but also negative impact on the environment and living conditions. Several of the Arctic Council's working groups have focus on monitoring and assessing the impact of industrial activities propose mitigation actions. AMAP has since 1995 produced a number of reports on pollution and contaminants from industries and proposed adaptation actions. ACAP works to encourage national actions to reduce emissions and other releases of pollutants.

Towns and larger settlements connected to industrial activities are scattered around the Arctic region, with the highest concentration in the European sector of Russia (Fig. 6). The climate warming caused by emission of CO2 from burning fossil fuel is changing the policy regarding oil and gas exploration, but the energy companies are still reluctant to phase out fossil energy because it is very profitable. The strategy of most energy companies is to replace fossil energy with renewable energy. In addition to energy extraction, the socio-economic conditions in the Arctic are changing because of severe impact of climate and environmental changes, technological advances, the geopolitical situation and the priorities of the Arctic states.

In 2021 the SDWG's Social, Economic and Cultural Expert Group published a book about the emerging forms of renewable economies in the Arctic (https://doi.org/10.4324/9781003172406). The book gives a multidisciplinary perspective on how these new economies are supported scientifically, economically, socially and politically by the Arctic states. Technologies which create new economies are discussed, where communication infrastructures with internet and mobile phones, digitalization, autonomous vehicles, Artificial Intelligence and other innovations have strong impact on the communities. The role of art and design in renewable economies is elaborated, suggesting that these creative industries can be important for sustainable development in the Arctic. Arctic tourism is another topic where impact on economy can be large if the industry develops in a sustainable direction. In a case study from Nunavut, it is demonstrated how local organizations can generate economic activities from enhancing social, cultural, health and environmental conditions of the communities and become less dependent on the extractive industries.

Energy is a key issue in all regions of the Arctic, because fossil fuel has been, and still is, the main energy source. Presently, there are several projects dealing with the transition to renewable energy, and one aspect of this transition is to ensure that the rights and needs of Indigenous groups and other local communities are taken into account. This is emphasized through the concept of energy justice. There have been examples of renewable energy projects that have had negative impact on local communities, leading to protests against windfarms.

Food supply is another vital part in all the communities. The connection and interaction between water, energy and food systems has been studied, showing that there are challenges as a result of climate change as well social and economic changes, but there are also opportunities. The food production chain, based on marine as well as terrestrial resources, has potential to grow significantly and become and export industry, but there are several obstacles that need to be solved.

Education is another important topic for Arctic communities, In 1998 the Arctic Council called for the establishment of the University of the Arctic (UArctic), and soon afterwards, UArctic was officially launched in Rovaniemi in 2001. In 2019 it was registered as a non-profit association under the Finnish

law. UArctic is organised in a network of more than 200 universities, colleges, research institutes, and other organizations concerned with education and research in and about the North. UArctic's annual magazine, Shared Voices, highlight the activities, the members, and broader issues in the Circumpolar North (https://www.uarctic.org/). In 2020 UArctic established the Læra Insitute which will renew and revitalize Circumpolar Education providing courses, workshops and symposia (https://laerainstitute.org/).

2.3 Research in the Arctic

There is a large and growing group people working in research programmes and projects in the Arctic or connected to the Arctic. The climate change, which is most significant in the Arctic, is clearly demonstrated by the thinning and reduction of sea ice, the melting of ice sheets and glaciers, thawing permafrost, more extreme weather events and increased risk for natural hazards. The impact of Arctic climate change on people and environment is a major motivation for scientists in many countries to study Arctic topics. The climate change will improve access to the Arctic and its resources, offering new opportunities for communities and for economic development related to exploration of natural resources, transport, and other industries. This changes lead to new requirements for planning and decision-making for people living and working in the Arctic. Such planning must be based on new scientific and economic assessments and predictions. The Arctic researchers come from numerous research organisations in more than 25 countries, and they have developed extensive collaboration over the last decades. The main collaboration initiatives are described in the following paragraphs.

Arctic Science Ministerial. Since 2016, when president Obama initiated the first Arctic Science Ministerial (ASM) in Washington DC, Arctic science has been brough to a higher political level. More than 25 countries, the European Union and various organisations gathered at the ASM in 2016 and the follow up events in 2018 and 2021 to strengthen efforts and collaboration in Arctic research. The third ASM in 2021 had "Knowledge for a sustainable Arctic" as the overarching theme. The main outcome of ASM3 was a Joint Statement to be signed by the Ministers of 27 participating countries and the EU proposing actions in the four priority areas:

Figure 7. ASM-3 logo

- Observe - Observing networks; Data sharing –towards implementation
- Understand - Enhance understanding and prediction capability on Arctic environmental and social systems and its global impact
- Respond - Sustainable development; Evaluation of vulnerability and resilience; Application of knowledge
- Strengthen - Capacity building; Education; Networking; Resilience –prepare the next generation

The International Arctic Science Committee (IASC) is a non-governmental, international scientific organization founded in 1990 by national scientific organizations in the 8 Arctic countries. Over the years, IASC has evolved into the leading international science organization of the North and its membership today includes 23 countries involved in all aspects of Arctic research, including 15 non-

Arctic countries (Austria, China, the Czech Republic, France, Germany, India, Italy, Japan, the Netherlands, Poland, Portugal, South Korea, Spain, Switzerland and the UK). IASC is convener of the International Conference on Arctic Research Planning (ICARP) every 10 years. ICARP has focus on long-term planning where Arctic researchers, Indigenous Peoples, policy makers, residents and stakeholders from around the world are to discuss the state of Arctic science, the place the Arctic occupies in global affairs and systems. The next conference (ICARP IV) will take place in 2025.

The Agreement on Enhancing International Arctic Scientific Cooperation (sometimes colloquially referred to as the Arctic Science Agreement) was signed by the eight Arctic Governments on May 11, 2017 in Fairbanks, Alaska. the Agreement entered into force on May 23, 2018. The Agreement facilitates access by scientists of the eight Arctic governments to Arctic areas that each government has identified, including entry and exit of persons, equipment, and materials; access to research infrastructure and facilities; and access to data. The Agreement also calls for the parties to promote education, career development and training opportunities, and encourages activities associated with traditional and local knowledge. More information at https://iasc.info/cooperations/arctic-science-agreement

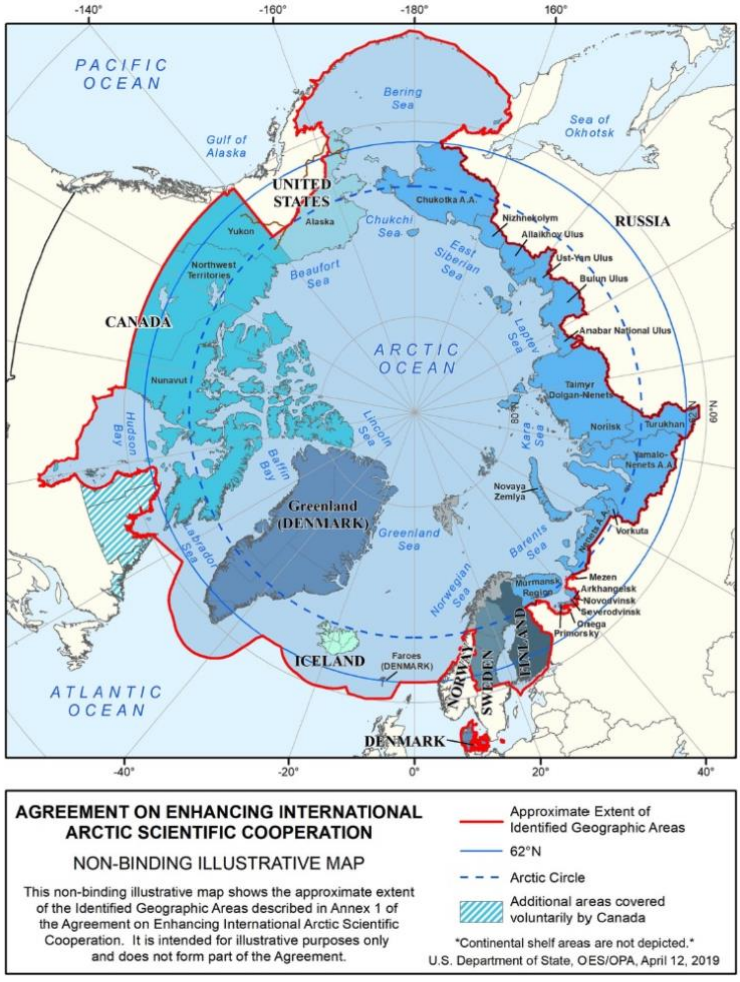


Figure 8. Map of the area included in the Arctic Science Agreement signed by the eight Arctic Governments

The European Union is developing an integrated policy for the Arctic, where research plays a central role. In the Joint Communication from 2016, it stated that EU's Arctic policy should focus on advancing **international cooperation** in responding to the impacts of **climate change** on the Arctic's fragile environment, and on promoting and contributing to **sustainable development,** particularly in the European part of the Arctic. In EU's updated Arctic policy from 2021, the aim is to help preserve the Arctic as a region of peaceful cooperation, to slow the effects of climate change, and to support the sustainable development of Arctic regions to the benefit of Arctic communities, not least Indigenous Peoples, and future generations. EU has become a major funder of Arctic research programmes and projects, supplementing national and other programmes (https://www.eeas.europa.eu/eeas/eu-arctic-fundingprogrammes_en) .

There are many European organisations, progammes, projects and networks dealing with polar research, where Arctic is one of two main polar regions. The EU Polar Cluster is a network of collaborative polar projects, which are funded by the European Commission, and three permanent members: the European Polar Board (EPB), Association of Polar Early Career Scientists (APECS) and Svalbard Integrated Arctic Earth Observing System (SIOS). The European Polar Board is an independent organisation focused on major strategic priorities in the Arctic and Antarctic. EPB Members include research institutes, logistics operators, funding agencies, scientific academies and government ministries from across Europe.

Figure 9. Logos of EU Polar Cluster and European Polar Board

The European Commission is a major contributor to Arctic research and has provided "An integrated European Union policy for the Arctic" with three priority areas:

- *Climate change and safeguarding the Arctic environment*
- *Promoting sustainable development in the region, and*
- *Supporting international cooperation on Arctic issues.*

In response to these priority areas, the EU-PolarNet project has coordinated the work to prepare a set of White papers (Fig. 10) describing the development of an Integrated Polar Research Programme for the European Commission. The white papers deal with (1) The coupled polar climate system, (2) Footprints on changing polar ecosystems, (3) Managing human impacts, resource use and conservation of the Polar Regions, (4) The road to the desired states of social-ecological systems in the Polar Regions, and (5) Advancing operational informatics for the Polar Regions.

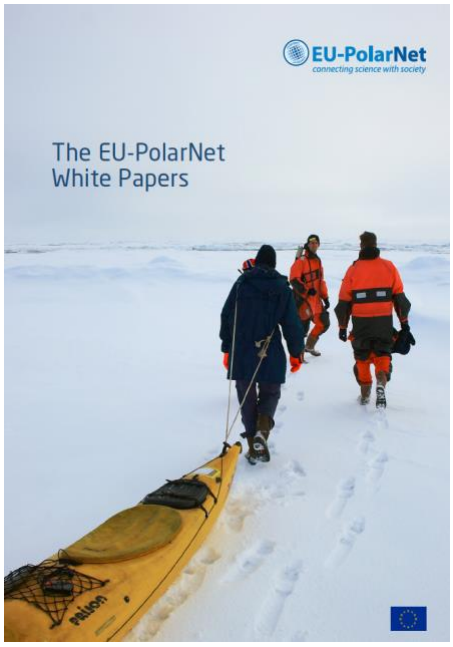


Figure 10. Cover page of the EU- Polarnet White Papers

Copernicus is the world's largest Earth Observation Programme provided by the European Union. Copernicus produces vast amounts of global data from satellites and ground-based, airborne, and seaborne measurement systems provide information to help service providers, public authorities, and other international organisations. The information services provided are **free** and **openly** accessible to users. While Copernicus has focus on delivering satellite data, the in situ data including airborne data need to come from various research infrastructures around the Arctic such as land-based stations, ships, icebreakers, subsea observatories, drifting buoys and aircraft. Information about science platforms and infrastructures is provided by Forum of Arctic Research Operators. For the sea ice areas drifting ice buoys are example of science platforms for collecting in situ data, which is organized under the International Arctic Buoy Programme. Land-based stations, aircraft, ships and icebreakers are national resources allocated to research, while observing platforms, instruments, field experiments, data management systems and personnel are supported by several national and international funding sources.

2.4 Climate and environmental impact assessments

The Arctic Climate Impact Assessment (ACIA) was the first comprehensive, multidiscilinary report on climate change in the Arctic published in 2005 by AMAP, CAFF and IASC. The 1042 page scientific report described how environment, economy and peoples' lives are affected, addressing four regions with different characteristics regarding climate change and its impact:

- Region 1: East Greenland, the North Atlantic, northern Scandinavia, and northwestern Russia;
- Region 2: Siberia;
- Region 3: Chukotka, the Bering Sea, Alaska, and the western Canadian Arctic; and
- Region 4: the central and eastern Canadian Arctic, the Labrador Sea, Davis Strait, and West Greenland

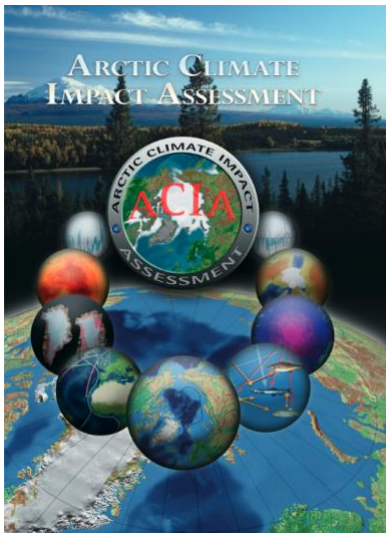


Figure 11. Cover page of the ACIA report.

The objective of the ACIA - as defined in the Arctic Council Ministers 'Barrow Declaration' - was "to evaluate and synthesize knowledge on climate variability and change and increased ultraviolet radiation, and support policy-making processes and the work of the Intergovernmental Panel on Climate Change (IPCC)." ACIA should address "environmental, human health, social, cultural, and economic impacts and consequences, including policy recommendations." ACIA was a milestone in that it was the first Arctic Council assessment to comprehensively include social science as well as natural science components - to assess the impacts of climate change on socio-economic conditions in the Arctic (https://acia.amap.no/). Since 2005 many follow-up documents have been produced by the Arctic Council on climate change, adaptation and resilience in the Arctic.

Increasing economic activity in the Arctic, including a growing number of large-scale research and industry projects with many people involved will increase the human footprint, affecting indigenous populations as well as the environment. On this background the Arctic Environmental Impact Assessment (EIA) project was run from 2017 to 2019. The EIA studied how to plan and design large-scale projects in a way that gives consideration and value to the voice and knowledge of Arctic inhabitants is a driving force behind the project. (https://sdwg.org/what-we-do/projects/arctic-eia-environmental-impact-assessment/) In detail, the project identified three current topics needing specific attention to improve EIAs in the Arctic: 1) Meaningful engagement 2) Utilization of Indigenous knowledge and local knowledge as complementary to scientific knowledge and 3) Trans- boundary impact assessments. The first two themes appeared consistently throughout the workshops of the Arctic EIA project with about 180 participants total. The third theme was valued as important by the Editorial Group of the project. The final report was entitled «Good Practices for Environmental IMpact Assessment and Meaningful Engagement in the Arctic – Including Good Practice Recommendations (https://oaarchive.arctic-council.org/handle/11374/2377).

The use of icebreakers is important for conducting research and provide logistical services in both Arctic and Antarctic (Fig. 12). Several countries build and operate icebreakers to be present in the Polar regions In the coming decade there will be serval new icebreakers conducting research, transporting tourists, exploring natural resources, providing logistical services and supporting local communities. There has

been little debate on the environmental concerns of operting icebreakers until now. Recently, a new article this concern has been raised where potential negative effects of breaking ice is discussed (https://steadystate.org/icebreakers-in-the-arctic-an-overlooked-environmental-concern/).

Figure 12. Left: Russian nuclear-powered icebreaker. CC BY-NC-SA 2.0, GRID-Arendal) Right: U.S. Coast Guard Polar Icebreaker/Research Vessel Healy breaking ice in the Arctic, November 30, 1999 Photo by U.S. Coast Guard/Handout via Reuters

The Environmental Impacts Action Group of the European Polar Board has produced a synthesis report on the environmental impacts of research and logistics in the Polar regions (Elshout et al., 2023). Field-based research is necessary to collect data to understand the climate system in the Arctic, but the field activities should be planned and conducted with minimal footprint on the environment. The report describes the impact of different types of infrastructures and field operations on the environment (Fig. 13) and summarizes the legal framework for polar research. The report also provides examples of best practice and experience of conducting field-based research with reduced impact on the environment.

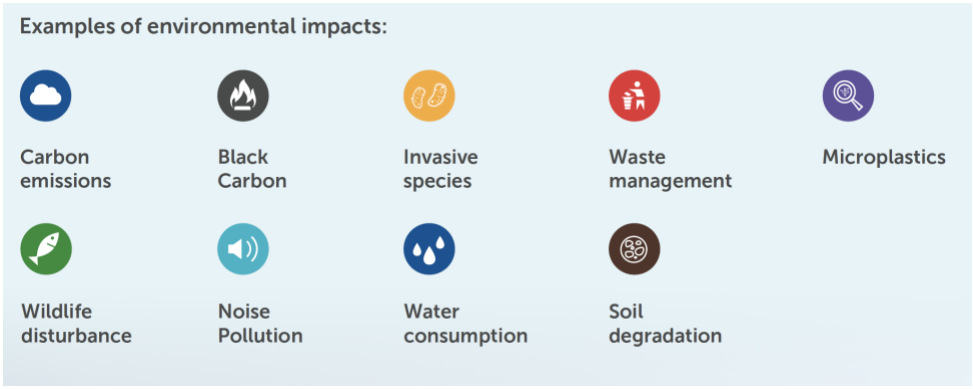


Figure 13. Types of environmental impact of polar research (from Elshout et al., 2023).

The Arctic Council's working groups have produced a number of environmental impact reports starting in 1992, which are available at https://arctic-council.org/resources/.

2.5 Shipping and tourism

Since the Arctic Council's PAME working group published the Arctic Marine Shipping Assessment report (AMSA) in 2009 is a framework policy document for the Arctic states. The recommendations from AMSA have been guidelines for development of sustainable Arctic shipping. A number of projects, policy documents and shipping activities have been conducted in the last decade. The reduction in sea

ice combined with the potential of a transarctic shipping using the shorter sailing routes between Asia and Europe can generate more ship traffic (Fig. 14).

Figure 14. Cover page of the AMSA report (left) and a map of the three major important Arctic shipping routes (right).

The Northern Sea Route is most important because a longer ice-free season is already observed and the ice conditions are more favourable compared to the other routes. In the last few years, transport of oil and gas form the Yamal field has become the most important ship transport in the Arctic. Ship traffic is also foreseen in the Northwest Passage and the central Arctic Ocean, but presently there is no regular ship traffic along these routes. PAME provides extensive information about Arctic Shipping projects, status report and other documents on their website (https://pame.is/arctic-shipping). PAME has also established the Arctic Ship Traffic Data system, where statistics of ship traffic has been provided from 2013 to 2019 (http://astd.is).

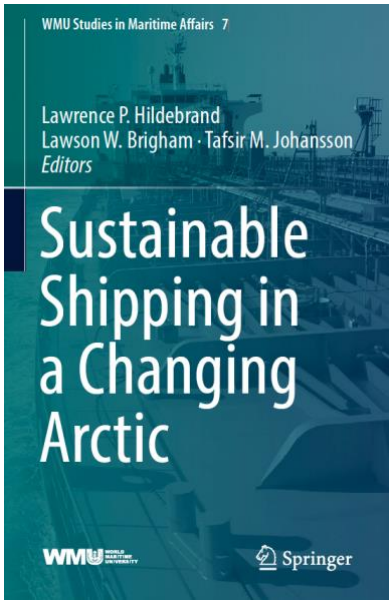


Figure 15. Cover page of the book by Hildebrand, Brigham and Johansson

The recent status and perspectives on Arctic shipping are described in the book "Sustainable Shipping in a Changing Arctic" (Fig. 15) edited by Hildebrand, Brigham and Johanson (2018) under WMU Studies in Maritime Affairs (https://doi.org/10.1007/978-3-319-78425-0).
WMU (World Maritime University) aims to develop capacity and expertise in maritime education and training; law and policy; safety and environmental administration; port management, shipping management, and logistics; maritime energy management; and ocean sustainability, governance, and management. The 23 chapters of the book describe different aspects of the fundamental changes that take place in the maritime Arctic with impact on shipping. The changes are connected to globalization where Arctic natural resources are part of global markets, dramatic climate change and its impact on

people living and working in the Arctic, and regional and global geopolitics where Russia is a key player because of the Northern Sea Route.

The Arctic has become an increasingly popular tourism destination. The increased interest in tourism in the Arctic has resulted in the building of relevant infrastructure and influenced the region, and the people inhabiting it. It has also had an impact on the cultural identity and traditional livelihoods of the region. In particular, the recent rapid growth of tourism, and activities associated with it, will have permanent impacts on the Arctic environment and cultures. In the 3-year project *Partnership for Sustainability: Arctic Tourism in Times of Change*, funded by the Nordic Council of Ministers, Rantala et al. (2019) studied:

1) Challenges with the seasonality of Arctic tourism; high activities in part of the year and otherwise low activities. This is challenging for employment and building up professional tourist activities and investment in facilities.
2) How "arctification" has impact on how the visitor imagines the Arctic as a cold and snowy destination, neglecting the distinct environmental seasons of the North
3) How global environmental change affects tourism in the Arctic with impact on an already sensitive region, along with its capacity for building resilience.

One segment of Arctic tourism is the expedition cruises, which has several challenges, including climate gas emissions and other pollution, large number of tourists visiting vulnerable sites, risks for ship accidents in remote areas where there is lack of infrastructure to support or rescue people and vessels. On the other hand, the expedition cruise industry is very profitable and grows fast. The industry is building several new ice-strengthened vessels that will operate both in Arctic and Antarctic in the coming years. The safety of operations in the Arctic is a larger challenge than in many other regions because of remoteness and long distance in case there are accidents and there is need for assistance.

Figure 16. Map of the area where AECO members organize tourist expeditions in the Arctic (left) and photograph of MS Roald Amundsen, the new tourist vessel owned by Hurtigruten Expedition. The state-of-the-art vessel features new and environmentally sustainable hybrid technology that will reduce fuel consumption and show the world that hybrid propulsion on large ships is possible (right).

The Association of Arctic Expedition Operators (AECO) is an organization of vessel owners, tourist operators and other companies involved in cruise tourism. The main goal of AECO to develop sustainable cruise tourism in the Polar regions by ensuring that the cruise tourism is environmentally friendly, responsible, safe and follows rules and regulations (Fig. 16). AECO is building competence in their member organization through development of guidelines for the tourist guides and the tourists. AECO also participates in Joint Arctic Search and Rescue exercises.

A major challenge for the Arctic tourism is to make it sustainable, which implies that it must balance between economic profit, environmental protection and the interest of local communities where the tourists visit. In Svalbard, for example, the government has imposed stricter regulations on the tourist activities to avoid too much pressure on the vulnerable environment (Hovelsrud et al., 2021). In Greenland, the tourist traffic is expected to grow significantly in the next 2 – 5 years because two new airports are built (Nuuk and Ilulissat) which will increase the air traffic to and from Greenland.

2.6 Arctic Economic Council

The Arctic Economic Council (AEC) is an independent organization that facilitates Arctic business-to-business activities and responsible economic development through the sharing of best practices. AEC was created by the Arctic Council during the 2013-2015 Canadian chairmanship. The members are corporations, indigenous groups and partnerships across the Arctic that have an economic interest in the region. The goal is to facilitate responsible business and economic development of the Arctic and its communities. AEC will share and advocate for best practices, technological solutions, and standards. Economic activities are expected to grow significantly in the future within marine and terrestrial resource exploitation, shipping, tourism, food production, and innovations following increased human activities.

Figure 17. Logo of Arctic Economic Council and map of countries with member organisations

3. Infrastructure, technologies and services

3.1 Definition of infrastructure

A useful definition of Arctic infrastructure is given by The Arctic Institute as follows: Infrastructure is a critical way for humans to engage with each other and the natural environment. Railroads, ports, broadband internet, essential services for towns and settlements, military outposts, ice roads, mines, and airfields – just to name a few – all mediate relationships within a region. As anthropologist Brian Larkin writes, *"infrastructures are built networks that facilitate the flow of goods, people, or ideas and allow for their exchange over space. As physical forms they shape the nature of a network, the speed and direction of its movement, its temporal items, and its vulnerability to breakdown."* Infrastructure facilitates access, connection, inhabitation, and productivity in the Arctic. It supports the essential processes of habitation, from the physical structures of settlements and the provision of services like energy, water and sewage, to the facilitation of industrial, economic, and military activities, such as

mining and communications. Its degradation takes place due to the effects of permafrost and inadequate maintenance and funding. This can inflict massive costs on individuals and local and municipal governments, sometimes even forcing migration or displacement.

In 2022 The Arctic Institute presented a series of articles on infrastructure and the built environment in the Arctic. The series of articles have shown how infrastructure makes a landscape productive, protected, and inhabitable. Infrastructure is a critical point of analysis for considering human impacts and needs in the Arctic, in that it acts as a mediator, or as an interface, between politics, government, people and the natural environment. The Arctic Institute also publishes weekly news and other documents on Arctic events both in North America and Europe.

3.2 Transport systems

Transport systems are essential parts of the infrastructure in the Arctic, and sustainable development in the region depends on advancement of transport services. The transport systems are limited in the Arctic, because large areas have no population or no exploitation of resources that need to be transported to the markets. In populated areas there are usually some type of transport systems by sea, air or land including rivers. Since most of the communities are living in coastal areas sea transportation is most important. Some communities can be isolated during the winter season when sea transportation is limited by sea ice. Ship transportation provides delivery of goods to local communities as well as export of resources from the Arctic to the markets.

Figure 18. Left: Map of sea transport of oil and gas from the Yamal area to ports in Murmansk and western Europe (from https://arctic-lio.com)

It is of concern that transport and logistics infrastructure is underdeveloped in large parts of the Arctic and the costs for operation is increasing. Methods to help in transport planning are presented by

Filippova et al. in the The Handbook of the Arctic (2022). There are examples of regions where transport systems are established and positive development takes place, such as in Longyearbyen, Svalbard and in Nuuk, Greenland.

Since the Arctic sea ice decreases the possibility to establish transarctic shipping routes between ports in Europe, east Asia and the of North America is predicted to grow. In particular the Northern Sea Route along the Russian shelf seas is expected to become important because the ice-free season becomes longer, which allows tankers, LNG ships and cargo vessels to sail along the route, Also in winter, the ice cover is thinner which makes it possible for vessels with ice class to navigate without icebreaker support. In recent years the transport of LNG from the huge gas fields in the Yamal peninsula to European ports has grown and is presently the most important shipping route in the Arctic, operating year-round (Fig. 18).

Land transport is limited because many areas have no roads. Existing roads are mainly constructed around local communities and between towns where to transport goods. During winter ice roads on frozen lakes, rivers and coastal seas has traditionally been important for transportation, but the climate change with thinner ice and shorter ice season will reduce the possibilities to use ice roads. Railways in the Arctic are mainly operated in Russia, where also ship transport is important along the major rivers. Air transport is important in many communities where this is the only means of sending goods and travelling outside their communities. In Greenland, there are air services to most of the communities either by fixed-wing aircraft or helicopter (Fig. 19).

Figure 19. Route map of Air Greenland's scheduled services to the towns and settlements in Greenland (https://www.airlineroutemaps.com/maps/Air_Greenland).

A comprehensive article on Arctic transportation systems has been published by Lavassiere et al. (2020) based on a systematic literature review of available academic articles.

3.3 Energy and other natural resources

The vast hydrocarbon resources in the Arctic is a major driver for the industrial and transport development in the Arctic. As shown in Fig. 5 there are oil and gas extraction fields in Alaska, Canada, Barents and Kara Sea and many places in western Russia. Energy in the Arctic is at the core of geopolitics, where Russia is the largest exporter of oil and gas from the region. In addition to energy reserves, critical minerals, and fisheries, newly opened shipping routes across the Arctic could potentially help to re-route global trade and enable high-speed Internet connectivity between Europe and Asia. The ability to exploit newly available Arctic resources is drawing increasing interest from both commercial and national actors to pour both political and financial capital into the region. For further reading about Arctic resources and geopolitics there are numerous interesting articles, such as *Arctic Competition* published by Foreign Policy (Fig. 20), Geopolitical Competition in the *The Arctic Circle* published by Harvard International Review, and the news website Arctic Today.

Figure 20. Map of Arctic territorial boundaries and disputed areas, with legend inserted. Source: Durham University, Department of Geography. The figures are presented in the article by Foreign Policy.

The pursuit for Arctic oil and gas has become more controversial because it is conflict with the Paris agreement on reducing climate gas emission and the political goal to shift to green energy. The demand for oil and gas from other countries than Russia increased dramatically after the Ukrainian war. This caused a strong pressure to increase the oil and gas production from the Norwegian fields in the Arctic. As a result, Norway overtook in 2022 Russia as Europe's biggest natural gas supplier and representatives for the government stated that Norway seeks to maintain Europe's energy security by exploring the Barents Sea for further oil and gas resources. The statement from the government caused strong reactions from the environmental organisations who protest against more oil and gas production in general and especially in the Arctic. This conflict has been frequently addressed in the news, such as in the CNBC article from May 22, 2023. In Norway, the largest gas field in the Arctic is Snohvit, a subsea production platform which contributes to Norwegian LNG export to Europe (Fig. 21). In Alaska a new gas field has been approved and will become a major supplier of LNG, much of it will be for the international market.

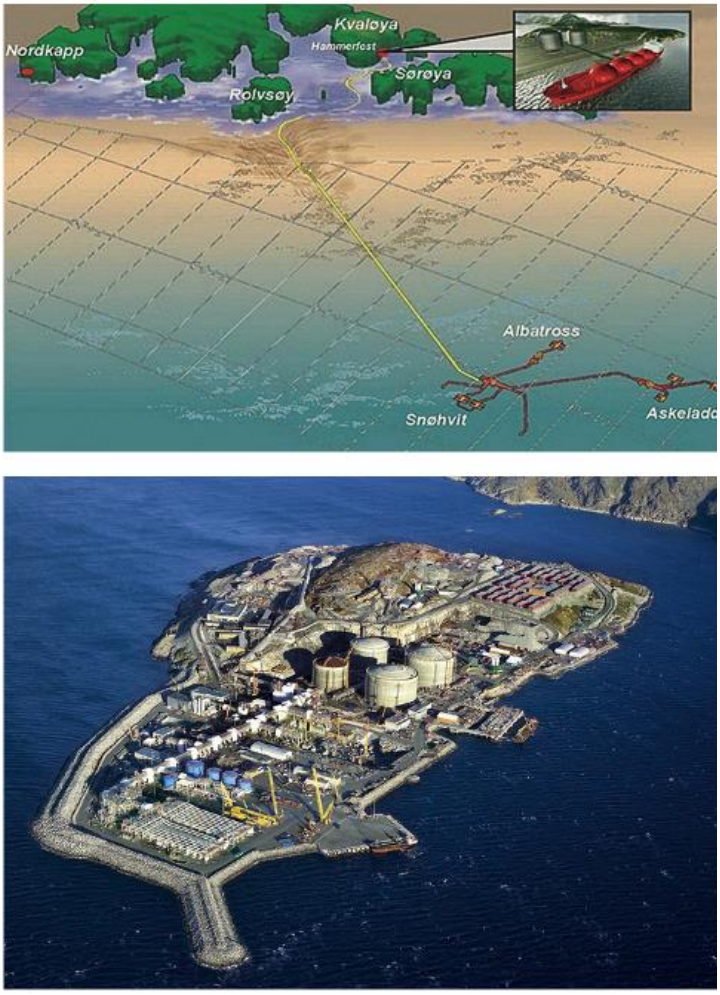


Figure 21. Map of the Snøhvit subsea production field in the Barents Sea off the coast of Northern Norway (left) and the 140 m pipeline to the LNG facility at Melkøya near Hammerfest (right). Courtesy Equinor and Norwegian Petroleum Directorate (https://snl.no/Sn%C3%B8hvit_-_petroleumsfelt).

At present people in the Arctic rely strongly on fossil fuels for their own consumption. Although large quantities of oil, natural gas and coal are exported from the Arctic, much of the fuel used locally are imported diesel, natural gas and coal. But there are ongoing efforts to change from less fossil energy to more renewable energy. In many locations, diesel fuel is augmented with local sources of renewable energy such as hydropower, wind, solar, biomass, marine hydrokinetic or geothermal energy. It is characteristic for Arctic communities to have local microgrids because they are not connected to the regional or nationwide power grid (Fig. 22). Microgrids can be stand-alone systems made to serve the needs of a specific local community or site. Microgrids are usually based on one or more sources, typically diesel and some locally available resources which are often renewable. Alaska plays a leading role to incorporate renewable sources into more than 75 community-scale microgrids. In Canada,

Greenland, Svalbard and other regions there are ongoing planning and testing how to best include renewable energy in their grid.

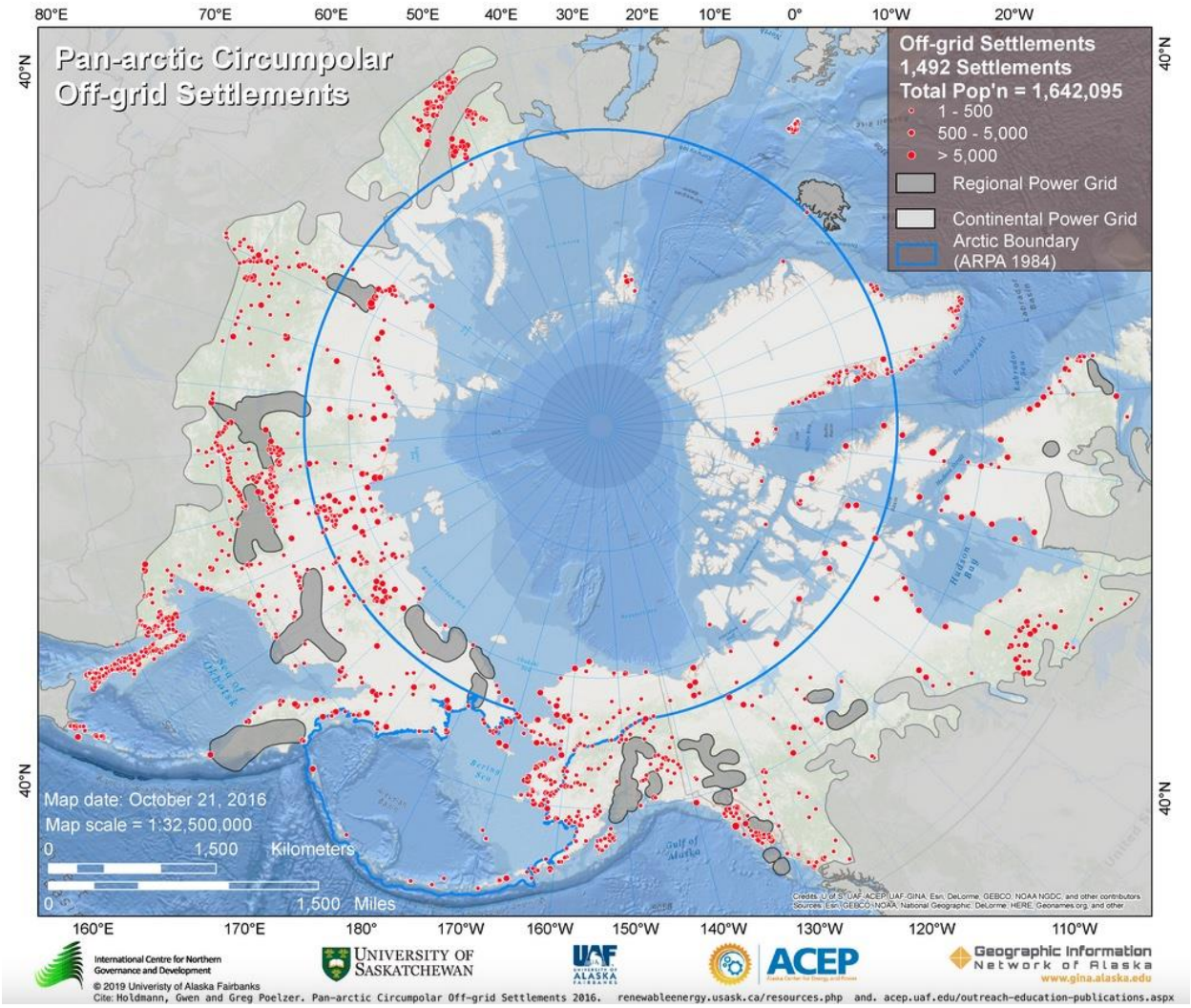


Figure 22. Map of Arctic settlements with off-grid power systems (microgrid). Image source: Holdmann, Gwen and Greg Poelzer. Pan-arctic Circumpolar Off-grid Settlements [map]. 1: 32,500,000. Fairbanks, Alaska: Alaska Center for Energy and Power. 2016. https://renewableenergy.usask.ca/resources.php and http://acep.uaf.edu/outreach-education-publications.aspx .

3.4 Food supply

The food supply in the Arctic is based both on local harvest/production and food transported from outside the Arctic. Some communities are almost completely dependent importing food while others can rely mostly on local resources. In many parts of the Arctic food production is important and represents a major source of income for the communities. There is significant potential for exporting more food from fisheries and other aquatic resources, meat from farming and hunting, agricultural production and many locally produced specialities building on traditions. However, there are many challenges for the food production, which are connected to access to raw material, marketing access, skilled workforce, environmental issues, and infrastructure.

In SDWG of Arctic Council initiated projects to assess the potential for increased production and added value of food from the Arctic. In the project "The Arctic as a food-producing region" the conditions for increased production are studied, both to improve food security in northern regions, and to increase the added value of food originating in the Arctic. The goal of the project was to identify new food production opportunities that could lead to sustainable economic development for Arctic communities. Preliminary results show that within the Arctic region there are considerable opportunities for commercial food production, both for export and for meeting local food needs. Food industries are producing large volumes of food commodities that are culturally compatible with indigenous\local food preferences and also have high export value. The final report from this project is published by the SDWG (Natcher et al., 2019).

Another project initiated under SDWG is the Arctic Food Innovation Cluster. This project will pull together relevant people in the Arctic foods value chain for a cluster-based approach to food production and regional economic development.

Figure 23. Fisheries and Agricultural Village in Lofoten, Norway (Photo Credit Nofima)

3.5 Health and well-being

Health and weee-being for people living in the Arctic are similar to people living other places, but certain issues are more important in specific Arctic communities. These include infectious deseases, heavy pollution in some industry regions, food insecurity because climate change have impact on fishing, hunting and other traditional food sources. COVID-19 was a particular severe pandemic, affecting also the Arctic communities awhere access to healtcare is limited . A number of studies have conducted , giving insight into how the pandemic affected communities (e.g. Petrov et al., 2021). An Arctic COVID-19 website was established and is now used to track the pandemic and provide reporting cards and other information material.

One of the tasks of the SDWG is to support public health systems and services by exchange of information, assessments and innovations through projects and expert groups, e.g. the Arctic Human Health Expert Group (AHHEG). This group works to increase awareness and visibility of health concerns of circumpolar residents in the field of health research. AHHEG also works to expand health and education networks.

3.6 Telecommunication in the Arctic

Until recently, the traditional fixed-line infrastructure has been the backbone of telecommuncation in the Arctic. In a review article the specific features of the Arctic, such as coldness, snow and ice, ground frost and permafrost have elaborated regarding impact on the telecommunication lines. Similarly, the environmental conditions, combined with long distances, small populations and limited economic opportunities, have all severe impact on building and maintaining the infrastructure. The construction of telecommunication lines has often been driven by industrial development, especially in exploitation of natural resources. In the last decade, mobile network in the Arctic has become the most important communication infrastructure, in cities, towns and smaller communities. However, mobile networks and access to internet is lagging behind in many rural areas, which hampers the development of new jobs and services.

The rapid evolution of satellite communication will in near provide broadband services covering the whole Arctic. The need for communication in the Arctic is growing because human activities are increasing due to ship and air traffic, exploitation of natural resources, research activities, and tourism. Several communication companies compete to offer satellite internet services. One example is STARLINK, operated by SpaceX, which started to launch small communication satellite in 2019 and has now over 4500 such satellites in low orbit. Another example is OneWeb, which used SpaceX Falcon 9 to put more than 600 internet satellites into low orbit from a series of launches. Inmarsat, the world leader in global mobile satellite communications, will introduce two new satellite payloads dedicated to the Arctic region in a partnership with Space Norway.

Figure 24. The new broadband satellites will provide coverage in Arctic regions, areas which up until now have been terra incognita for internet surfing and the sending of large data. (Illustration: Northrop Grumman Space Systems).

Submarine cables using fiber-optic technology constitute a critical infrastructure which is th ebackbone of global communication today, although satellite communication plays an increasingly important role. In the Arctic, several submarine cables are planned, but few are implemented so far. In Alaska Quintillon has built the Alaska portion of the subsea cable shown in Fig. 25, which is connected to the terrestrial line from Prudhoe Bay to Fairbanks. Greenland is connected to Iceland and Canada through the Greenland Connect with landing points in Nuuk and other towns on the west coast.

Figure 25. The Quintillion Subsea Cable System, where Phase 1 was implemented in 2017 and the Phase 2 and 3 are planned.

A submarine cable between Norway and Svalbard was planned and implemented by Space Norway between 2002 and 2004 to support the data transport from Svalbard Satellite Station and provide state-of-the-art internet connection for the Svalbard community. In January 2022 one of the two cables was cut and had to be repaired and there were speculations in the media about sabotage or other man-made damage, especially trawling by fishing vessels. This incidence illustrated how vulnerable subsea cables can be, nor only in the Arctic. In an article entitled «Geopolitics of Subsea Cables in the Arctic» the various plans in recent years are discussed in light of the increased geopolitical situation in the Arctic.

3.7 Arctic safety and security

As a result of increased human activities in the Arctic, there is now more focus on safety in all aspects of living, working and travelling in the Arctic. “Arctic safety” is developing as a new scientific topic because there is a growing need for knowledge to prevent accidents, damages or loss of lives and

equipment. The various definitions of "Arctic Safety" are reflected in safety science as a multifaceted topic and multidisciplinary field (Le Coze et al. 2014) which is as relevant to the Arctic as for other parts of the world. Safety science works across different domains, dealing with technological topics (e.g. transportation, aviation, industrial activities) as well as social science topics (businesses, community services, safety of individuals). The characteristics of the Arctic with direct impact on safety are:

– cold conditions and extreme weather conditions
– remoteness and long distances
– limited infrastructure
– climate change

These characteristics imply that accidents in the Arctic are different from their warm counterparts in three ways (Cedervall Lauta et al., 2018): 1) due to cold temperatures and harsh weather conditions there is a pressuring time limit regarding survival which implies that timely emergency response is critical; 2) the accidents are likely to happen in sparse and remote areas with limited available infrastructure; and 3) it might be unclear who is responsible for emergency response due to ambiguities in the mandate and obligations that countries and authorities involved might encounter in the area (Albrechtsen and Indreiten, 2021).

The development of safety science in the Arctic has focus on :

- Generation of knowledge about Arctic phenomena, events and processes related to safety;
- Development and application of concepts, theories, approaches and methods to understand, assess, manage and communicate safety in an Arctic context, and
- Establishment and preservation of research societies, educational programs, conferences and journals addressing Arctic safety.

At the University Centre in Svalbard (UNIS) the Arctic Safety Centre (Fig. 17) has been established to offer research-based and practical knowledge and expertise related to safety for the local community, with businesses and other actors who conduct field activity on Svalbard. Focus areas are supporting field safety, societal safety, and emergency preparedness – all in an Arctic context with natural hazards and climate adaptations as important factors. More information is found in a special issue of Safety Science journal with seven articles resulting from the first Arctic Safety Conference in Longyearbyen in May 2019 (Albrechtsen and Indreiten, 2021).

Figure 17. Logo of Arctic Safety Centre at UNIS.

Maritime safety and security have been thoroughly studied by Jones et al., (2022) as part of the H2020 ARCSAR project. The authors have analyzed various methods to balance and prioritize needs for research and innovation across multidisciplinary topics.

"Arctic security" is a different notion from Arctic safety" because it deals with state-based and militarized security, environmental and climate security and geopolitics. Environmental security is about damage done to the environment by people or impact of environmental and climate change on goods and human values. It is noteworthy that security affairs were not included in the Ottawa declaration from 1996 when the Arctic Council was established.

A recently published Routledge Handbook of Arctic Security (Hoogensen Gjørv et al., 2020) gives a comprehensive examination of security in the region, including perspectives on climate, environment, economies and societies. Nuclear safety and security is a particular issue in the Arctic because of the large amounts of nuclear facilities in the region, such as nuclear-powered vessels and nuclear waste storage. The increased militarization of the Arctic in recent years is of major concern with ramification on all activities in the region (Lysenko et al., 2022, Rumer et al., 2021). After the Ukrainian war started in February 2022, Arctic security has become a major issue for the Arctic countries as well as other countries with interests in the region.

Another handbook on geopolitics and security in the Arctic provides an overview of the most crucial geopolitical and security related issues in the Arctic. It discusses established shareholder's policies in the Arctic – those of Russia, Canada, the USA, Denmark, and Norway – as well as the politics and interests of other significant or future stakeholders, including China and India. Furthermore, it explains the economic situation and the legal framework that governs the Arctic, and the claims that Arctic states have made in order to expand their territories and exclusive economic zones. (https://link.springer.com/book/10.1007/978-3-030-45005-2)

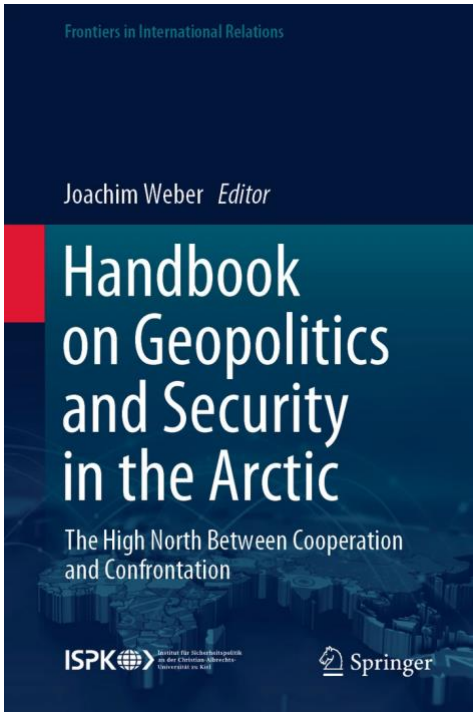


Figure 18. Cover of the Handbook

4. Conclusion

This report gives an overview of the main aspects of the actors in the Arctic, infrastructure technologies and services that are requirement by people living and working in different regions. The report is not discussing the extensive changes in climate and environment, but more focus on the impact of the changes on people and their activities. The report is also addressing safety and security issues, which has become the dominant factor in every aspect of the Arctic as the geopolitical tensions is growing . In the coming years it will be important to see how the Arctic Council activities will be resumed after the suspension following the war in Ukraine. When Norway took over the chairmanship of Arctic Council in May 2023, the working groups and expert groups will start to work again after a 1.5 year break.

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6	NINA	STIFTELSEN NORSK INSTITUTT FOR NATURFORSKNING NINA	NO
7	UCPH	KOBENHAVNS UNIVERSITET	DK
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