CAPARDUS - Capacity-building in Arctic standardization development

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Authors: Stein Sandven, Finn Danielsen, Martin R. Nielsen, Torill Hamre, Peter Pulsifer, Astrid Stallemo, Lisbeth Iversen, Roel May, Michael K. Poulsen, Mona Estrella Backmann, Martin Enghoff, Henrik Melby, Birger Poppel, P. Jakobsen, Søren S. Nielsen, Noor Johnson, Nathan Kettle, Olivia Lee, N. Haycock-Chavez, Jay Pearlman, Francoise Pearlman, Siri Jodha Khalsa, Uffe Jakobsen, Pauline Simpson, Rene Garello, Pier-Luigi Buttigieg, Annette Breckwoldt, Nike Fuchs, Gesche Krause

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EXECUTIVE SUMMARY

This report is a synthesis of the work performed from WP1 to WP6 in the CAPARDUS project.

Framework for Arctic standards

The development of a comprehensive framework for Arctic Standards started with a review of documents, followed up by analysis and use of a graph database model. The framework seeks to integrate standards used by communities active in the Arctic including research and services, local communities, commercial operators and governance bodies. This will support sustainable economic development, safe activities, emergency prevention and response, and improved understanding and conservation of the environment. The work has focused on selected topics of importance in the Arctic, in particular observing systems and data systems, natural resource management, tourism, shipping, safety, community planning, and responsible research. The results are summarized in the following points:

- Implementing standards requires a deep understanding of the domain of interest (e.g. observing, safety, a research discipline) to select the appropriate type of standard and standardization process required.
- The Arctic comprises many domains including communities with Indigenous and non-Indigenous residents, multiple governance models, operational environments, research with many individual disciplines and sub-disciplines, civil society actors, and many social, economic, and environmental dimensions. This complexity prevents development of a simple standards framework for the Arctic.
- A standards framework requires a practical model that can document and analyse this complex system to identify the nodes or entities (standards, people, organizations) that can play a role in enhancing standardization. This must be a "living" model that engages the community in its construction and is regularly updated.
- There are many existing frameworks, programs, projects, and activities that can be leveraged to enhance standardization.
- A graph database using the RDF Model is a practical method for documenting and analysing the arctic standards ecosystem. The prototype-database created in CAPARDUS is available through the project website, with supporting tools in GitHub.

- A working group will be proposed under the Arctic Data Committee to continue the development of the CAPARDUS framework for standards.

Regional case studies

The four regional case studies performed in WP2-WP5 were central in the project, addressing different Arctic regions in Europe (Svalbard and Russia), Greenland and North America. The motivation for including these regions was to have representation from different cultural, social and economical environments. The climate change and new socio-economic situation are severely impacting all the regions in various ways. The Arctic is a very heterogeneous region and development of standards and practices is often a bottom-up process. This required that we communicated with many stakeholder groups through dialogue meetings, workshops and events at conferences.

In **Greenland** management of natural resources is one of the major challenges in development of sustainable communities. Good management practices depend on ecosystem knowledge obtained through environmental monitoring, and methods for estimating the climate-driven changes in fish stocks and other food resources and likely outcomes of management interventions. In the case study we have investigated how the community-based monitoring (CBM) systems are used in Greenland and how guidelines and standard for CBMs are developing. Several workshops and dialogue meetings have been organised in Greenland with participation from national and regional authorities, local fishers and hunters, research groups and international organisations.

The work has also included use of Bayesian Belief Network model, where local knowledge is combined with scientific knowledge to support management of halibut fisheries. Scenarios of future livelihood for fishers and hunters were developed based on synthesizing information on wildlife stock trends from litterature, climate change predictions and dialogue with fishers and hunters. This information is important for industries and communities that are dependent on exploiting wildlife resources. Finally, testing of automated translation from Greenlandic was tested using machine translation tools. For Greenlandic these tools are not functioning very well yet, but the technology is evolving rapidly. In a few years such translation tools are expected to become standard tools in communication with Greenlandic and other Indigenous languages.

The main challenge in the **Svalbard** community is to adapt to the severe effects of climate change and the transition from a mining town to new activities, especially tourism and research. The main activities are research with collection of environmental and climate data, preservation of cultural heritage, tourism, shipping, safety of operations, community planning. Svalbard is exposed to severe climate warming with melting of permafrost, increased coastal erosion, snow avalanches, melting of glaciers and reduction of sea ice, all of this have direct impact on people living, working and travelling in Svalbard.

The case study has organized several meetings and workshops with Longyearbyen Local Council, the Governor of Svalbard, tourist operators, shipping companies and other actors to identify standards, practice and guidelines for various activities that are important in Svalbard. Several global citizen science projects are active because tourists and other visitors collect data which they upload it to central repositories. One recommendation is to establish citizen science methods where tourists and others can use mobile phone with apps to monitor cultural heritage sites around Svalbard. By involving the public, new data can be collected from a wider area, results shared more effectively through society, and environmental issues better understood. The tourist operators in Svalbard has strong focus on developing sustainable tourism, which means that the quality in all parts of the industry should be improved and that the value creation for the society should increase. This means that sustainable tourism should be developed as follows:

- Be responsible and safe

- Reduce climate emission and leave no traces
- Operate the whole year and provide activities for the dark season such as cultural history, and northern light experience
- Length of each visit should be longer, avoiding the short visits

The Arctic Safety Center at UNIS plays a central role in providing training, education and research within safety, because increased human activities in the region will require more knowledge about different safey aspects in the Polar regions. The key factors are:

- cold conditions and extreme weather conditions, leading to higher risk that people and equipment will not function
- remoteness and long distances implies that assistance in case of accidents will take much longer time
- limited infrastructure, implying that most human activities are more difficult
- climate change is stronger, leading to more extreme weather events and consequently more severe natural hazards

In the **Russian** case study, community-based monitoring (CBM) was the main topic, with the goal to further develope 'good' practices and standards, continue to improve environment/resource monitoring, and promote the rights of Arctic Indigenous and local communities in resource management. The overall coordination of the case study was undertaken by the Center for Support of Indigenous Peoples of the North (CSIPN) – an NGO with many years of successful activities on different issues concerning Indigenous peoples of the Russian North, Siberia and the Far East. CSIPN has also experience with international projects. The project activities were implemented in two regions: in the north-west of the country, in the Murmansk region (Kola Peninsula) and in the east – in the Republic of Sakha (Yakutia). The key issues in the case study were:

- Control of fishing grounds and access to fishing, where CBM plays an important role.
- Understanding developments in key fish populations, where climate change has impact
- Access to hunting territories and permission to hunt key species such as moose and wild reindeer
- Using the CBM work to monitor and manage Traditional Territories of Land Use
- The domestic reindeer industry continues to be in crisis. Use of CBM to monitor and propose management interventions still needs to be further developed.
- Predator populations (wolf and brown bear) continue to constitute a major problem, which has been documented by CBM data.

In conclusion, CBM activities in Russia have been further developed, capacities have been strengthened, Indigenous Peoples and other communities have been able to use CBM as a tool for promoting their rights, and further agreement and exchange of good practices/standards on how to undertake CBM work in Russia. Participating project partners have also been able to bring CBM into the international debate on IP rights and implement international biodiversity conservation measures.

The case study in **USA** was focused on Indigenous communities in Alaska and how they use community-based observations of the environment, which is vital for fishing, hunting and travelling in the region. The study was performed by ELOKA (Exchange for Local Observations and Knowledge of the Arctic) in collaboration with International Arctic Research Canter at University of Alaska Fairbanks under subcontracts with NORDECO.

The following work was conducted: (1) identify the types of community-based monitoring (CBM) information used to plan for and respond to coastal risks and hazards; (2) study how existing knowledge and data from community-based monitoring programs are situated in relation to other types of information used in risk and hazard mitigation; and (3) discuss the role of standardization in connecting community observations with decision processes. Due to the The topics addressed for the CBM programs were (1) permafrost thaw and coastal erosion and (2) harmful algal bloom (HAB) in the coastal waters.

Permafrost thaw, leading to coastal erosion flooding are major threats to communities all around Alaska, but mostly in the coastal regions. In the Statewide Threat Assessment report (UAF, 2019), detailed analysis of the various natural hazards has been performed and recommendations for actions were provided for a number of communities across Alaska. Regarding Harmful algal blooms, there are many organisations and agencies involved in CBM work, where the Alaska Harmful Algal Bloom (AHAB) Network plays a central role in providing a mechanism to support ongoing communication and collaboration.

A key learning from the interview phase of the case study was a strong interest in use of observations to support action that would be beneficial to community members. The use of information can inform either short or long term decision-processes. For example, HABs and water quality monitoring programs can help resource users decide whether or not it is safe to eat shellfish (short-term), they can also inform decision-making about sustainable planning for mariculture farms (medium-term). Erosion monitoring programs, in contrast, are more focused on providing information related to coastal hazards that can affect infrastructure in the medium and long term.

Arctic Practices System

The main objective was to propose a design for an Arctic Practices System (APS): a digital system to promote the sharing of methodological knowledge about living, working, researching, and sustainably managing the Arctic and its resources. Such a system would address challenges such as fragmented and limited access to Arctic practices, by providing an integrative platform for discovery, access, and collaboration. It builds upon the successful implementation of the IOC-UNESCO Ocean Best Practices System (OBPS), and its emerging federation of providers, which focused on the marine domain.

As shown in the case studies, many of the user groups have their own information systems that they want to develop further or they plan to design new systems. An APS should therefore not replace existing systems, but rather be connected to them in a federated way. This means that the APS will have a number of subsystems. Based on broad user requirements, the components and modules of the system are determined, with focus on a core set of modules identified in the case studies and user profiles. In brief, tailored user interfaces (UIs) and user experiences (UXs) will draw content from a secure database storing stakeholders either submitted directly to the APS or harvested from existing systems and filtered through a set of processing modules to identify, structure, and translate content to increase its value to users. User feedback modules will support iterative refinement and improvement, ensuring that the APS can meet the needs of its intended users as they change in a rapidly changing Arctic. From the case studies, a number of user profiles were identified, where requirements for an APS were discussed.

A design document for an APS was prepared, describing how an APS can be implemented. The realization of an APS would be a goal for a follow-up project.

Table of Contents

1. Introduction

This report provides a synthesis of the results obtained in the CAPARDUS project which has the overall objective to

Establish a comprehensive framework for development, understanding and implementation of Arctic standards with focus on environmental topics. The framework seeks to integrate standards used by communities active in the Arctic including research and services, local communities, commercial operators and governance bodies. This will support sustainable economic development, safe activities, emergency prevention and response, and improved understanding and conservation of the environment.

The project has been implemented through the following workpackages:

WP1: Establishing a Comprehensive Framework for Arctic Standards
WP2: Case studies in Greenland
WP3: Case studies in Svalbard
WP4: Case studies in Russia
WP5: Case studies in USA
WP6: Arctic Practices System
WP7: Synthesis, requirements and recommendation
WP8: Communication and outreach
WP9: Coordination and management
WP10: Ethics requirements

WP1 has reviewed and analysed a number of documents regarding standards within selected topics, e.g., observing systems and data systems, natural resource management, community planning and decision making, shipping, tourism, safety, ethics and responsible research. Then a framework model for standards has been developed.

The case studies in WP2-WP5 have focused on four different Arctic regions in Europe (Svalbard and Russia), Greenland and North America (Fig. 1.1). The motivation for including different regions was to have representation from different cultural, social and economical environments. The climate change and new socio-economic situation are severely impacting all the regions in various ways. The Arctic is a very heterogeneous region and development of standards and practices is often a bottom-up process. This required that we communicated with many stakeholder groups through dialogue meetings, workshops and events at conferences. The project activities have included:

- Documentation of practices, guidelines and standards and framework development
- Support to community-based monitoring (CBM) and citizen science (CS)
- Development of Bayesian Belief Network for fisheries management
- Identify requirements for an Arctic Practice System to serve different communities

In Greenland the work has focused on how to improve management of natural resources by including knowledge from local fishers and hunters and their observations using community-based monitoring. The work has included use of Bayesian Belief Network model, where local knowledge is combined with scientific knowledge to support management of halibut fisheries. In Svalbard, the studies addressed how Longyearbyen has transformed from a coal mining town to a community with focus on tourism and research including cultural heritage management.

At the University Center in Svalbard (UNIS) Arctic safety is developing as new field for research and education. In Russia, the work was focused on supporting the development of CBM projects in the Republic of Sakha (Yakutia) and in Kola Peninsula in collaboration with Center for Support of Indigenous Peoples of the North (CSIPN). The collaboration the Russian CBM projects was halted when the Ukrainian war started in 2022, but CSIPN has continued to work with the CBM projects since then. The Alaska case study had focus on CBM programs for coastal erosion, permafrost thaw, and coastal sea ice monitoring and how these programs can contribute to data gathering on coastal hazards.

Finally, the concept of an Arctic Practice System (APS) has been studied, building on the requirements from different communities, and resulting in a design and roadmap document for an APS. The APS is envisaged to be a digital repository and knowledge hub for a broad range of Arctic topics, thus contributing to sustainable development in the Arctic.

Figure 1.1 Map showing the areas where the CAPARDUA case studies were conducted.

2. Arctic Standards, protocols and framework model

2.1 About practices and standards

There is a range of practices and standards to consider when looking to support the information needs across the Arctic. Table 1 presents a spectrum that moves through informal methods at the top to legally enforceable documents at the bottom. The most appropriate type varies depending on users' needs and objectives. No single instantiation fits all cases. In the most general sense, a standard is something established by custom, general consent, or authority as a model to be compared against, a rule for measuring the quantity, weight, extent, value or quality of something. When we speak of technical standards, we are speaking of published documents that establish specifications and procedures designed to maximize the reliability, interconnectivity, interoperability, and performance of materials, products, methods or services. There are different forms of standards, as shown in Table 1.

Table 1. Types of formal and informal standards and practices (Pearlman et al., 2022)

Type	Origin	Process	Authorship	What is the form?	How is conformance determined, enforced?	Who is affected?	What is the impact on those affected?
Norm/ethic/ tradition	need for functional society	informal	members of a society	interpretation	parental, societal pressure	members of a society	Allows for cohesion and interpretation
Practice	practical experience	informal	practitioners	practice	voluntary	self-selected	Provides norms for processes; encourages interoperability and allows for fluid evolution
De Facto Specification	need for compatibility	formal, informal	practitioners	as built	non-binding	practitioners	Widely adopted process, may be a best practice
Standard Profile/ Extension	need for more specificity	formal, informal	standards adopters	Software	conformance clauses	specific community	Consistency of implementation, easier to assess conformance
De jure standard	compatibility, interoperability, reliability,	managed development	affected stakeholders	Device, procedure	conformance clauses	narrow/broad stakeholder community	Provides formalized, stable process descriptions for production and interfaces
Code	need for safety, reliability	deliberations	responsible officials	practice	law enforcement	local jurisdiction	Defines requirements for process implementation for safety and conformity
Policy/Law	public interest	lawmaking	lawmakers	practice	law enforcement	jurisdiction	Legal requirements for societal safety and economic growth
Treaty	international relations	negotiations	government officials	practice	economic, military	nations	Establishes relations between different governing bodies for security and commerce.

Different *practices, norms, ethics, traditions, etc.* are presented in Table 1 in comparison with other types of standards. *De jure* standards, for example, are distinguished mainly by the fact that they were created under processes managed by a standards development organization. The benefit of working under a Standards Development Organization (SDO), such as ISO or IEEE, is that it provides the rules and governance for standards creation that are needed to ensure fairness and transparency, as well as the mechanisms to assist in the distribution and maintenance of the standard. A community can modify a de jure standard to suit its particular interest by creating extensions, where new elements are added, or profiles which define specific ways certain elements of a base standard must be used.

There are also *de facto* standards, which can be just as rigorous as *de jure* standards and have influence by virtue of their widespread adoption. An example of evolution from de facto to de jure status is the Portable Document Format (PDF). Created by Adobe in 1993, it became a widely-used de facto standard and in 2005 it became a de jure standard as ISO 19005-1:2005.

Methodologies, standard operating procedures, handbooks, or traditional community practices are different forms of Arctic practices. While there is flexibility, there is also a need to identify the most appropriate type for a given need or application. There is also a question of to what extent the future Arctic Practices System should include all these types of practices and standards.

Standards can act as common language and practices among stakeholders when aiming to share and use observing systems, data, ensure safety, and many other activities in the Arctic. Equipment manufacturers, observing programs, data producers, citizens, and governments all benefit from the creation of open standards.

To study how standardization develops it can be useful to consider top-down and bottom-up process in parallel. In many cases standards are results of top-down decisions, implying that high-level bodies (e.g. UN, EU, national legislation) define official standards related to transport, food, construction, etc. Standards are often connected to regulations, legal framework, treaties, etc. An example is the Polar Code implemented by IMO after development by the member countries over many years[1]. The regulations in the Polar Code are expected to spin-off standard development related to safety and responsibility of shipping in the Arctic (and Antarctic). There are also many bottom-up processes to establish best practices, recommendations and guidelines which evolve over time as they gain support from a wider community (Fig. 2.1). When dealing with rapid technological, environmental and socio-economic changes, best practices can develop rather quickly and become *de facto* standards, and some may become *de jure* standards.

It is vital that the standards development process ensures that all interested parties work together in the context of openness and transparency. In particular as data becomes the world's most valuable resource, it becomes ever more important that the digital ecosystem for data be designed and managed in a way that ensures sufficient user access, transparency, accountability, and quality assurance.

[1] https://www.dnvgl.com/maritime/polar/index.html

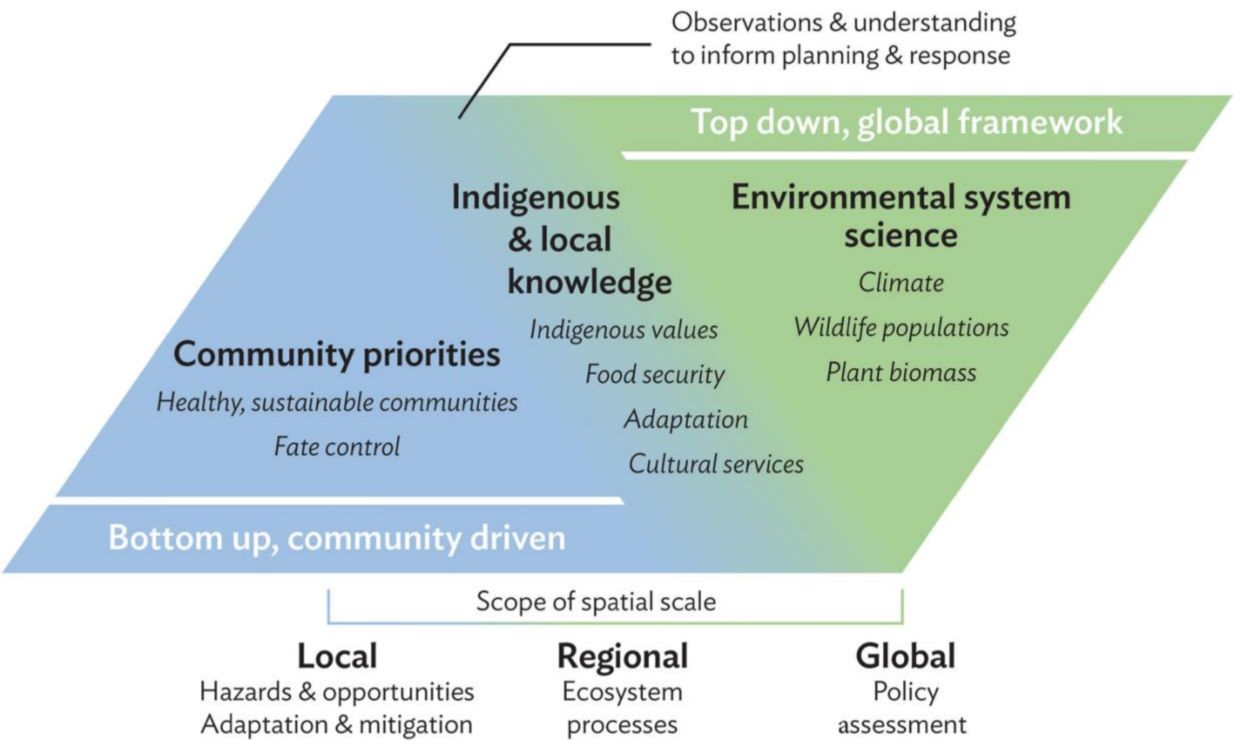

Figure 2.1 Illustration of how top-down and bottom-up processes are connected regarding environmental observations (from Eicken et al., 2021).

2.2 Towards a theoretical and practical framework for implementing standards and best practices.

The work in CAPARDUS has documented that standardization is a challenging and complex process. The term standard can be vague: some may see a standard as a formal set of documents and compliance process, while others see a set of rules or agreements established by a "community" that are based on norms and ethical behaviors. In this broad gradation, there is overlap between more formal top-down standards and bottom-up community developed "conventions" or "best practices".

To add to the complexity in the Arctic context, standards do not exist in a single research or social domain. Research includes many disciplines, the peoples of the Arctic and focusing on many economic, social, and research opportunities. Governments have a mandate to cover all aspects of the Arctic at the same time as the world experiences dramatic environmental, social and geopolitical change. Definition of a «framework» can be as follows:

- a basic **structure** underlying a system, concept, or text.
- a supporting **structure** around which something can be built
- **a system of rules, ideas, or beliefs that is used to plan or decide something**
- the ideas, information, and principles that form the **structure** of an organization or plan
- a supporting structure around which **something can be built**

2.3 Methodologies used in the work

The primary method used was a systematic literature review focused on four key domains relevant to standardization:

1. cross-cutting themes,
2. observing systems,
3. arctic safety and
4. data systems

The literature reviewed was stored in an online bibliographic database which is available for community use through the CAPARDUS website. The detailed results of the work is presented in *D1.2 Report on Arctic standards, protocols and framework model*.

In this study we have reviewed documents in a subset of Arctic domains that could benefit from some level of standardization. Standards are typically technical documents, while standardization is a human process that takes place in an ecosystem of interrelated and interdependent human actors, institutions, norms, and practices (including standards), technologies, information objects, and relationships. To enhance standards adoption, it is equally important to understand the ecosystem and its subsystems (general kinds of things, linkages and flows in the system) and the details of its interacting parts (e.g., the specific organizations, technologies, people and their needs). To manage this complex task, a relatively simple framework has been introduced, using visualizing graph presentation. This method is supported by emerging advanced information structures (linked open data represented using the Resource Description Framework – RDF) that helps to document and understand the ecosystem to support standards development, maintenance, and implementation.

RDF is a World Wide Web Consortium (W3C) standard for describing resources on the Web, in the form of subject - predicate - object triplets. The predicate describes the relationship between the subject and the object, e.g., between a more general concept like “DataStandard” and a more specialized concept like “InteroperablityStandard” (see example in Figure 2.4). An RDF triplet can be visualized as a graph with the resources as nodes, and the relationships as directed arcs between the nodes. By describing the resources relevant to Arctic standards as a collection of RDF triples, we can build a database containing a network of such resources, including, among others, common practices, standards, technologies, organizations, and people. The database can then be visualized and navigated as a graph to explore how different entities are connected. This will improve the understanding of the complex landscape of Arctic standards.

2.4 Review and analysis results

The review materials inform a reference framework proposed as an approach to enhancing standards, standards development processes, and adoption of standards. Central to this approach is conceptualizing the Arctic community and standards-related entities as an ecosystem “of interrelated and interdependent human actors, institutions, norms, and practices (including standards), technologies, information objects, relationships, and the broader socio-technical environment in which it exists” (Pulsifer et al., 2020, p. 270). The results of the literature review and analysis showed that cross-cutting themes such as governance and local knowledge comprise many entities relevant to enhancing standardization (Fig. 2.2). In the case of governance, the lack of a centralized arctic governance regime makes standardization challenging.

Similarly, increasing recognition of local knowledge and related topics such as Indigenous data sovereignty and ethical use of representation of Indigenous Knowledge, highlights the critical importance of including Indigenous peoples and their representative organizations in the standardization dialogue. Analysis of the observing system revealed similar patterns.

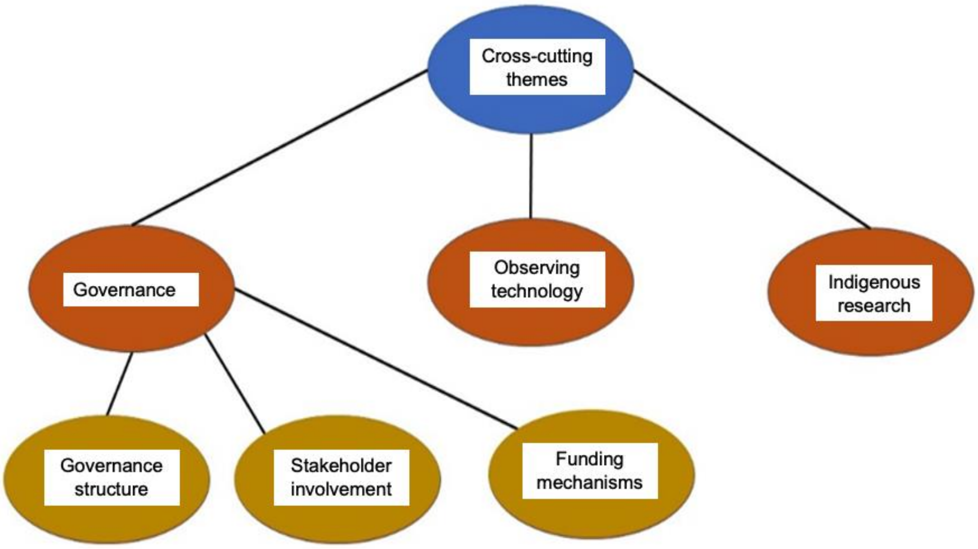

Figure 2.2 Cross-cutting themes and sub-themes

Observing networks and other programs and projects that are relevant to and could act as hubs and provide a foundation for standardization already exist regarding observing technology and need to be harnessed (Fig. 2.3). The situation is similar in the domain of arctic data. Relevant organizations within and outside of the arctic community already exist, however, areas such as governance need to be enhanced to move to the next stage of meaningful standardization. Standardization in the areas of operations, hazard response, shipping, and tourism would greatly enhance safety. There are many challenges in achieving safety-related standardization including adequate education and training, funding and recognition of the significant risks posed by failure to establish standards (e.g. sub-optimal to totally inadequate hazard response).

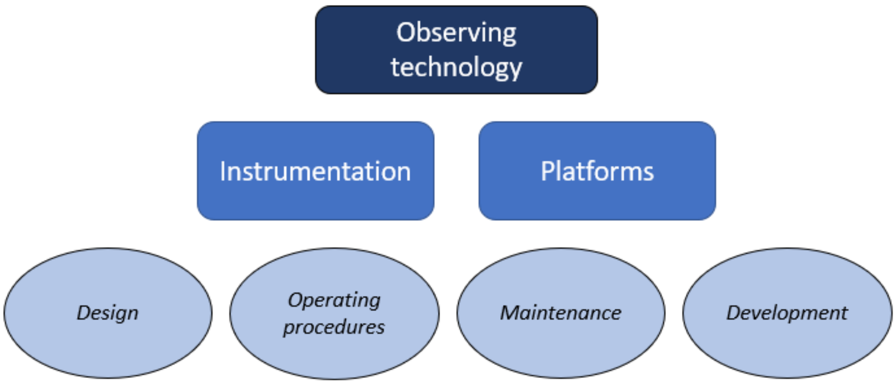

Figure 2.3 Sub-themes of Observing Technology

Many concepts important to standardization and many individual projects, programs and initiatives that are relevant to standardization were identified. These concepts (e.g. governance) and individuals (e.g. the Arctic Data Committee) have existing relationships, or require that relationships be established. These concepts, individuals and relationships are documented and discussed, including references to related resources. A key result of this section is the revelation of the breadth and complexity of the human and technical systems as implicated in standards and standardization.

2.5 A framework for implementing standards and best practices

A method for documenting and understanding an arctic standards framework is described in *D1.2 Report on Arctic standards, protocols and framework model*, which represents the various relevant systems of organizations, individuals, technologies etc. Due to the breadth, depth and complexity of the systems involved, a simple report documentation method is not adequate nor able to capture the dynamic nature of standardization through updates. A graph database model is presented based on a free and open source tool called WebVOWL. This prototype graph database captures the key concepts (classes), individuals and relationships in the systems. This knowledge graph (database) can be a dynamic framework to enhance standardization.

Several key results were obtained that are critically important in establishing a framework for arctic standardization. They include:

- Implementing standards requires a deep understanding of the domain of interest (e.g. observing, safety, a research discipline) to select the appropriate type of standard and standardization process required. What works for one community of practice may not work for another.
- The Arctic comprises many domains including communities with Indigenous and non-Indigenous residents, multiple governance models, operational environments, research with many individual disciplines and sub-disciplines, civil society actors, and many social, economic, and environmental dimensions. This complexity prevents development of a simple and unified standards framework for the Arctic.
- A standards framework requires a practical model that can document and analyse this complex system to identify the nodes or entities (standards, people, organizations) that can play a role in enhancing standardization. This must be a "living" model that engages the community in its construction and is regularly updated to reflect the situation at any given time.
- There are many existing frameworks, programs, projects, and activities that can be leveraged to enhance standardization. In the domains surveyed, there would be little need to establish new organizations or standards bodies to move forward.
- A graph database using the RDF Model is a practical method for documenting and analysing the arctic standards ecosystem (Fig. 2.4). The prototype-database created in CAPARDUS will be made public through the project website, with supporting tools in GitHub. A working group will be proposed under the Arctic Data Committee to continue the development of the CAPARDUS framework in line with recommendations of the Third Arctic Science Ministerial.

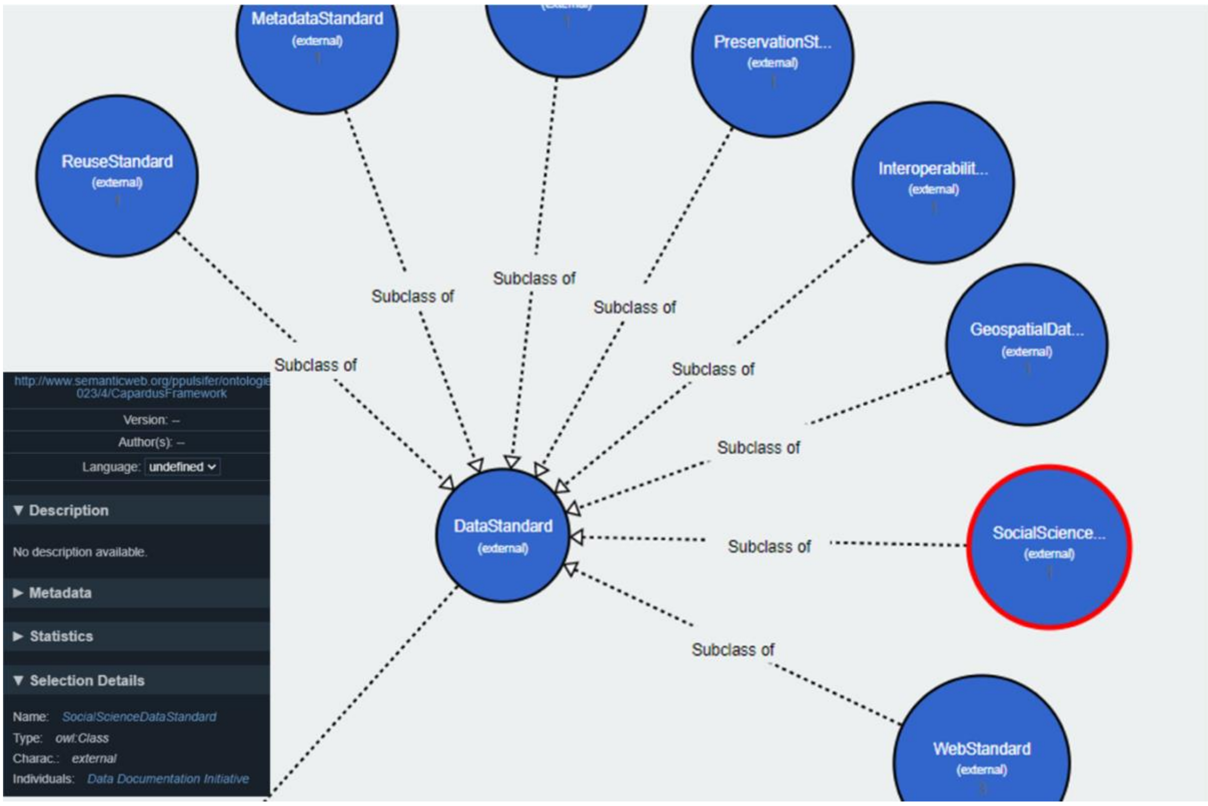

Figure 2.4 An enlarged view of the DataStandards subclasses in the CAPARDUS Arctic standards framework. Note in the lower right corner of the image a list of instances (i.e. Data Documentation Initiative) can be viewed by selecting a subclass.

3. Results of case studies in Greenland

3.1 Workshops and dialogue meetings with Greenland actors

In Greenland management of natural resources is one of the major challenges in development of sustainable communities. Good management practices depend on ecosystem knowledge obtained through environmental monitoring, and methods for estimating the climate-driven changes in fish stocks and other food resources and likely outcomes of management interventions. In this case study we have investigated how the community-based monitoring (CBM) systems are used in Greenland and how guidelines and standard for CBMs are developing.

The climate change and its consequences in the region leads to new requirements for planning and decision-making based on scientific and economic data, assessments, and predictions. A prerequisite for good planning is access to data and information of relevance to people living and working in the Arctic. In Greenland, the Ministry of Fisheries and Hunting established the PISUNA (*Piniakkanik Sumiiffinni Nalunaarsuineq*) programme in 2009 through which experienced fishermen and other resource users started to systematically document and discuss their observations of the environment and propose management interventions to the authorities.

International agreements and Arctic Council declarations emphasize the importance of engaging community members with local knowledge (LK) in decision-making on natural resource management. In recent years, several initiatives have been taken on cross-fertilizing LK with scientific knowledge. Nevertheless, Greenland government agencies' decision-making on quota-setting and resource management still do not fully consider the LK often because they are informed by international management bodies. Among the international management bodies of greatest importance to the lives and livelihoods of Greenland fishermen and hunters are NAMMCO (The North Atlantic Marine Mammal Commission) and CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora).

Figure 3.1. Logos and mandates for NAMMCO and CITES.

While the international management bodies are also supposed to incorporate LK into their advice to governments, this rarely happens in practice. Advances in online platforms have made it possible to share community-produced observations across sites and scales of decision-making but such tools are not being fully used by the international management bodies.

On 21 February 2021, an online workshop was organised by NORDECO as joint event between CAPARDUS and KNAPK (Association of Greenland Fishermen and Hunters). The context was the PISUNA programme where environment and resources are observed and documented (Fig. 3.2). Although the fishermen and resource users spend time on communicating their knowledge and observations of the environment to the government agencies, this information is not often being used for decision-making.

Decisions are normally made based on advice from international management bodies who use inputs from scientists in the different countries. In practice, there is limited LK flowing to these management bodies and there is limited use of whatever LK finds its way to the international management bodies.

From the workshop discussions, it was clear that international and national bodies claim that LK is relevant. Inclusion of LK is often stated as a requirement in the various agreements, objectives or legislation related to these bodies. But ensuring the actual use of LK for management decision-making is a major challenge. In Greenland, there are now movements (with a new executive order) towards ensuring a more structured and legally required use of LK. As is the case now in most of the Arctic, there are bits and pieces of LK feeding into the national and international level.

Figure 3.2 Fishermen who are part of the PISUNA climate stewardship program in Attu, Greenland, are monitoring a key species around their island — the Atlantic cod. (Photo by Meral Jamal, Nunatsiaq News, 24 Dec. 2022, https://nunatsiaq.com/stories/article/chasing-the-atlantic-cod-with-pisuna/)

Possible actions to promote the further incorporation of LK and its greater influence in various management bodies were formulated at the workshop and include:

1) Develop structured and systematic collection of LK through CBM programmes nationally, knowledge that is legally required and considered equally important to the management processes as input from scientific studies.
2) Develop explicit demand within the various national and international management bodies for the incorporation of CBM/LK data into all biological population assessments.
3) Explicitly mentioning the involvement (or absence) of CBM/LK data in various assessment reports related to living resources.
4) Ensure better, continuous, legally-required and structured dialogues between holders of LK and scientists. Encourage joint analyses to be undertaken and published in reports.
5) Through international management bodies push (a) for more coverage in time and space by CBM programs, and (b) to make more LK available in web-based, searchable databases.
6) International management bodies should promote the value of LK by showcasing the use of LK and demonstrating how to use the information in a way that is scientifically credible and acceptable to peers.
7) Further involve users/hunters in relevant committees, not just as observers but as real members and further involve users/hunters in surveys and in national government delegations.

Figure 3.3. Work on management of marine mammals. Photos provided by Amalie Jessen in the Wildlife and Hunting Division of the Department of Fisheries and Hunting.

A physical workshop was organized in Aasiaat from 29 November to 1 December 2022 with the title "Towards 'good practice' in the use of local and scientific knowledge for informing natural resource management". The workshop was attended by 45 participants, some attended online, representing fishers and hunters, public decision-makers, natural resource managers, representatives of civil society associations, and social and natural scientists. The main objectives were to review the future to see how local knowledge can contribute to informing decision-making on natural resources, and to explore how the financial and organizational sustainability of CBM programmes can be assured and how CBM and scientific observations can be connected. The workshop was thereby working towards the development of global 'good practice' guidelines in community-based monitoring and the management of natural resources.

The workshop agreed on the following topics:

1) That pilot initiatives whereby fishers and hunters in Greenland have followed the status and trends of the living resources and shared this knowledge with decision-makers have provided useful experiences.

2) That these pilot initiatives should be continued and further organized and scaled up, and that they should be supported by legislation.

3) That a systematic approach should be established to connect user knowledge with conventional scientific knowledge to inform decision-making.

4) That financial means should be secured for the fishers and hunters who are engaged in this work, and for the organizational framework for their work.

Moreover, it was decided at the workshop to set up a working group to support the involvement of user knowledge in resource management in Greenland "The Working Group for Action on the Involvement of User Knowledge in Resource Management in Greenland". The working group was led by the PISUNA Coordinator in Attu village (Working Group chair) and the head of KNAPK (vice-chair). It was also decided to jointly update the "Manaus Letter: Recommendations for the Participatory Monitoring of Biodiversity" in the coming months. Finally, the conclusions from the workshop were sent to the Secretariat of the Convention on Biological Diversity to inform the discussions on the new global agreement, the Kunming-

Montreal Global Biodiversity Framework. The framework includes an enhanced mechanism for planning, monitoring, reporting and reviewing implementation, the necessary financial resources for implementation. This implies that CBM will become more important as method for monitoring biodiversity.

Figure 3.4 Some key participants in the workshop. From left: (1) Amalie Jessen, Ministry of Fisheries and Hunting, APN Hunting; (2) Karl Tobiassen, Minister of Fisheries and Hunting: (3) Per Ole Frederiksen, PISUNA in Attu and (4) Nikkulaat Jeremiassen, KNAPK.

The Working Group explored how a government civil servant can handle information from different forms of knowledge in the management of living resources, even when they point in opposite directions. It was discussed that five steps may be useful to assess if a species in an area can be managed with the use of several knowledge types (for example, knowledge from users and knowledge from scientists). One is envisaged to focus on one species (population) at a time, and to take the same steps, species by species.

These are the five steps:

- **Step 1** Is there a need for knowledge-based management of the species as a resource?
- **Step 2** How many regularly collected forms of knowledge contain knowledge about the status of the species?
- **Step 3** Are the different forms of knowledge about the same population?
- **Step 4** Is the population shared with another country?
- **Step 5** Develop a framework for sustainable management of the species. Make decisions about adapting the management of the species within this framework.

A one-day seminar was organized by Ilisimatusarfik as part of the final project workshop in Nuuk on May 20, 2023. At the seminar, the preliminary findings of the Working Group were presented and discussed. The key conclusions were:

1) Community-Based Monitoring is not spreading like a wildfire. It needs development of management systems to handle user knowledge. It needs to describe how administrations/civil servants should act, for example, what knowledge sources to use for what and when, and what to do when the information from scientists and local communities differ. How do you in practice take decisions? That question is not answered today. We can only learn how to do it by trying to do it. So, a pilot testing activity is needed to try this in practice. Try to integrate and try to take decision based on this integration.

2) Try out management models in practice. Develop concrete pilot initiatives with APN and one or two municipalities. The pilot initiatives should show how to manage selected species and populations with several forms of knowledge.
3) Assist communities interested in documenting user knowledge of living resources with financial support. Make funders aware of opportunities for supporting fishers and hunters' documentation of living resources.
4) Further clarify barriers to involving user knowledge in decision-making, and find solutions.

On May 21, 2023, the final presentations of the CAPARDUS project were given by members of the consortium and invited participants from institutions in Greenland. The detailed results of the workshops and dialogue meetings are presented in deliverables D2.1 and D2.3.

3.2 Integration of local knowledge in Bayesian Belief Model

Climate change is occurring faster in the Arctic than in any other region, with tremendous consequences for Arctic biodiversity and the local communities that depend on it. Climate and biodiversity change can undermine established production patterns of hunting, fishing, gathering and herding by Arctic communities, negatively influencing their welfare and wellbeing. The ecological and societal changes facing small-scale rural users and in the Arctic may surpass their resilience and adaptive capacity.

Future scenario analysis incorporate uncertainty arising from complex interactions between climate and biodiversity change and other sector activities are increasingly relevant for conservation and development planning in the Arctic to encompass the intertwined interactions between humans and their natural environment. Bayesian Belief Network (BBN) models offer an opportunity to explore such complex socio-ecological systems with limited data by incorporating scientific knowledge as well as local and knowledge (LK), making it possible to make predictions about the outcome of management interventions in future scenarios (e.g. May et al., 2019, Nielsen et al, 2019).

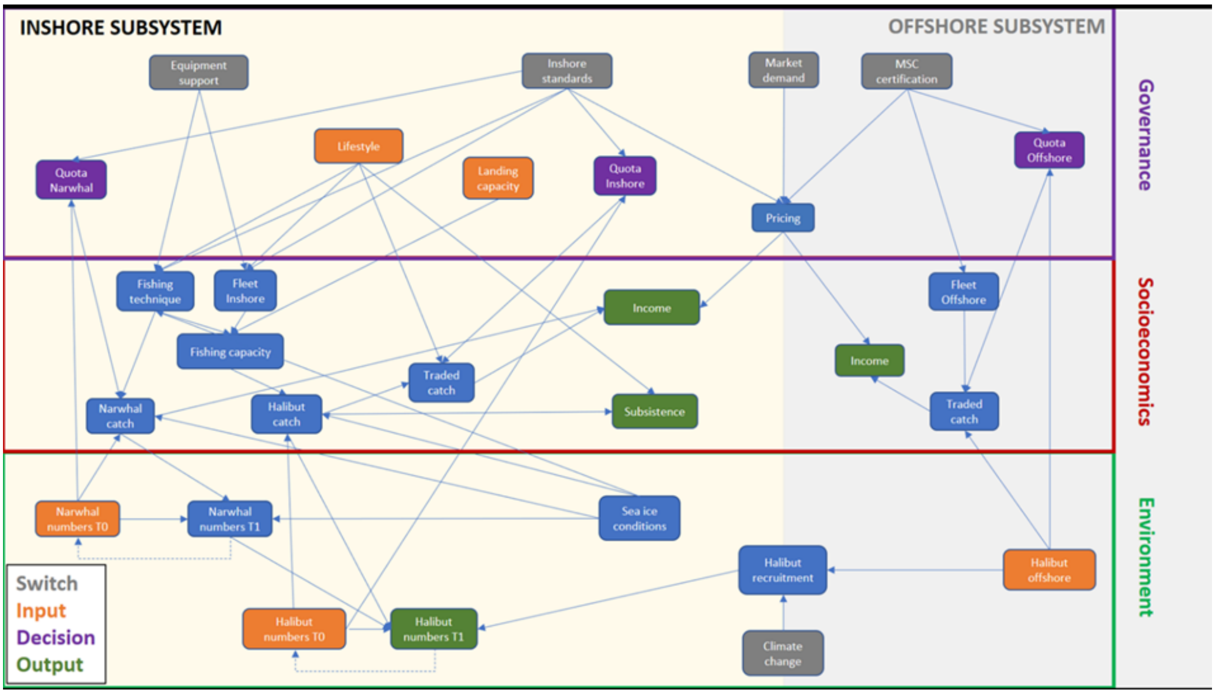

Figure 3.5 Conceptual model structure for the BBN on coastal halibut fisheries in West Greenland.

In this case study the potential of BBN models as a flexible tool to combine scientific data and local knowledge has been explored. BBN models can reflect complex socio-ecological systems and assess the outcome of potential policy interventions meant to address natural resource management problems in Greenland. We have presented a preliminary model for the coastal halibut fishery in West Greenland implemented in the *surBayes* platform (Fig. 3.6). We provide a step-by-step introduction to this software. We then use available experience in the literature, mainly on community-based monitoring in Greenland and elsewhere, to reflect on guiding principles and ethical considerations as well as how to promote the inclusion of LK in BBN models for natural resource management in Greenland. The method and results are presented in deliverable D2.2 Report on BBN model for halibut fisheries in Greenland.

There is growing recognition of the need to engage with and utilize LK in a more comprehensive and meaningful way to improve our understanding of social-ecological interdependencies, promote innovation, and contribute to the identification of desirable pathways for the future with increased legitimacy and trust in decision-making. Participatory modelling approaches, including co-developing BBN models, can draw on the subjectivity that is inherent in sustainable use contexts when local stakeholders are utilizing wildlife or fish resources of high economic value and when they simultaneously have a major stake in the management of this resource. Still challenges in the use of LK exist regarding language barriers and differing worldviews that can hinder communication, mutual understanding and reaching consensus. We briefly review the relevant literature and provide recommendations for a set of standards for inclusion of LK in BBN models.

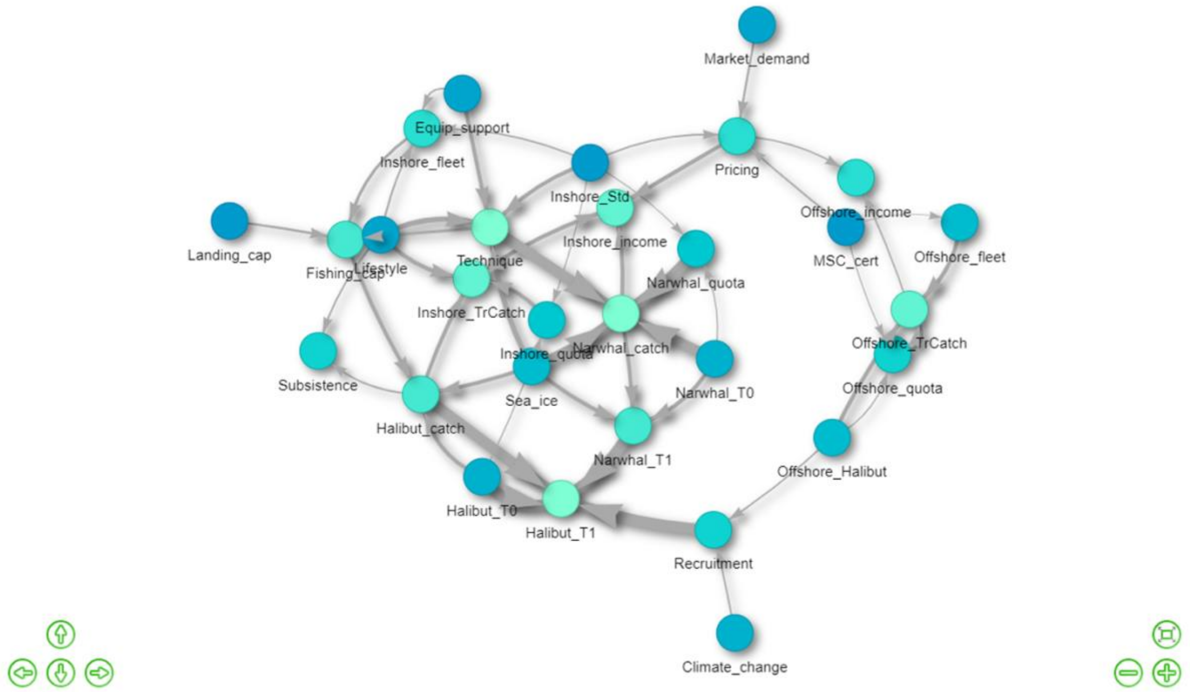

Figure 3.6. Screenshot of the inshore halibut fisheries in West-Greenland model in the surBayes application.

The use of LK may also have ethical implications. Efforts to integrate local and science-based knowledge systems for co-management of wildlife have, in some cases, led to the de-contextualization and compartmentalization of local knowledge through its translation (and distortion) into forms that can be incorporated into existing management bureaucracies and acted upon by scientists and resource managers. How to ethically appropriately connect information generated by different knowledge systems to inform natural resource management remains a key challenge. Guidelines for appropriate ethical conduct in relation to obtaining LK for BBN models have been synthesised, from literature see Standards and practices for use of Local Knowledge in BBN models.

There is lack of experience how to best promote the use of LK informed BBN models by government administrations for natural resource management, especially in an Arctic context. However, valuable insights may be gained from studies describing experience with community-based monitoring and a community-based harvest calculator in Greenland as well as a review of literature about connecting top-down and bottom-up approaches in environmental observing.

3.3 Scenarios for evaluating welfare consequences for the hunter and fisher families in Greenland

Synthesizing information about wildlife stock trends and developing plausible future scenarios for the catch of stocks in the face of climate and other ongoing changes can enable the Greenlandic Self-Rule Government, relevant sectors of industry and the communities that depend on these resources to address these changes proactively. By combining a literature review, forecasts of catch, and focus group discussions with local hunters and coastal fishers the expected development of the catch of all targeted species can be estimated. We modified Sutherland's framework (2022) to weigh evidence on the three axes: information and source reliability, and relevance to assign a strength of evidence for a directional trend (49 species with several sub-populations). The detailed results of the synthesis work are presented in deliverable *D2.4 Establishing scenarios for evaluating the welfare consequences of climate and other changes for the hunter and coastal fisher families in Greenland*. This report has focus on assessing scenarios of selected species, while the socio-economic and welfare consequences for the local population is further studied in the FutureArcticLives project.

Overall, the literature predicts that a common pattern referred to as borealization - an influx of boreal species pushing Arctic species further northward - will become increasingly prevalent in Greenland, resulting in a profound transformation of the Arctic marine ecosystem to one characterized by subarctic conditions, subarctic species, and corresponding interactions. Borealization will lead to a decline in taxonomic and functional diversity, diminishing ecosystem's adaptive capacity.

However, the literature research provides a mixed picture of how Greenlandic species populations are evolving. Borealization is expected to lead to declines of resident ice-associated and benthic fish species populations, including Arctic cod (moderately strong evidence for a decline) and growing populations of pelagic fish species such Atlantic cod (moderate evidence of an increase in East and West Greenland). However, our literature research found mixed evidence for this pattern depending on species and location – e.g. there is strong evidence for an increase of capelin in Northeast Greenland but also strong evidence for a decline in East Greenland overall and stable populations in West Greenland – contrary to expectations.

In addition, populations of several boreal cetaceans are expected to expand their ranges into new ice-free habitats. Here we found strong evidence for an increasing abundance of minke whales (Fig. 3.7, 3.8) and humpback whales in East Greenland (but strong evidence for a decline and moderate evidence for a stable abundance of both mink and humpback whales in West Greenland) and an overwhelming lack of information about fin whales.

We also found strong evidence for an increase of harbor porpoise in West Greenland, moderate evidence for an increase of white-beaked dolphins in East Greenland, and strong evidence for an increase in killer whale abundance in general. On the other hand, there is a lack of evidence for other stocks and species, including white-sided dolphin and long-finned pilot whale.

Meanwhile, the range of the nine mammal species native to the Arctic is expected to decline or shift northward. This includes the bowhead whale (overwhelming evidence for a decline of several populations), narwhal (moderate to overwhelming evidence for a decline of most stocks), beluga (moderate to strong evidence of decline), walrus (moderate and weak evidence for a decline of the Greenland winter aggregation and Northeast Greenland stock, respectively), polar bear (overwhelming evidence for a global decline), and the sea-ice associated seals, including bearded seal (weak evidence for a decline in Eastern Canada/West Greenland), ringed seal (strong generic evidence for a decline in Greenlandic populations), hooded seal (moderate evidence for a decline) and harp seal (moderate evidence for a decline). Nevertheless, there is also here contradictory evidence, including strong evidence for an increase of bowhead whales in West Greenland, stable Melville Bay narwhal stock, strong evidence for a stable hooded seal stock in the Greenland Sea and strong evidence for an increase in the Northwest Atlantic stock.

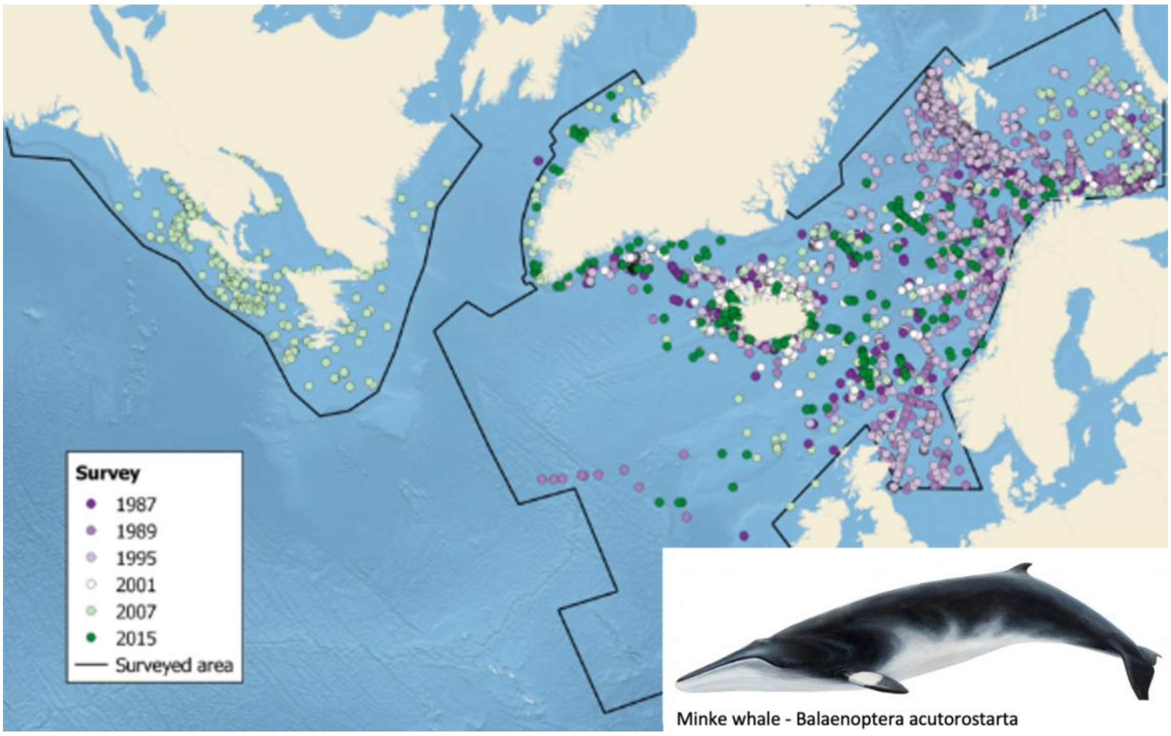

Figure 3.7. Observations of Minke whales from all surveys 1987 – 2015 (NAMMCO)

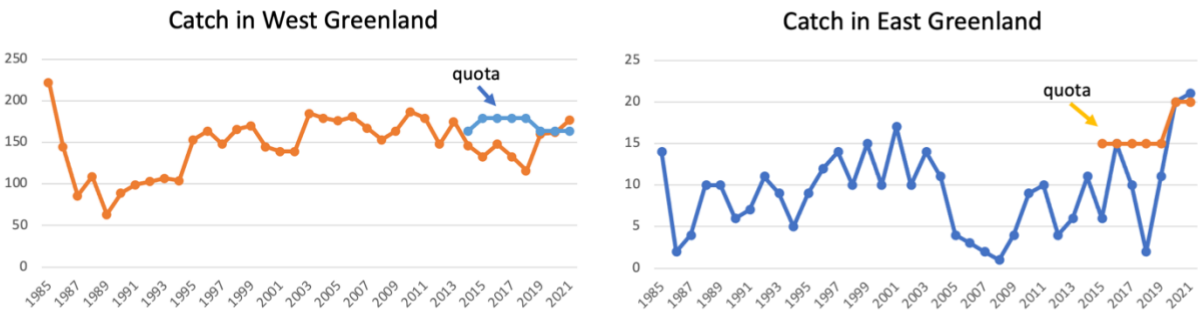

Figure 3.8. Total catch of Minke whale and quotas (in number) for West and East Greenland (NAMMCO).

For walrus, there is strong evidence for an increase and moderate evidence for an increase for the West Greenland winter aggregation and Northeast Greenland stock, respectively (Fig. 3.9). For polar bears, although there is overwhelming evidence that global polar bear populations will decline, the evidence range from overwhelming evidence for a decline to overwhelming evidence for an increase for individual sub-populations and in some cases, there is equally strong evidence for opposite trends for the same population.

Many Arctic seabirds are sensitive to rapid changes in sea surface temperature in both directions, expected to lead to massive population declines. This includes thick-billed Murre (strong evidence of a decline in East and West Greenland and overwhelming generic evidence that this species is or will decline in Greenland) and black-legged kittiwake (weak evidence of a decline in all Northwest Greenland, South Greenland and East Greenland). On the other hand, many gulls are expected to show positive population trends. This includes the glaucous gull (strong evidence of an increase in West and East Greenland), the Icelandic gull (strong evidence for an increase in West and East Greenland), and the great black-backed gull (strong evidence of an increase in West and East Greenland). Non-Arctic species that are poorly adapted to foraging in Arctic waters, such as the great cormorant (strong evidence of an increase in West and East Greenland) and Mallard (overwhelming evidence of an increase in East Greenland) are also expanding their range into Greenland. Geese such as the Canada goose (weak evidence of an increase in East and West Greenland), Greenland barnacle goose (strong evidence for an increase and moderate evidence for a stable population in East Greenland), and pink-footed goose (moderate evidence for an increase in Greenland) are also expected to benefit greatly from the warmer climate, reduced snow cover, and early spring. Their numbers have increased by a factor of two to six, and they continue to spread to new breeding areas. Again, there is also evidence pointing in the opposite direction, including weak evidence for an increase in black-legged kittiwake and strong evidence of a decline in great black-backed gulls in West and East Greenland, respectively.

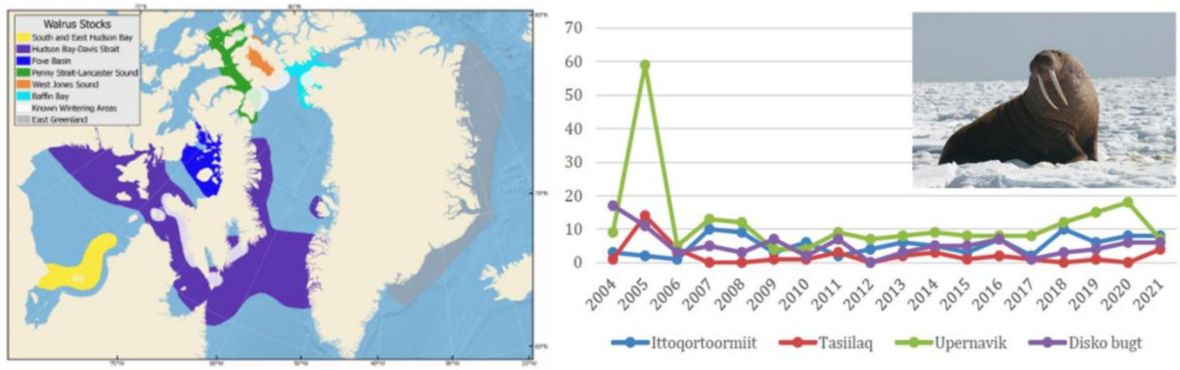

Figure 3.9 Left: distribution of walrus (Odobenus rosmarus). Right: catch of walrus per year in Ittoqortoormiit, Tasiilaq and Upernavik districts and in the Disco Bay

These findings highlight the importance of scenarios being developed at the relevant population level, as far as possible. Furthermore, local hunters and fishers often disagree with the results of scientific surveys. Main trends predicted by scientific studies and by the catch forecasts were discussed in workshops leading to a large number of possible scenarios (4 districts multiplied by 49 potential species and scenarios based on observed and predicted trends, correction for underreporting and alternative scenarios based on changes in management regulations or infrastructure).

Communities are cognizant of climate change and have observed various detrimental impacts, including increased unpredictability of travelling on sea ice and the change in access to various species that limit catch or offer new opportunities. Climate change is expected to lead to decreasing catch of hooded seals until 2030 (proposed 20% reduced catch compared to 2012-20 average) in Tasiilaq due to restricted access in the fragmented ice. But it is also expected to lead to increasing catch of young harp seals (proposed 10% increase compared to 2012-20 average) due to easier access in new ice-free periods (Fig. 3.10). However, climate change also offers opportunities for more intensive fishery, which may reduce the catch of some species as hunters increasingly shift into the fishery sector. Workshop participants in Upernavik, for instance, expected decreasing catch of young harp seals (proposed -25% compared to the 2012-20 average) due to declining profitability compared to fishing.

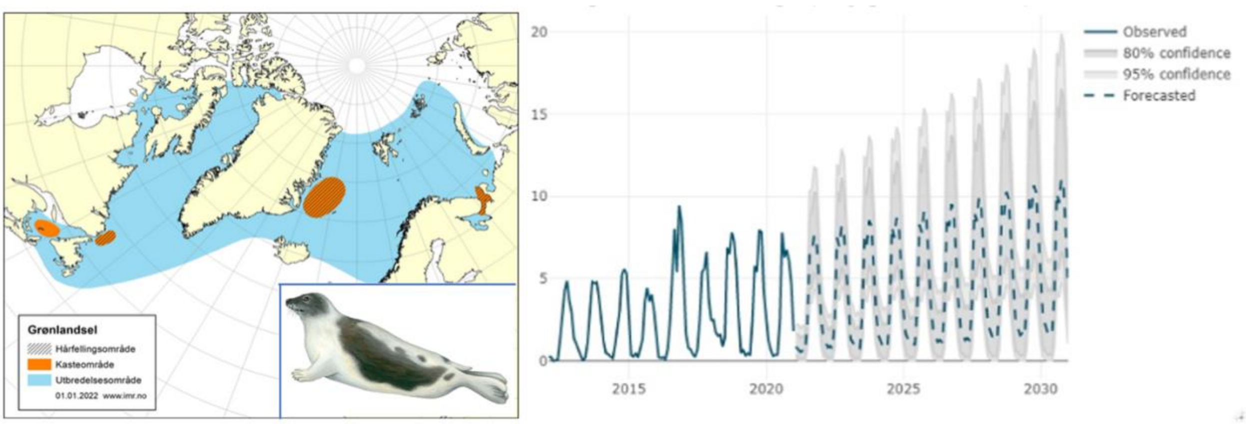

Figure 3.10 Left: Distribution map for harp seal (Pagophilus groenlandicus), where the brown patches show the whelping areas. Right: Average catch per hunter of young harp seal in the Tasiilaq district with future scenarios.

Regardless, living in a highly fluctuating and unpredictable environment, climate change is often seen as something that one adapts to and less of a problem than poor infrastructure and the management regulations imposed by the Self-Rule Government and international organizations. Hence, the scenarios proposed to be explored by focus groups centre more around these aspects than climate change. This includes an increased trade-in of young harp seal skin in Ittoqqortoormiit (proposed 30% increase compared to the 2012-200 average) if a processing facility (i.e. scraping machine) is established (already allocated in the district budget). Similarly, the occupational hunters in Tasiilaq suggest banning part-time hunters from catching ringed seal to reduce overharvesting of this species and provide a source of income for the occupational hunters through local trade (i.e. zero catch by occupational hunters and a 10% increase compared to the 2012-20 average for occupational hunters). Another much-emphasized alternative scenario is removing the trade ban on polar bear skin, which to many, is considered unfounded when the catch is based on a sustainable quota.

As apparent, the number of scenarios is large and further synthesis is not feasible at this stage due to the many species and locations that each may warrant separate scenarios. Our studies only included data from workshops in four districts and did not include input from scientific experts at this stage. Additionally, workshops are planned for later in 2023 as part of the FutureArcticLives project to specify and develop scenarios for South Greenland districts. Furthermore, interviews will be conducted with scientific experts and managers to validate and provide input on the literature synthesis and scenarios. Generally, workshop participants found it difficult to imagine climate change and stock developments beyond 2030. Hence, scientists will be asked to provide input for more extreme future scenarios.

Hence, Deliverable 2.4 is the first iteration in the process and will be updated and expanded with data from additional locations and input from scientific experts. Once all relevant input has been incorporated, we plan to settle on three overall scenarios: one that incorporates *underreporting*, one that is based on *climate change projections* (which in reality will incorporate expected changes for each species and population) and one that involves *optimization of infrastructure and management regulations* (i.e. investments in processing facilities, fishing vessels and management regulations).

The detailed scenarios for a number of species (presented in D2.4) is meant as a tool for projects working with Greenland's hunting and coastal fishery sector and is therefore a highly exploitable result. The FutureArcticLives project will, for instance, use this deliverable to implement scenarios that adjust the income portfolio at the household level through, e.g. a Monte Carlo simulation (using data supplied by Statistics Greenland) to explore the welfare consequences of climate and other changes for the hunter and coastal fisher families across Greenland.

3.4 Test of automated translation of Greenlandic language

Translation to and from Indigenous languages is a major issue for CAPARDUS and other projects which involve cooperation with Indigenous People. Before the final meeting in Nuuk, a preliminary study was conducted in collaboration with Sigmund Kluckner and Maria van Veldhuizen, which consisted of two parts: first to create a general overview of tools available and of their capabilities, to show the range of actors engaged in translation and what they offer; and second to assess the overall technical capacity of translation tools to produce fluent, accurate translations of scientific/academic texts. The study is documented in the report "Assessment of Online Translation Tools for Indigenous Languages in the Ocean Domain".

Artificial Intelligence (AI) tools are machines or software that can perform cognitive functions that we associate with human minds, such as perceiving, reasoning, learning, problem solving, and even exercising creativity. AI tools have evolved over time with advances in computing power, algorithms, and data availability. One of the main branches of AI is machine learning, which is based on algorithms that can learn from data and improve over time without explicit programming.

Machine learning can be further divided into subfields such as deep learning, natural language processing, computer vision, and reinforcement learning. AI tools are already in widespread use in various domains and for various purposes, such as voice assistants and smart speakers, chatbots, facial recognition, medical diagnosis, gaming, marketing, and automated language translation. The most recent breakthroughs in AI were the release of large language models (LLMs).

Machine translation (MT) tools are software programs that can translate text or speech from one natural language to another. Machine translation tools can be customized for specific domains or purposes, such as legal, medical, or literary translation. Though machine translation tools have improved greatly over the past several years, they are not perfect and for most purposes still require human intervention or postediting to improve their quality and accuracy. Where they are used without human intervention, such as on social media platforms, incorrect translations have occasionally caused problems.

Neural machine translation (NMT) is a form of machine translation that uses Artificial Intelligence (AI) in the form of deep neural networks to encode and decode languages in a vector space. NMT has the advantage of being fluent and natural, but it also has the disadvantage of being opaque and data-hungry. With increasing computing power, NMT has become the dominant machine translation method. It is the focus of the work done for CAPARDUS, because it performs better than other methods and is still rapidly improving.

A comparison was made between automated translation from Greenlandic/Kalaallisut into English with human-written English of a text from the document "Local documentation and management of living resources: User Guide" . The only machine translation tool that offered this language pair was Alibaba translate, which performed poorly (analogous to its performance with major languages). An example of translation is shown in Table 2.

Table 2. Exemplary test translations from Greenlandic to English, including the human-created English version of the same paragraphs

Original Greenlandic	English Machine Translation	Human-created English translation from the report
Pinngortitalerinermi apeqqutaasinnaasut, assersuutigalugu: 1. Uumasut amerliartussappat imaluunniit ikiliartussappat? 2. Aalisakkat pisarineqartartut alliartussappat imaluunniit milliartussappat? 3. Uumasut takkuttarnerat pisarnermiit Kingusinnerulissava imaluunniit siusinnerussappat?	For example: 1 Will the animals be multiplied or decreased? 2 Should the fish grow, or should they grow up? 3 Animals arrive later Be ahead ?	Biological questions, e.g.: 1. Are there more or fewer animals? 2. Are the fish caught bigger or smaller? 3. Are the animals arriving/leaving later or earlier than 'normal'?
Ullumikkut pisuussutinik nalunaarsuisarneq. Kalaallit Nunaata pisuussutaanik uumassusilinnik nalunaarsuineq ullumikkut annerusutigut pisanik nalunaarsuinermi katersivimmut Piniarnermut nalunaaruteqarnikkut, ilisimatusarnikkullu misissuisarnernit pisarpoq.	The present - day treasure - making process. Recording the earth's resources is a major event in the world By giving a report to the branch office of Jehovah's Witnesses, and from scientific research.	Existing resource documentation and monitoring. Monitoring of Greenland's living resources is currently taking place primarily through reports made to the catch database Piniarneq and research-based studies. Experience indicates that there is great potential for managing knowledge on living resources among Greenlandic hunters and fishers.

Additionally, we tested the translation tool "Nutserut.gl", which is provided by the "Language Secretariat of Greenland". As mentioned previously, this rule-based machine translation tool supports translations between Greenlandic and Danish. We translated the texts from above into Danish and asked a bilingual professional translator to assess the quality. The response was that these results were unusable, and there is still a need for human translators.

The result of the comparison shows that the translation tool used on Greenlandic (Alibaba translate) was not too bad for the simple sentences (upper row in Table 2), but it was meaningless for the more complicated sentence (lower row). It is important to note that the translation tools are making great progress and can be quite useful if some precautions are taken with the original text.

The assessment showed that machine translation tools struggle with specific sentence constructions and issues such as ambiguity, which could be avoided in original texts. If authors adjusted their writing style to accommodate machine translation, by using shorter sentences with clearer structures and less ambiguity, that would also benefit non-native speakers and lay readers. The tools tested do not provide any support for the Indigenous and/or rare languages of interest to this project. The study showed that even major tools struggle with low-resource languages, and even if such languages are offered, that does not mean that translations will be of high quality. However, innovative strategies and technologies for training AI based on limited data are emerging that may make high-quality translations from and into low-resource languages possible in the future.

4. Results of case studies in Svalbard

The main challenge of the Svalbard community is to adapt to the severe effects of climate change and the transition from a mining town to new activities, especially tourism and research. The case study has organized several meetings and workshops with Longyearbyen Local Council, the Governor of Svalbard, tourist operators and other actors to identify standards, practice and guidelines for various activities that are important in Svalbard. The main activities are research with collection of environmental and climate data, preservation of cultural heritage, tourism, shipping, safety of operations, community planning. Svalbard is exposed to severe climate warming with melting of permafrost, increased coastal erosion, snow avalanches, melting of glaciers and reduction of sea ice, all of this have direct impact on people living, working and travelling in Svalbard. The University Centre in Svalbard (UNIS), established by the Norwegian Government in 1993, has become a major Arctic research and education facility located in Longyearbyen. It hosts more than 800 students attending academic courses in Arctic physical sciences and plays a central role in the Svalbard community. The results from the case studies are presented in two deliverables: *D3.1: Report from workshops and activities in 2020-2022*, and *D3.2 Report form workshops and other activities in 2022-2023.*

The CAPARDUS activities in the pandemic period was limited to online meetings with representatives from the local community in Svalbard, the Svalbard Social Science Initiative and other research projects addressing the climate and societal changes in Svalbard.

Figure 4.1. Longyearbyen, Svalbard, Norway. A community with about 2500 inhabitants. Shutterstock.com

In March 2021 a workshop was organised online in collaboration with the CULTCOAST project, funded by the Research Council of Norway, with the objective to monitor, manage and protect sites and landscapes in Svalbard under climate change. The objective of workshop was to initiate collaboration with cultural heritage scientists, managers, national authorities, cruise operators, local guides and others who are involved in protecting cultural heritage sites in Svalbard.

In October-November 2021, the first physical workshop in Longyearbyen after the pandemic was organised by NERSC in collaboration with Svalbard Social Science Initiative. The objectives were to build connections between Svalbard-related social science research and the local community in Longyearbyen in the context of climate change and its impact (Fig. 4.2). The Svalbard Social Science Initiative is an association of social science, humanities and arts-based researchers working with a wide range of issues in Svalbard. Since it was established in 2019 the SSSI has organized a number of events in collaboration with NERSC and with support from the Svalbard Strategic Grant, the H2020 INTAROS and the CAPARDUS projects. During the Svalbard Science Conference in Oslo in November 2021, a side-meeting was organized with 30 participants from both social science and physical science projects working in Svalbard. The goal was to strengthen interdisciplinary collaboration between social science, natural science, and the Svalbard community to meet the challenges from climate change as well as socio-economic changes in the region.

Figure 4.2 From a public panel discussion in the library during the Svalbard Social Science Initiative workshop in Longyearbyen 29-31 October 2021. Photo: S. Sandven.

In August 2022, a 4-day workshop with field excursion was organized in collaboration with CULTCOAST project, followed up by 2-day workshops in February 2023 and June 2023. The topics of addressed in the workshops were (1) Community-based monitoring and Citizen science; (2) Cultural heritage research and management; (3) Tourism; (4) Arctic shipping and safety; and (5) Arctic repository and Arctic Practice System. Representatives from the Svalbard community participated in the workshops together with representatives from different research projects. A summary of these workshops are presented in the following sections.

4.1 Cultural heritage research and management in Svalbard

Svalbard's environment is extremely vulnerable to impacts from climate change in combination with human footprint from increased tourism. The industrial remains, whaling and hunting infrastructure and remains of the early scientific expeditions are key elements of Svalbard's environment. The early mining industry provided accommodation and easier access to the archipelago, paving the way for tourism, which dates to the 1800's and focuses on both natural and cultural environments. Tourism is one of the key economic pillars of developing a sustainable society of the archipelago (Hovelsrud et al., 2021). The recent recommendations by the Norwegian Environment Agency for stricter regulations of human traffic on Svalbard will have major ramifications for the tourism industry, including new limits on marine-based activities and access to sites, increased safety and insurance regulations, and likely more requirements for certified guides. The overall purpose of regulatory strengthening is to limit and reduce impacts to the natural environment and cultural heritage.

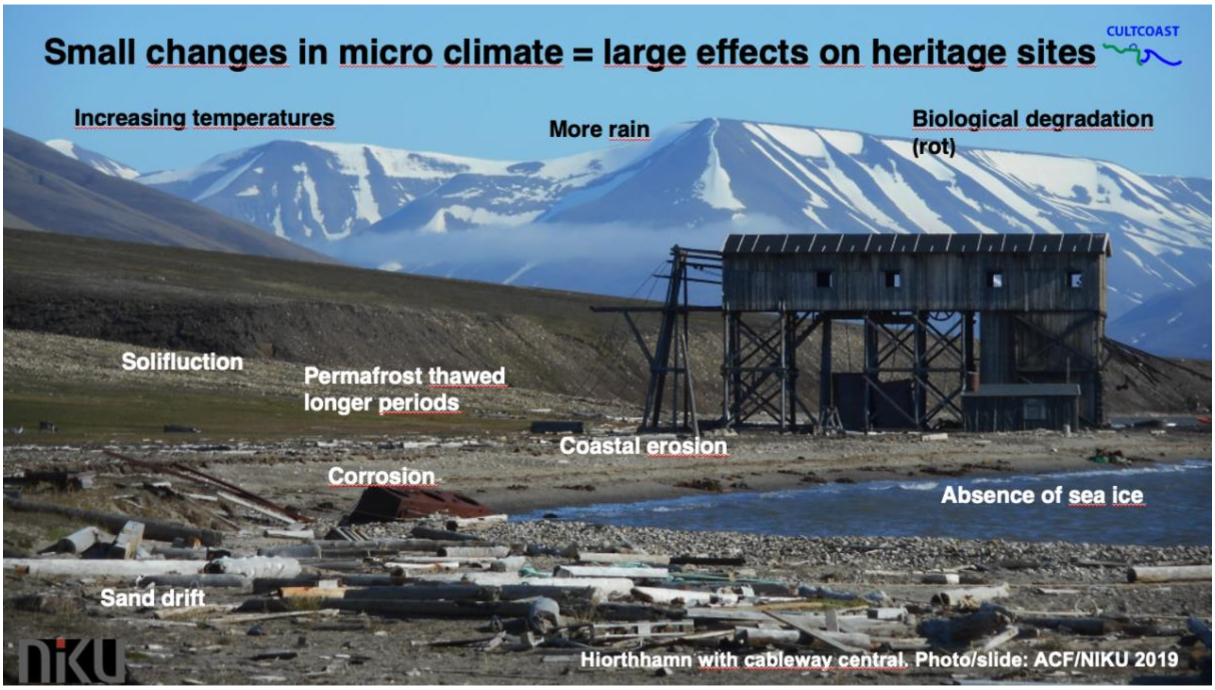

Figure 4.3 Photo of cultural heritage remains in Hiorthhamn in Svalbard, combined with climate change impacts.

The Norwegian Cultural Heritage Act (1978) and the Svalbard Environmental Protection Act (2001) make it a national responsibility to safeguard cultural heritage as a scientific source material and as an enduring basis for understanding and linking present and future generations to history. Due to the rapid manner by which climate change impacts on fragile Arctic nature and cultural heritage environments (Fig. 4.3), and the increasing pressure from tourists visiting the remote and exotic archipelago, there is an urgent need for knowledge-based inputs to inform decision-making and help develop strategies for natural and cultural heritage management at different levels. One recommendation is to establish citizen science methods where tourists and others can use mobile phone with apps to monitor cultural heritage sites around Svalbard. By involving the public, new data can be collected from a wider area, results shared more effectively through society, and environmental issues better understood. The result will be a greater awareness of challenges which can prompt changes in people's behavior.

4.2 Community-based monitoring and citizen science in the Svalbard region

In August 2022, a 4-day workshop was organized with the title "Community-based monitoring and Citizen science in the Svalbard area". The objectives of the workshop was to (1) review status of Community-based monitoring and Citizen Science (CBM-CS) systems in Svalbard and other Arctic areas and identify issues in further development of the systems; (2) plan and identify CBM-CS activities in support of cultural heritage research in Svalbard; (3) review guidelines, practices, standards and regulations which are relevant for CBM-CS activities in Svalbard and Arctic in general; and (4) discuss how an Arctic Practice System should be designed to be a useful digital resource for people living and working in Svalbard.

Community-based monitoring and Citizen science are often used synonymously, but there are differences between the two terms, as shown in Fig. 4.4. There are numerous CBM-CS projects active in the Svalbard area, and these project play an increasingly important role in environmental and climate data collection. While CBM initiatives are mainly bottom-up initiatives in local communities the CS projects are often driven by scientists and can range from large global-scale projects (e.g. bird watching) to local initiatives on topics of importance in specific areas (e.g. snow avalanche observations). Common for all CBM-CS projects is that they need to be highly relevant and appealing for the public to be successful.

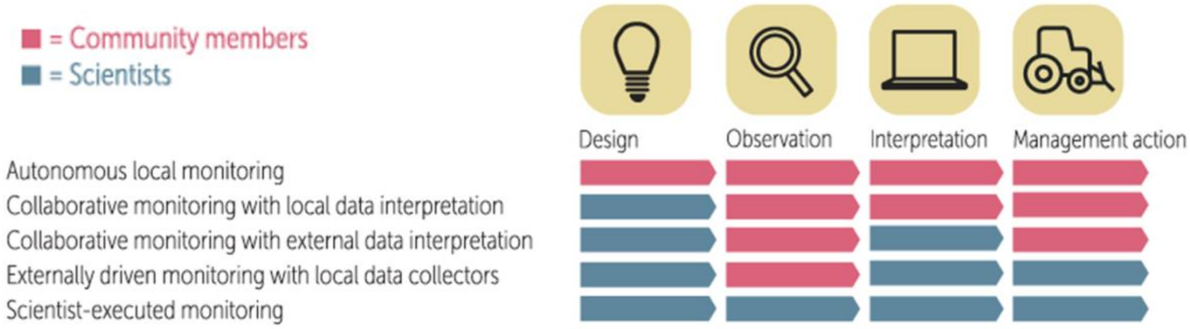

Figure 4.4 Transition between Community-based monitoring and Citizen science (Danielsen et al., 2021)

In the whole Arctic about 170 CBM programs were identified during the INTAROS project, of which 45 were analyzed and the results were reported by Danielsen et al. (2018) in INTAROS Deliverable 4.1: Community based monitoring programmes in the Arctic: Capabilities, good practice and challenges. CBM programmes can be significant contributors to international environmental agreements (e.g. Kunming-Montreal Global Biodiversity Framework) and the UN Sustainable Development Goals, but there are challenges to fund and operate many of the CBM initiatives. The most successful citizen science projects have been built up over many years and support for large organisations (e.g. NASA, university labs, foundations).

In the Svalbard region several global citizen science projects are active because tourists and other visitors collect data and upload it to central repositories. One large project is *eBird* , which is a global observing system for birds, established and operated by Cornell Lab of Ornithology for the last 20 years. The goal is to gather information from birdwatchers, archive it, and freely share it to power new data-driven approaches to science, conservation and education. *eBird* is among the world's largest biodiversity-related science projects, with more than 100 million bird sightings contributed annually by birdwatchers around the world and an average participation growth rate of approximately 20% year over year. An example of data from Svalbard registered in *eBird* is the Atlantic Puffin, which is listed as globally threatened by the World Conservation Union in the category Vulnerable (Fig. 4.5).

Hearts in the Ice (HITI), run by Hilde Fålun Strøm together with Sunniva Sorby, conducts citizen science work for different projects (https://www.heartsintheice.com/). During their overwintering 2020-2021 at Bamsebu in Svalbard, they collected data for NASA, UNIS, Norwegian Polar Institute and other research institutions. Such overwinter expeditions provide a unique possibility to collect in situ data in areas and seasons when such data are difficult to obtain.

Other major citizen science projects are:

- **Aurorasaurus** - Track auroras around the world (NASA Science Activation)
- **NASA GLOBE Clouds** - Cloud Observations & Atmospheric Measurements (NASA GLOBE Observer
- **Happywhale** - Marine Mammal Photo-ID (International Whaling Commission and multiple regional research partners)
- **iNaturalist (**California Academy of Sciences and the National Geographic Society).
- **FjordPhyto** Phytoplankton Sampling (Vernet Lab at Scripps Institution of Oceanography

Figure 4.5 Records of Atlantic puffin Fratercula arctica (n = 622 records) from Svalbard 2002-2019 in the eBird database (Photo by Henrik Kisbye).

UNIS started cooperation with the tourist company Hurtigruten some years ago to collect oceanographic and marine biological data as part of the tourist cruises around Svalbard. Now, tourist operators who are members of the Association of Expedition Cruise Operators (AECO) have included citizen science as a central part of their programme because they receive positive feedback from the customers (Fig. 4.6). When the tourists participate in research and data collection they get direct access to observation of the climate change and thereby a deeper understanding of the environment they are visiting.

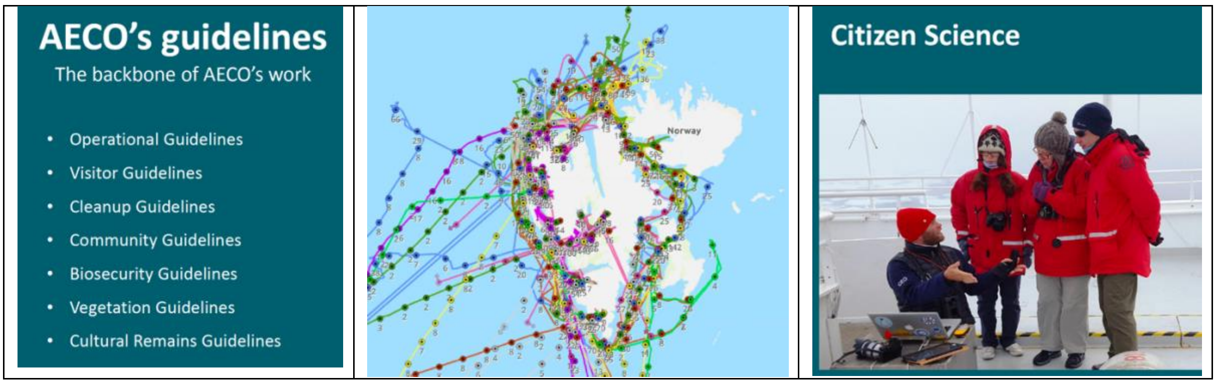

Figure 4.6. The list of guideline documents provided by AECO (left), ship track of cruises around Svalbard organised by AECO (center) and invovement of tourists in Citizen Science activities on the cruises (courtesy Gyda Gudmundsdottir, AECO).

For the scientists, the expedition cruises offer a way to collect more environmental data from larger areas, compared to what the scientists can do alone. Tourists can become important contributors to scientific data collection onboard vessels travelling in different parts of the Arctic. The collaboration between tourists and scientists is of mutual benefit, where the educated tourists become ambassadors for the environment.

4.3 Development of tourism in Svalbard and its impact on the environment

Tourism in Svalbard is increasing year by year and is identified as a key economic pillar for future development in Svalbard. Although tourism provides new economic opportunities, it can often result in pressure on infrastructures and contribute to problems for the local inhabitants. For instance, port facilities and services for the cruise vessels can be congested and overloaded in the high season when many vessels and tourists arrive at the same time.

Except for the pandemic years 2020 and 2021, the number of hotel guests in 2022 was at the same level as in 2019. The growth in number of visitors to Svalbard from 2012 to 2022 is shown in Fig. 4.7, where visits are grouped into three seasons: June - September (high season), October – January (low season) and February – May (transition season). Note that these figures represent guests staying at hotels, not the passengers who stay onboard the cruise vessels.

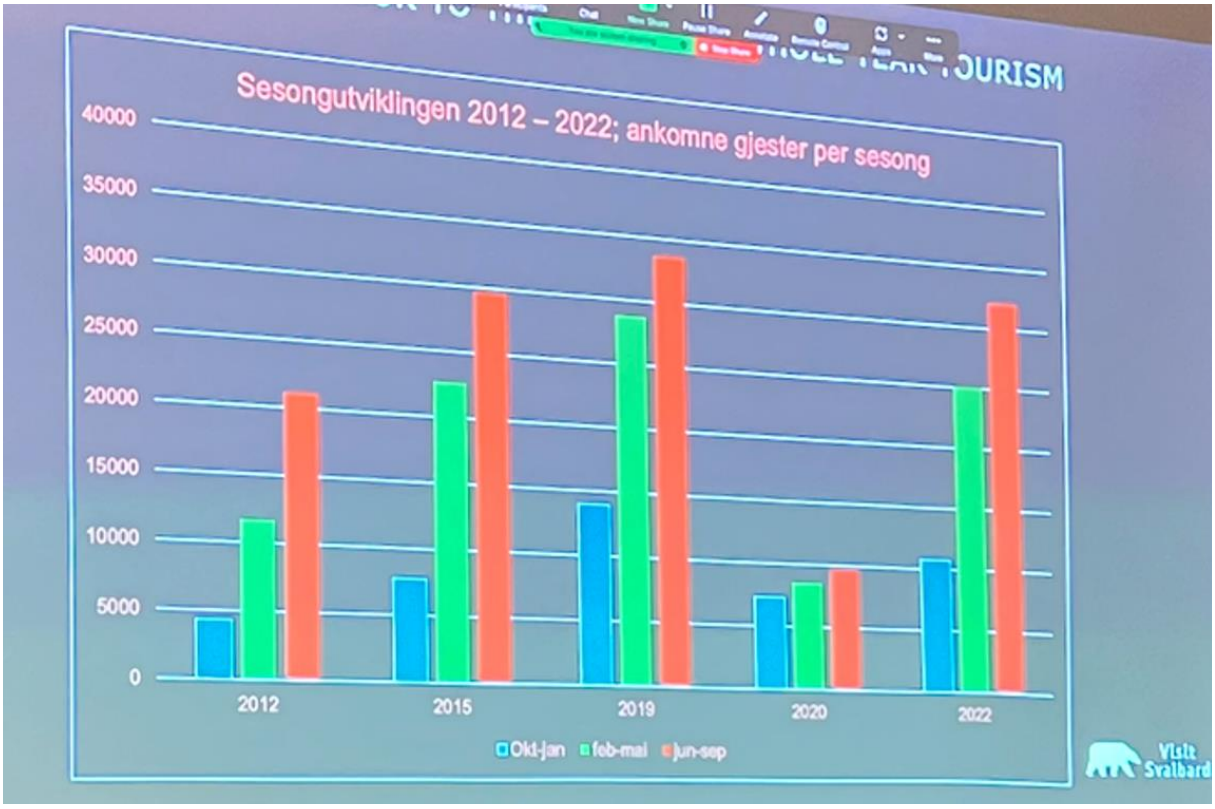

Figure 4.7 Statistics on guests visiting Svalbard 2012 – 2022 (R. Brunvoll, Visit Svalbard).

Visit Svalbard is the official tourism board for Svalbard and Longyearbyen. Visit Svalbard is a member based organisation and a neutral development and coordinating body of the local tourism industry. They are also responsible for the official travel portal for Svalbard with tourist information.

Hurtigruten Svalbard is the largest tourist operator in Svalbard and a major operator in other Arctic and Antarctic areas. The company provides full tourist packages including cruises with expedition vessels, hotels, restaurants, shops, activities. In 2019 their new ice-strengthen cruise ship MS Roald Amundsen was launched with hybrid propulsion that will reduce fuel consumption and CO2 emissions (Fig. 4.8). The company hires scientists to be responsible for organizing citizen science activities onboard their vessels in collaboration with science projects. The scientist onboard are involved in many of the major citizen science projects in the Arctic and Antarctic (Fig. 4.9). Several guides are employed to educate the guests about the climate and environmental changes in the polar regions, and to disseminate this information to the outside world.

Figure 4.8 The ice-strengthen cruise vessel MS Roald Amundsen

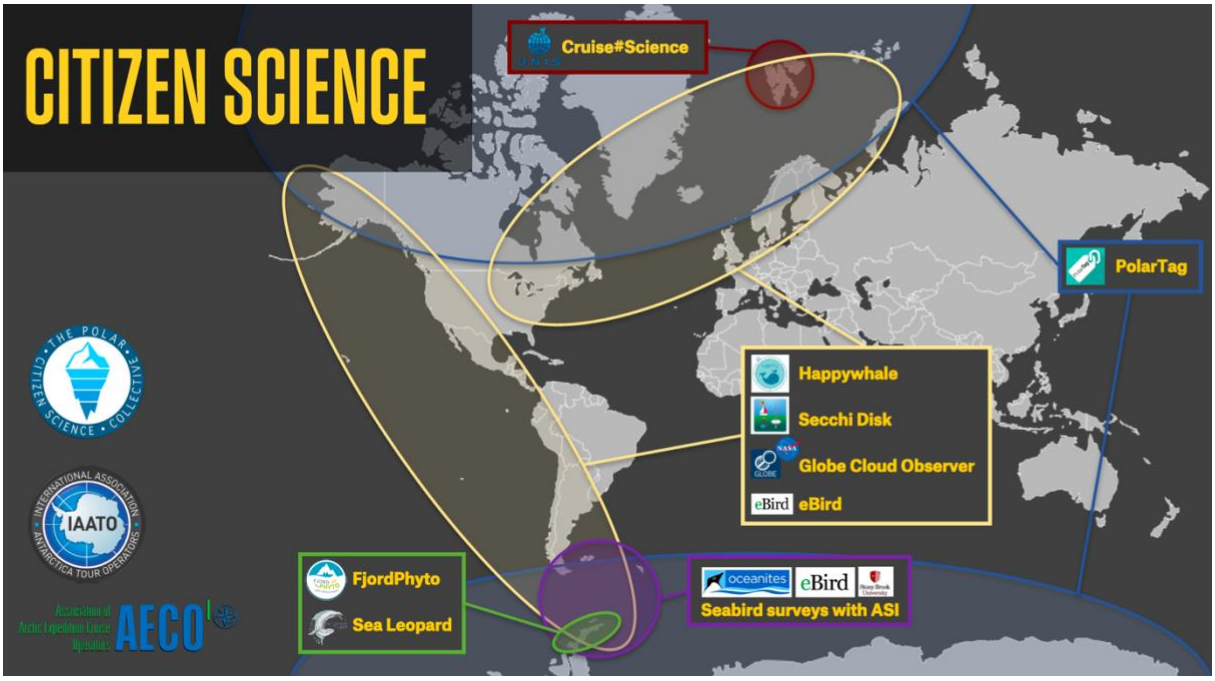

Figure 4.9. Map showing the citizen science programmes where Hurtigruten Svalbard is involved (Melina Verandi).

Association of Arctic Expedition Cruise Operators (AECO) was established in 2003 and has now 63 international members and 57 operating vessels. Many of them operate in the Svalbard area, bringing tourists to the region. The goal of AECO is to develop environmentally friendly, responsible and safe cruise tourism in the Arctic. AECO has therefore produced a number of guidelines to be used by the tourist guides and the cruise passengers during the expeditions. AECO is an industry association for expedition cruise vessel with up to 500 guests, in comparison with the conventional cruise vessels and the small vessels, who are not members of AECO (Table 3). In addition to citizen science activities, all AECO members provide onboard lectures in different subjects like biology, climate and environmental topics in the polar regions.

Table 3. Operational characteristics of three types of cruise vessels (Gyda Gudmundsdottir, AECO)

Operational characteristics	Conventional cruise operations	AECO expedition cruise operations	Small vessel cruise operations
Legal framework	IMO	IMO or National/Flag State regulations	National and/or Flag State regulations
Size	Mostly more than 500 guests	Mostly up to 500 guests	Mostly up to 12 guests
Fuel	HFO & MGO	MGO, sail & hybrid technology	MGO, sail & hybrid technology
Infrastructure and harbour needs	High	Low	Low
Itineraries	Fixed	Highly flexible	Highly flexible
Desinations	Towns/populated areas	Nature landings and local communities	Nature landings and local communities
Product focus	Vessel experience, entertainment onboard, destination highlights	Destination immersion and learning experience	Various
Industry associations	CLIA	AECO	None
Industry standards	Indsutry policies guide, company minimum standards	Mandatory industry standards and guidelines	Individual company standards

From 1 January 2020 the Government implemented new regulations for ships around Svalbard where all ships with more than 750 passengers were banned (see section 4.5). The number of passengers on conventional cruise ships (more than 500 passengers) was about 20000 in 2022 compared to 40000 in 2019. However, the number of passengers on the explorer vessels (less than 500 passengers) grew from 22000 in 2019 to 28000 in 2022.

The policy for further growth in the tourist traffic is to have more visitors in the dark months and not increase the traffic in the peak season. The Local Council has also decided to stop further building of new hotels. This will allow better to use of existing hotel capacity and provide more year-round employment of the tourist operators. The policy for further growth in the tourist traffic is to have more visitors in the dark months and not increase the traffic in the peak season.

For the tourist operators, managers, and government it is important to build up knowledge about the impact of tourism on the environment and how the tourism should be developed in a responsible way (Hovelsrud et al. 2020). The impacts from tourism can be diverse encompassing effects on the natural as well as the socio-cultural environment. The high Arctic environment is in general considerably more vulnerable than regions further south. Of particular concern is disturbance to feeding, nesting and denning areas for birds and mammals in both terrestrial and marine environments, not least because exotic wildlife is a prime attraction for tourism (Øian and Kaltenborn 2020). Human traffic on the tundra can also cause soil erosion, trampling of vegetation, scars from campfires, contamination from human waste and littering. Cultural heritage sites are also often in a 'delicate' situation due to some of the same factors. In addition, there have been instances where tourists have disturbed graves, littered sites and taken wood from old buildings and historical constructions for use as firewood. Human traffic can therefore change the appearance of attractive tourist sites, and thus alter the social experience and socio-cultural meaning of these markers of salient history (Holmgaard et al. 2019).

Visit Svalbard has strong focus on developing sustainable tourism, which means that the quality in all parts of the industry should be improved and that the value creation for the society should increase. This means that sustainable tourism should:

- Be responsible and safe
- Operate the whole year and provide activities for the dark season such as cultural history, and northern light experience
- Length of each visit should be longer, avoiding the short visits
- Reduce climate emission and leave no traces

Figure 4.10. Visit Svalbard has provided training of guides since 1998, which is important for the safe and responsible tourist activities (Visit Svalbard).

The stricter regulations of human traffic on Svalbard will have major ramifications for the tourism industry, including new limits on marine-based activities and access to sites, increased safety and insurance regulations, and likely more requirements for certified guides. The regulations will mostly affect the sea-based traffic and very little for the local inhabitants compared with the existing regulations. The overall purpose of these regulations is to limit and reduce impacts on the vulnerable environment in Svalbard. Visit Svalbard has made comments to these regulations, where some are problematic for the tourist operators, such as no travel on sea ice and restriction on landing sites for explorer cruises.

Education and training of tourist guides is a key factor in developing the tourist industry in a sustainable way, which means that the operator must have focus on quality, safety and minimal human footprint of their activities. Visit Svalbard and the major operators such as Hurtigruten offer internal training for their guides, but the need for more formal education becomes more important as the industry is growing (Fig. 4.10). University of Tromsø in collaboration with UNIS offers a 1-year educational program, called Arctic Nature Guide, which is a practical course and can take about 30 students each year. The Arctic Safety Centre at UNIS plays a key role to develop competance and provide course in safety (see section 4.4).

4.4 Shipping in the Svalbard region

A large number of research vessels, tourist vessels, and other vessels are operating in the Svalbard waters and use the services Longyearbyen can offer. The Port of Longyearbyen is the main logistic point for the ship traffic, while the airport with daily flights to and from the mainland is important for transport of tourists and other personnel. From 2012 ship traffic data has been systematically collected and archived by PAME's Arctic Ship Traffic Data project based on AIS data from satellites and coastal stations. The AIS data are mandatory for ships above 300 tonnes or with more than 12 people. This means that ships are monitored in near realtime and are presented at the website of MarineTraffic.

In the Svalbard area, studies of the ship traffic has been published by e.g. Stecker et al, 2020, showing that fishing vessels are present year-round, while in the summer months there is considerable traffic with passenger vessels (Fig. 4.11).

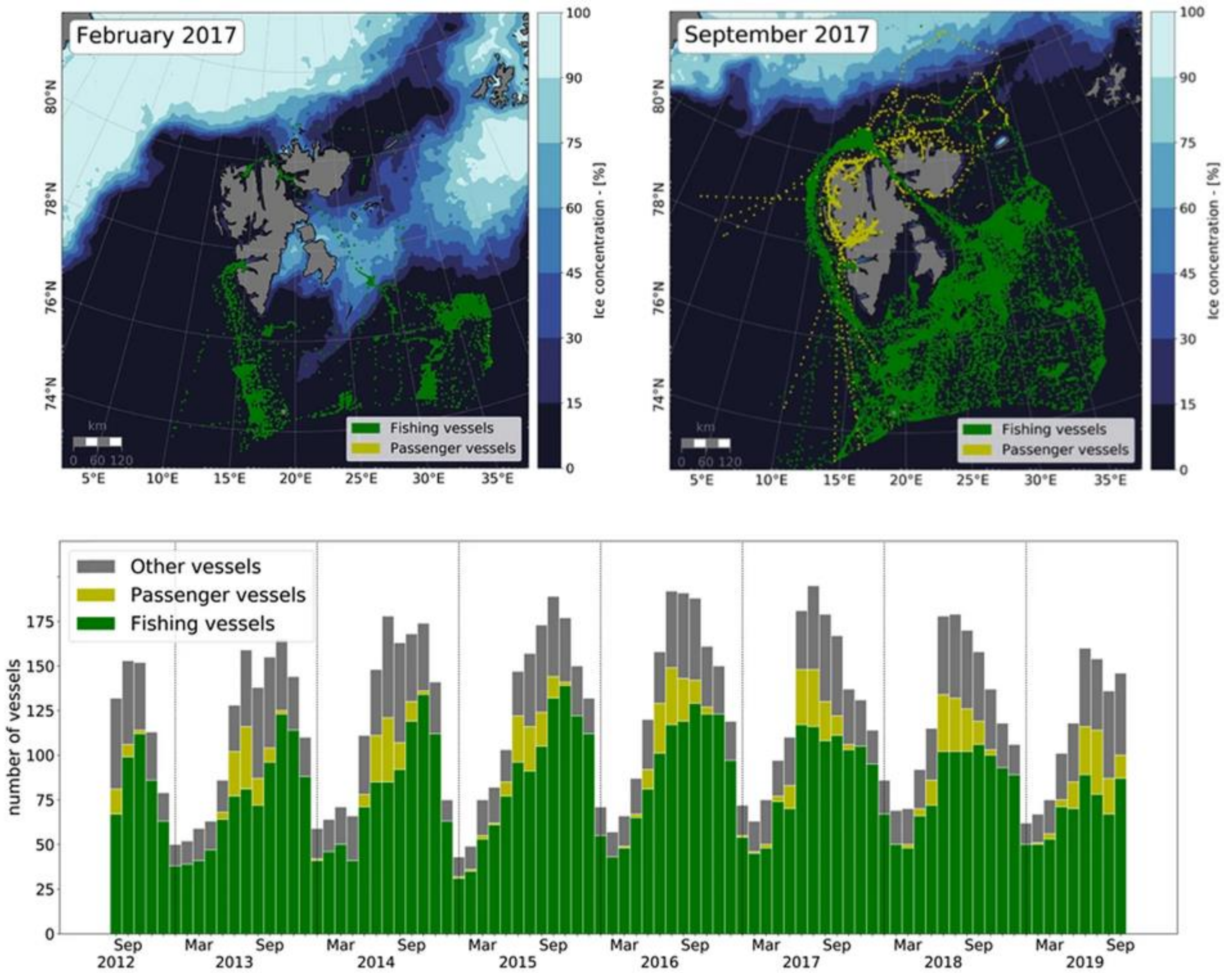

Figure 4.11. Upper graph: Ship traffic from AIS data around Svalbard in February and September 2017. Lower graph shows the number of ships in the Svalbard area for each month from 2012 to 2019 for three types of vessels (from Stecker et al, 2020).

From 2020 Norwegian Maritime Authority (NMA) has implemented new rules for passenger shipping in Svalbard. The regulations require all vessels to comply with IMO's Polar Code (January 2017 enforced, for polar water shipping) which is mandatory under both SOLAS (Safety of Life at Sea) and MARPOL (Prevention of Pollution from Ships) maritime conventions. NMA's new rules apply to both Norway- and foreign-flagged vessels navigating in Svalbard's waters. When the Corona virus crisis started in 2020, border closure and severe travel restrictions were imposed. In 2021, after the Coronavirus restrictions were lifted, the Norwegian government imposed new regulations for ships visiting Svalbard. One was to ban cruise ships from offering helicopter tours and mini-submarine tours in Svalbard, due to concern about how tourism affects the fragile arctic environment. Useful information about Svalbard cruise traffic is also available at www.cruisemapper.com.

4.5 Arctic safety

In Svalbard and other Arctic regions, the increased human activities requires that knowledge about safety is built up and disseminated to people who travel, work or live in these regions. There have been many accidents, or near accidents, because unexpected situations have occurred and people were not properly equipped or did not have necessary knowledge about the risks. Ships can be damaged by ice or grounded, infrastructures and people on land can be hit by snow avalanches, flooding or landslides. Climate change is a driving force which enhances the risk for these natural hazards to happen more frequently and with more severe consequences.

Figure 4.12 Arctic safety is a central part of most human activities and infrastructure: snow avalanche protection in Longyearbyen, rescue operation of a grounded ship, scooter trips with risks for accidents, and iceberg calving with risks of ice pieces hitting personnel or equipment (from M. Indreiten, Arctic Safety Center)

The factors that make safety more challenging in the Arctic compared to other places are the following:

- cold conditions and extreme weather conditions, leading to higher risk that people and equipment will not function
- remoteness and long distances implies that assistance in case of accidents will take much longer time
- limited infrastructure, implying that most human activities are more difficult and time consuming
- climate change is stronger, leading to more extreme weather events and consequently more severe natural hazards

There is a number of research projects addressing risk and safety for terrestrial as well as maritime activities, many of which have focus on the Svalbard region. The Governor provides information on safety measures for tourists and visitors regarding clothes and equipment during field excursions, polar bear protection, weather and snow conditions, and other environmental hazards. At UNIS the Arctic Safety Centre has been established providing research, education and training in Arctic safety topics, because there is a growing demand for knowledge among visitors as well as the local inhabitants (Albrechtsen and Indreiten, 2021). UNIS has now a leading role in developing safety standards for outdoor activities in Svalbard (Fig. 4.13).

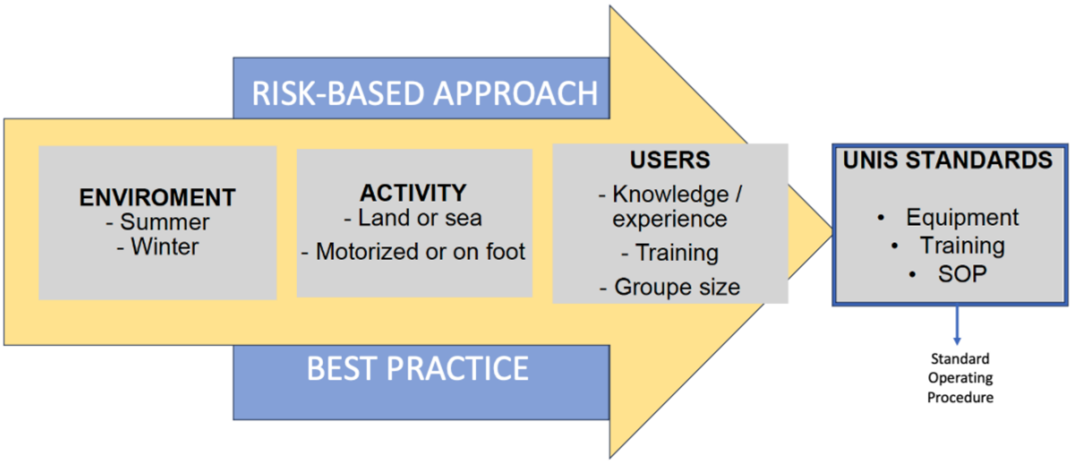

Figure 4.13. Development of Arctic safety standards at UNIS (From M. Indreiten)

The project ArctRisk (Risk governance of climate-related systemic risk in the Arctic) develops knowledge and tools to deal with effects of climate change on citizens and infrastructure. The project uses Svalbard as case study, where new technologies to monitor snow is demonstrated.

In addition to the safety activities in the Svalbard area, there are Pan-arctic maritime safety arrangements under the Polar Code (from 2017) and the Arctic Council (from 2011). The first international agreement made exclusively for the Arctic region was signed at the ministerial meeting in Nuuk, May 12 2011. The agreement, which deals with search and rescue of aeronautical and maritime vessels and passengers, is also the first international agreement made under the auspices of the Arctic Council. The agreement delineates the search and rescue responsibility areas the Arctic nations (Fig. 4.14).

In Norway, the search and rescue (SAR) operations are organized by the Joint Rescue and Coordination Center, (JRCC), which has a wider range of resources to its disposal for quick, safe and effective SAR operations. JRCC is coordinating the first EU funded project on Arctic safety, ARCSAR (Arctic and North Atlantic Security and Emergency Preparedness Network) from 2018 to 2024. The project involves companies, academia, NGOs and professional security and emergency response authorities and practitioners from 12 countries. JRCC has also a key role in the development of SOPs (standard operating procedures) for maritime SAR operations. Another project is MAREC: "The inter-organizational coordination of mass rescue operations in complex environments", which had focus on understanding the challenges of large-scale emergency response, including the knowledge on the management systems, as well as exercise schemes.

The Arctic Council's working group PAME provides useful information on Arctic shipping projects and the Arctic Shipping Best Practice Forum. The EPPR working group is running a dozen of projects related to safety and search and rescue. The ship traffic in the Arctic is expected to grow with many implications for safety and search and rescue services. Therefore, shipping operators, search and rescue agencies, NGOs and academia are enhancing their efforts to safe and sustainable shipping in Arctic waters.

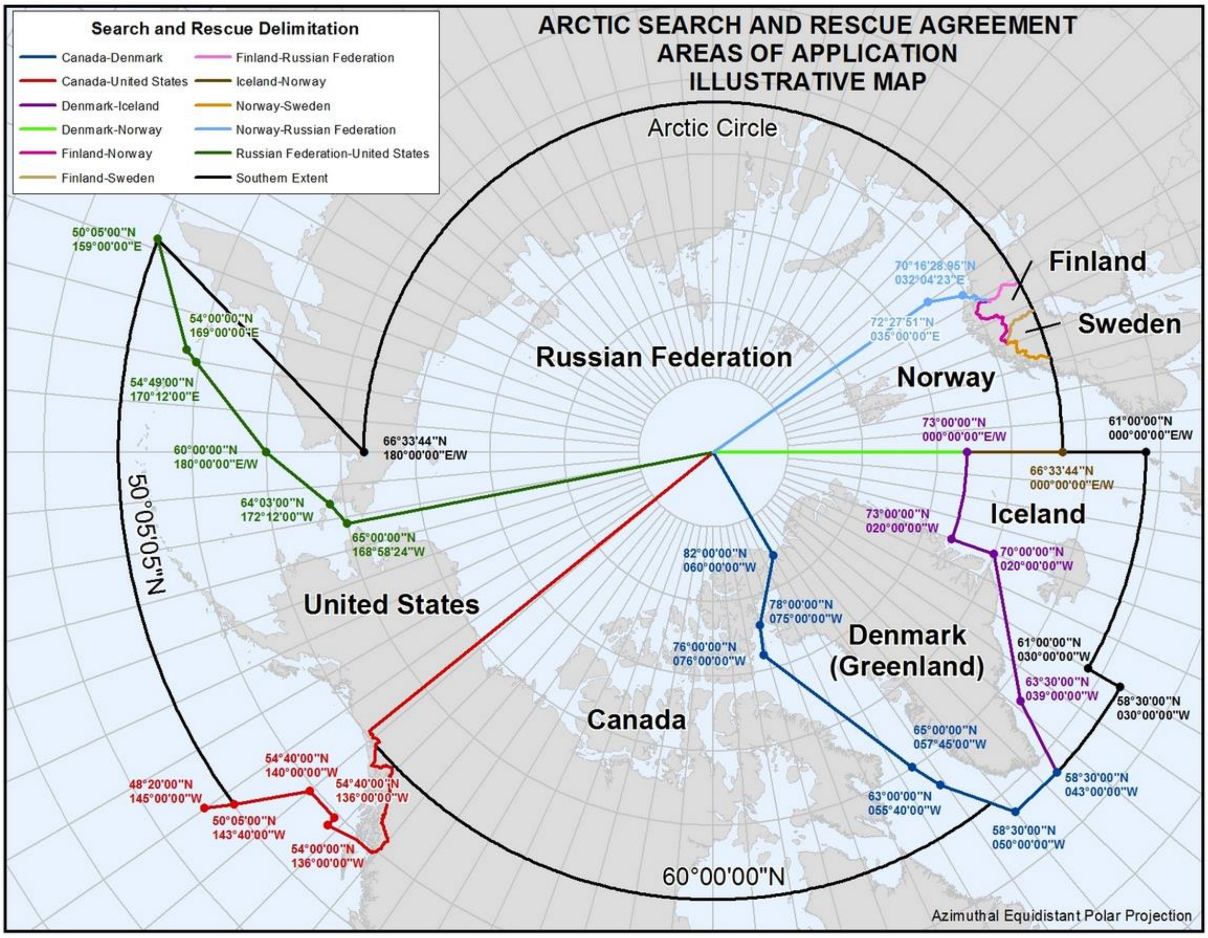

Figure 4.14. Map of the search and rescue responsibility areas in the Arctic according to the agreement by Arctic Council from 2011.

5. Results of case studies in Russia

5.1 Introduction

In the case study, community-based monitoring (CBM) has been addressed in terms of further strengthening capacity and further developing 'good' practices and emerging standards with a view to continuing to support improvements in environment/resource monitoring and promote the rights of Arctic Indigenous and local communities in resource management. The overall coordination of the case study was undertaken by the Center for Support of Indigenous Peoples of the North (CSIPN) – an NGO with many years of successful activities on different issues concerning Indigenous peoples of the Russian North, Siberia and the Far East. CSIPN has also experience with international projects. In November 2019, CSIPN was forcible closed down in Russia and had to move its activities abroad.

By the start of the case study, it was decided that project activities should be implemented in two regions of Russia – in the north-west of the country, in the Murmansk region (Kola Peninsula) and in the east – in the Republic of Sakha (Yakutia). The choice was based on the previous experiences with CBM implementation in these areas, on the strength/interests of the Indigenous Peoples (IP) communities, and on the strong dependence on living natural resources among the IP communities in the areas. The work was a continuation of the CBM activities under the INTAROS project, reported in *"INTAROS Community-Based Monitoring Capacity Development Process in Yakutia and Komi Republic, Arctic Russia" (Enghoff et al.,2019).*

Due to the pandemic, it was for long periods during 2019-2022 difficult or impossible to travel internationally and to undertake forward planning of events that involved physical meetings and travel. The case study was stopped in February 2022 due to the Ukrainian war, but most of the work had been done before this date. The workplan was therefore reduced and revised in the contract amendment in November 2022. The results of the CBM work are presented in *D4.1 "Report from work in local communities in Russia"* which was submitted 31 January 2023.

5.2 Results from Yakutia

In Yakutia, the project involved the Indigenous communities of the Evenk people, one community living along the Lena River in Zhigansk District and another in the Olenek District (Fig. 5.1). Mr. Slava Shadrin, a representative of the Russian Association of Indigenous Peoples of the North, (RAIPON), took on the role of regional project coordinator.

The project was involved in CBM activities in 11 local communities and supported the extension of the CBM work to new communities in Yakutia (Fig. 5.1). Here, the project has promoted dialogue with local communities, authorities, and other actors. This was facilitated through the conduct of CBM and co-management processes that documented Indigenous knowledge and observations on development and living resources. The processes involved representatives from resource users, authorities, youth, and members of Indigenous Peoples' organisations. Active CBM groups have been collecting local observations and communicating their local knowledge. They are contributing to dialogue and are building cases of what constitutes best practice.

The Indigenous communities involved have mainly been fishers, hunters and reindeer herders who are heavily dependent on the living natural resources in remote areas of the region. All areas have Indigenous communities making important local use of living resources but who are, at the same time, facing serious challenges in relation to accessing these resources due to changes in resource availability and threats, including pollution and resource depletion caused by various forms of mining and resource extraction as well as companies utilising and increasingly monopolising the fish resources. Most of the areas are classified as traditional territories of land use. This is a legal status that gives Indigenous communities in Russia a degree of protection but, in practice, it has proved difficult to enforce this status in relation to protecting the rights of Indigenous communities.

Fig 5.1 Map of Sakha Republic – Yakutia. The red circles indicate the Zhigansk District on Lena River and the Olenek District in the northwest. By Pline - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3721571

Several collaborative workshops have been supported at community level. Issues that continued to be high on the agenda included:

- Control of fishing grounds and access to fishing. The process has stressed the importance of CBM addressing the status of fishing and rights to fishing. Ensuring that this is central to CBM practices is an important good practice and needs to be part of any relevant CBM system in the Russian Arctic.
- Understanding developments in key fish populations. The activities have made it clear that much is changing in terms of fish populations, including the populations of key economic/livelihood fish species. Calling for a better understanding of such fish population development is a key aspect of making CBM relevant for the Arctic communities.

- Addressing access to hunting territories and access to hunting of key species such as moose and wild reindeer remains of key importance. Using the CBM group to address issues of hunting regulations and hunting fees has become a very important aspect of the CBM work.
- Using the CBM work to address the actual aspects that are needed in terms of monitoring and managing Traditional Territories of Land Use gained greater importance during the project work.
- The domestic reindeer industry continues to be in crisis. Use of CBM to monitor and propose management interventions still needs to be further developed.
- Predator populations (wolf and brown bear) continue to constitute a major problem and CBM is clearly documenting this.

Figure 5.2 Photo from a Siberian community involved in CBM work (photo: F. Danielsen)

The general status of the CBM process is that local communities and Indigenous Peoples' representatives continued to be interested in and supportive of the CBM activities. The use of CBM has been understood and is seen as a relevant activity that will provide the local communities with an improved way of developing and presenting local knowledge on resources and resource use. Local authorities are supportive of the activities. The Republic's Indigenous Peoples' organisation has taken a leading and crucial role in activities and ensuring linkages with the communities. Input from the CBM groups (information, analysis and recommendations) has been used by the Republic IP organisation to seek influence over the management of a number of subject areas related to resource management at both Republic and District level. It has further been used as a basis for national and international advocacy on CBM that is supportive of IP rights. Organising and communicating information is being undertaken using short and relevant forms, which are filled out by the CBM groups, and which include resource information, analysis of information and suggested actions.

5.3 Results from Kola Peninsula

During project implementation, CSPIN identified options for expanding the CBM activities to Saami communities on the Kola Peninsula in Murmansk Region (Fig. 5.3). This area was not part of the original plan for the CBM activities, but it was viewed as a strategically important move to include this area since the communities here had expressed strong interest in participating. The CBM ideas had previously been shared with the Saami community here, but it was only in early 2020 that the local interest succeeded in translating into actual and continuous CBM activities on the ground. A local coordinator, Andrey Danilov, was in charge of the CBM activities, while CSPIN supported the implementation.

A seminar was organised in early 2020 in the village of Lovozero (the informal centre for Saami people on Kola Peninsula) for representatives of the Saami communities. At the seminar, Mr. Danilov convincingly presented the possible prospects for CBM and spoke in detail of how this project could become an additional – and effective – tool for Indigenous communities to defend their right to traditional natural resource use. Five Saami communities in the Kola Peninsula took part in the project's CBM activities. In 2020, the pandemic delayed the development of the project, as severe restrictions were imposed on various kinds of meetings. By the first quarter of 2021, the CBM activities had commenced in earnest. Three out of five communities were particularly active: one in the north-east of the peninsula, where it is engaged in sea fishing, and two in the centre of the peninsula, where their main occupation is lake fishing. Reindeer herding was also important in one of the communities. Fishing and hunting, including reindeer (in one community), were thus the main focus of the participating CBM groups.

Fig. 5.3 Map of Kola peninsula (from http://geo.web.ru/druza/L-Kola.htm)

Throughout the project period, a range of meetings took place with local CBM groups, and these local groups worked throughout the period to observe, meet, fill out CBM matrices and communicate their findings. The CBM work is contributing to dialogues and building cases of what constitutes best practice. Contributions to documentation and mapping of Indigenous knowledge are thus being made together with contributions to the development of standards. It is expected that the work of the Indigenous communities of the Kola Saami will develop further such that it not only includes effective practical monitoring of the resources of their traditional territories of land use but also includes presentation of their results to those State structures that regulate the possibilities of their traditional nature management. An exchange of CBM experiences between Yakutia and the Kola Peninsula that was facilitated by the project has helped in the process of making CBM a tool for promoting Indigenous rights.

The impacts of the project in the Kola Peninsula can be summarised as follows: CBM has been established in such a way that it is likely to be continued and it is likely that, in the future, it can be further used as a tool for promoting the rights of the Saami communities.

5.4 Pan-Russian Experience exchange on CBM

Over the past few years, the national and regional coordinators of the CBM programme in Russia have regularly spoken at various forums of the Indigenous Peoples of the North, Siberia, and the Far East of the Russian Federation with information on the project and they have each time received an interested response from representatives of the Indigenous communities from different regions of Russia.

In response to the interest shown by various Indigenous groups across Russia and the growing need to expand CBM activities further across Arctic Russia, CSPIN organised a workshop in Moscow on March 3, 2022. It was attended by 17 representatives of Indigenous Peoples from seven regions of Russia (Murmansk, Tomsk, Khanty-Mansiysk, Taimyr, Yakutia, Primorye (Vladivostok) and Khabarovsk. The main objective was to exchange of knowledge on CBM best practices and information between the participants. The general presentation of CBM was made by CSIPN coordinator Nikita Vronski. Before the conference, the CBM guide "Introducing CBM activities – a guide for training", developed by NORDECO and CSPIN, was first prepared in English and then translated into Russian.

The workshop participants discussed the information system that is relevant for CBM data, which will give meaning to how the various communities are living in their respective territories. Participants discussed how CBM can improve and expand traditional knowledge by using the various ways of collecting and communicating their knowledge on a continuous basis. Best practices were discussed together with how such best practices or relevant standards could be exchanged and shared. A summary of Good Practice for CBM activities was prepared to help in starting new activities. The importance of having some form of regional and/or national collection and communication of CBM information also formed part of the conference discussions.

Mr. Gennady Shchukin, one of the leaders of the Indigenous Peoples of the Arctic, spoke about how CBM can be used in Taimyr. Representatives of the youth of the Indigenous Peoples of the Tomsk region shared their thoughts on what objects – animal species, environmental phenomena – might be important for community monitoring in their areas. In general, the work of the conference provided participants with the skills that would enable them to organise CBM in their respective territories on their return.

In summary, CBM activities in Russia have been further developed, capacities have been strengthened, local Indigenous Peoples communities have been able to use CBM as a tool for promoting their rights, and further agreement and exchange of good practices/standards on how to undertake CBM in Russia has taken place. Participating project partners have also been able to bring CBM into the international debate on IP rights and implement international biodiversity conservation measures.

6. Results of case studies in USA

6.1 Introduction

The case study was focused on Indigenous communities in Alaska and how they use community-based observations of the environment, which is vital for fishing, hunting and travelling in the region. The study was performed by ELOKA (Exchange for Local Observations and Knowledge of the Arctic) in collaboration with International Arctic Research Center at University of Alaska Fairbanks under subcontracts with NORDECO. There are numerous initiatives to establish community-based monitoring programs which draw on Indigenous Knowledge as well as scientific approaches to monitoring, which are presented in the Atlas of Community-Based Monitoring, which is a partnership project between the Inuit Circumpolar Council and ELOKA, with various content partners and SAON. This Atlas is an attempt to provide an overview of CBM activities in the Circumpolar region, but it depends on participation from the active programs to be updated.

The goal of the case study was to identify: (1) the types of community-based monitoring (CBM) information used to plan for and respond to coastal risks and hazards; (2) how existing knowledge and data from community-based monitoring programs are situated in relation to other types of information used in risk and hazard mitigation; and (3) the role of standardization in connecting community observations with decision processes. Due to the COVID-19 travel restrictions, the main methods were to analyze documents, organize workshops and conduct online interviews with selected CBM programs. The topics addressed for the CBM programs were (1) permafrost thaw and coastal erosion and (2) harmful algal bloom (HAB) in the coastal waters.

The case study was implemented in three phases as shown in Fig. 6.1.

Figure 6.1. The three phases of the Alaska Case Study. Phases 1 & 2 were led by researchers at the IARC/UAF; Phase 3 was led by researchers at ELOKA/CU. Researchers from both universities worked closely throughout the entire case study process.

The CBM data are collected in multiple ways. Some classifications of how observations are collected include: standardized vs. non-standardized observations; scientific instruments vs. personal observations; paid observers vs. volunteers; and manual vs. automated observations. Several specific procedures for collecting CBM data were also identified (Table 4), each method often reflecting the specific capacities and constraints of the region. In several cases, communities send their data to other agencies and organizations for processing, as they do not have the internal capacity and resources for these analyses.

Table 4: Some data collection methods for CBM in Alaska.

Coastal erosion and hazards
Community members take photos, if safe during a storm
Regular observations of ice and weather conditions and explanations of sea ice features
Install a flood staff and survey staff when flooding happens, if safe
Time lapse cameras and having a stake in the ground to measure the coastline
Surveying with auto levels and stadia rods
Harmful Algal Blooms
Tow/pull a phytoplankton net from a deck or dock, look at it under a microscope. Sample sent to a lab
Manually collect a sample of water and run through a qPCR test. This lets you see the gene sequence of the organism you looking for and how much of it is there
Set up a hanging basket of blue muscles that hangs off the dock, and then sample on a weekly basis
Collect mussels at low tide
Sample from the nearshore

The data collection protocols were influenced by factors such as local contexts and capacities, internet availability, staffing levels and experience, geography (e.g., on and off-road communities), and infrastructure. Feedback from communities also influenced data collection such as where to sample, how to sample, and what to sample. Feedback was obtained via talking circles, steering committees, and ongoing conversations.

6.2 Permafrost thaw, erosion and flooding

Permafrost thaw, leading to coastal erosion flooding are major threats to communities all around Alaska, but mostly in the coastal regions (Fig. 6.2). In the Statewide Threat Assessment report (UAF, 2019), detailed analysis of the various natural hazards has been performed and recommendations for actions were provided for a number of communities across Alaska.

a b

Figure 6.2 (a) Crumbling blocks of permafrost along the Beaufort Sea coast (photo courtesy of the USGS). (b) Flooding in Galena, Alaska (photo courtesy of the National Weather Service). From the Statewide Treat Assessment Report (2019).

The document analysis showed several reasons for establishing CBMs: (1) the need to initiate a CBM system within their climate adaptation plan; (2) the need for local baseline data for risk assessments, expressed by Alaska Native Tribal Health Consortium (ANTHC, 2021); (3) developing a plan for permafrost monitoring locally to track change over time; (4) creating a unified system for coordinating data collection and sharing; and (5) developing a more complete picture of change in communities. In conclusion, the analysis showed that standardization protocols for CBM can give communities the data they need to document changes and to enable meaningful sharing of observations between different local networks.

A guidebook on standardized data collection protocols and data management was developed by the Alaska Division of Geological & Geophysical Surveys (DGGS), Fig. 6.3.

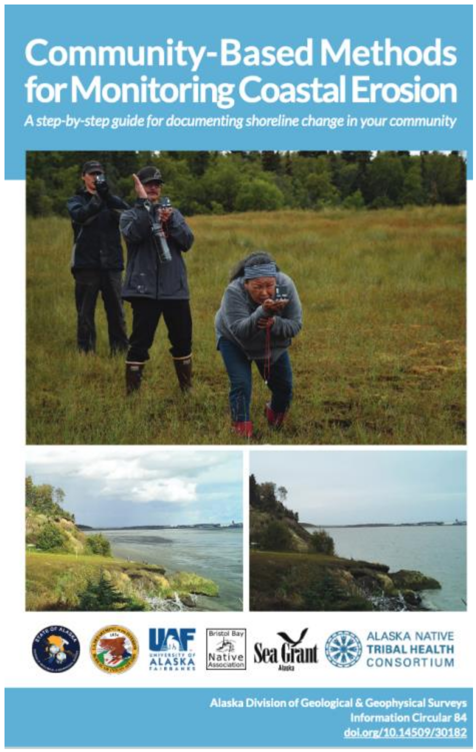

Fig. 6.3 Guidebook on CBM methods for coastal erosion (Buzzard et al., 2019)

In spite of clear benefits of standardization, some different opinions were expressed during the workshops. One comment was: "There is value in standardizing, but it needs to be flexible to the specific questions asked by groups launching the effort. It's hard to standardize first until you know the questions that are of interest locally" (Pletnikoff et al. 2017, p. 36).

Additionally, it was recognized that under rapidly changing conditions it might be better to get observations started, rather than waiting for the perfect data collection protocol to be defined.

Clarifying procedures for working with federal and state agencies was viewed as important for enhanced coordination with the goal of creating a network with fewer points of contact that could make it easier for small communities to work with them" (Pletnikoff et al. 2017).

6.3 Harmful algal blooms

The document analysis identified many organisations and agencies involved in CBM of harmful algal blooms across coastal Alaska. The Alaska Harmful Algal Bloom (AHAB) Network plays a central role in providing a mechanism to support ongoing communication and collaboration as well as facilitating data consolidation and synthesis of local, regional, and statewide data into resources and products. The AHAB network consists of over 100 individuals from over 30 institutions and organizations.

These HABs CBM programs emerged from strong cultural traditions and connections to shellfish, their importance for food security, a high level of risk to paralytic shellfish poisoning (PSP), limited access to medical care, and no statewide program to monitor recreational and subsistence harvest of shellfish. As such, several tribes desired a better understanding of baseline conditions, sought answers for why there were increases in PSP, and desired actions that could be taken to reduce risks. At the same time, these CBM programs face several challenges in the collection, analysis, and dissemination of HABs information (Fig. 6.4).

a b

Figure 6.4 (a) Undergraduate student Hector Dominguez gathers water samples from a pond. Utqiagvik, Alaska. Photo by Monica Nuñez (PolarTREC 2019), Courtesy of ARCUS. (b) Jennifer Hanlon, Environmental Coordinator for the Central Council Tlingit and Haida Indian Tribes of Alaska, uses a microscope to identify phytoplankton and algal species (NOAA, 2022)

First, the wide variety of environments with low population densities along with the harsh environment complicates the use of high-tech sampling methods (e.g., imaging flow cytobots). At the same time, Tribal members have intimate knowledge of Alaska's coastline and are well positioned to take measurements. Second, there is often not a local laboratory for testing, so samples are often sent to Anchorage or other regional hubs for testing. However, rural communities face significant challenges in transporting samples to urban centers for testing in a timely and cost-effective manner, especially due to limited and often weather-dependent air service.

The document analysis showed that HAB data are used for many purposes, such as providing information about toxicity of sea food in different areas, give input to management plans for e.g. shellfish harvesting and provide better knowledge of when and where HABs are likely to occur in a warmer climate (NOAA, 2022).

The AHAB monitoring network emphazised the need to follow approved protocols for data collection and analysis (e. standardization). For example, proven CBM techniques for HABs developed by the NOAA National Centers for Coastal Ocean Science (NCCOS) and the Phytoplankton Monitoring Network were often applied and adopted in other regions (NCCOS). Training and education is particularly important for HAB monitoring both field work and lab analysis. The AHAB network (managed by the Alaska Ocean Observing System) was viewed as especially important by several interviewees in supporting collaboration among CBM programs.

6.4 Focus group discussions

A key learning from the interview phase of the case study was a strong interest in use of observations to support action that would be beneficial to community members. The use of information can inform either short or long term decision-processes. For example, HABs and water quality monitoring programs can help resource users decide whether or not it is safe to eat shellfish (short-term), they can also inform decision-making about sustainable planning for mariculture farms (medium-term). Erosion monitoring programs, in contrast, are more focused on providing information related to coastal hazards that can affect infrastructure in the medium and long term.

The participants in the interviews were invited to join the focus groups, which had two separate 2-2.5 hours zoom sessions, with 6 – 8 participants in each. The focus groups were given three themes for discussion:

(1) ***The use of community-based observations to support decision-making and planning***. The participants were asked to help identify products that use CBM and users of CBM information based on the interviews, and add more examples of products and users.

(2) ***The role of standardisation in supporting use of CBM observations.*** The participants were asked: What do you see as the highest priority areas for standard development for CBM programs? What is preventing greater standardization across CBM programs?

(3) ***The role of coordination and networks in supporting use of CBM observations.*** The participants were asked: what are the biggest areas of opportunity for coordination and collaboration among CBM programs? What kind of support would be most helpful to improve coordination

The results of the focus group discussion on theme (1) are presented in Fig. 6.5.

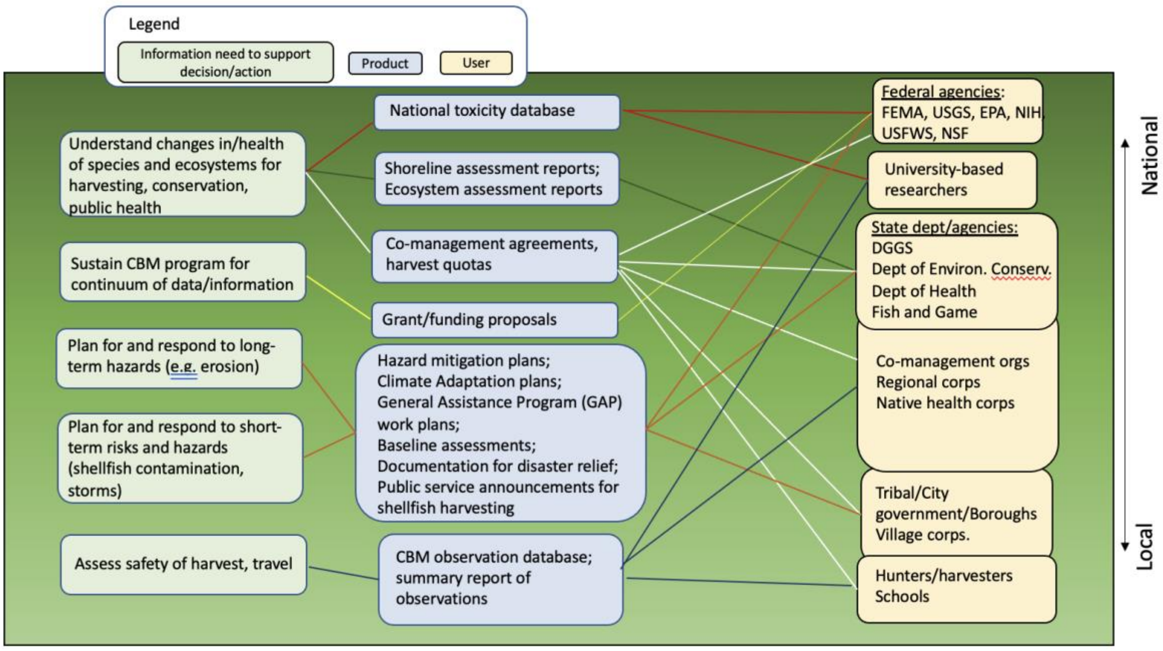

Figure 6.5. This figure illustrates how specific products using CBM information are linked to several information needs for decisions/actions using CBM data and how these products are connected to users at different levels, from community level users to federal agencies. The same color connecting lines illustrate product specific linkages.

Standard Development for Data Collection. Participants highlighted the following priorities:

- Training programs that have common elements or can be conducted for more than one program to build a shared understanding
- Development of shared data sovereignty recommendations and practices
- Developing EPA quality assurance project plans that are usable and referenceable by the local program/IGAP coordinator
- Shared metadata formats (meaning standard formats for what information is stored about CBM such as who collected it, when it was collected, where it was collected, etc.)

The following factors were mentioned as challenges for standardisation:

- Turnover of staff, which creates challenges for data collection (making sure observers are paid is one way to address this issue)
- Lack of access to regular training for community members and CBM staff
- Lack of community level baseline data needed as reference points
- Funding for long-term efforts remains a challenge

Finally, the case study emphasized the need for increased coordination between CBM programs, which would need more resources. In the plans for the next years the Arctic research communities are emphasizing the importance of developing more collaboration with the Arctic Indigenous People for sustainable economics and livelihood (Fig. 6.6). This will facilitate for more use of CBM programs.

Figure 6.6. Frontpage of the Arctic Research Plan of the [Interagency Arctic Research Policy Committee.]

7. Arctic Practice System

One of the objectives of CAPARDUS was to propose a design for an Arctic Practices System (APS): a digital system to promote the sharing of methodological knowledge about living, working, researching, and sustainably managing the Arctic and its resources. Such a system would address challenges such as fragmented and limited access to Arctic practices, by providing an integrative platform for discovery, access, and collaboration. It builds upon the successful implementation of the IOC-UNESCO Ocean Best Practices System (OBPS), and its emerging federation of providers, which focused on the marine domain (Fig. 7.1). The results of the work are presented in *D6.2 "Design for an Arctic Practices System (APS) and roadmap for its realization"*.

As a testbed for an Arctic Practice System (APS) a repository was set under the Ocean Best Practice System, where documents on practices, guidelines and standards of importance for the could be uploaded. The Ocean Best Practice System which was formally established as an IOC project in 2019, is a global, sustained system comprising technological solutions and community approaches to enhance management of methods as well as support the development of ocean best practices (Fig. 7.2). The concept is that users can search for best practice documents in the repository as well as submit own documents that contribute to populating the repository. The APS testbed is available at CAPARDUS Practices repository where more than 240 Arctic-related documents (as of June 2023) were uploaded and can be searched. An instruction video about the Ocean Best Practice System was prepared and made available as a tool to help to search for documents or upload documents to the repository.

What is Ocean Best Practice ?

"A method adopted by many people to carry out a task within ocean observation, research activities, assessment of environment, etc."

Figure 7.1. Demonstration of how to use an ocean observing instrument

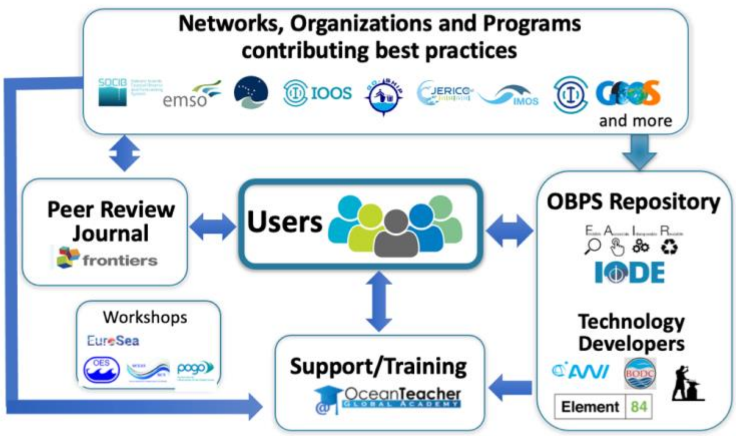

Figure 7.2. Diagram of the components of the Ocean Best Practice System. The Arctic Practice System will involve a wider group of networks, organizations and programmes covering the marine, terrestrial and other Arctic specific disciplines as well as CBM systems.

Motivation for the APS comes from the need for multidisciplinary collaboration and the need for co-design and co-production of knowledge in collaboration with different users' groups in the Arctic. The climate change combined with the socio-economic changes have dramatic impact on people living and working in the Arctic. To meet these challenges, it is necessary to strengthen collaboration between scientists, local communities, and other user groups. More holistic observations and syntheses of knowledge are needed, particularly those which effectively include the perspectives of Arctic local knowledge holders. This implies that the different cultural, social, and economic settings across the Arctic region are acknowledged and represented in planning and decision making. As the communities and regions are different regarding culture, history and language is unique, it is desirable to foster better dialogue across the different knowledge realms and communities which face common challenges in the Arctic.

Collecting requirements for an APS was done through workshops and dialogue meetings with various stakeholders, knowledge holders and other relevant actors from the case studies in WP2 – WP5.

When contacting the users, they were asked some basic questions on how they currently archive and converge methods and practices, and then how an APS should be designed to be useful for them. In dialogue with different groups, it is important to make our assumptions clear. The expectations of various groups for an APS can be very different, depending on the interests and priorities of the groups. One APS cannot include everything and be applicable for all types of users, because the topics are very broad and the communities are very different. The content of information ingested in the APS must be organized in a societal context, as illustrated in Fig. 7.3. Here the actors who work in fisheries and food production will need an APS to share information within this topic.

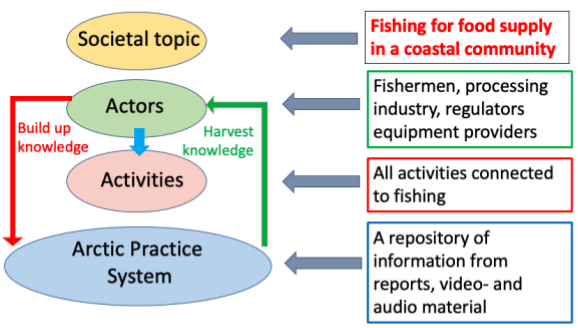

Figure 7.3 Concept of an Arctic Practice System in a societal context: fishing for food supply in a community

How can practices be documented and stored in a repository ?

* Written documents (most common)
* Photos with documentation
* Video recordings
* Audio recordings
* Combinations: e.g. storymaps

Many of the user groups have their own information systems that they want to develop further or they plan to design new systems. An APS should therefore not replace existing systems, but rather be connected to them in a federated way. This means that the APS will have a number of subsystems.

Through the case studies in WP2 - WP5 the partners have obtained valuable insight into the context and role of an APS system. The core value of the APS lies in facilitating the discovery and understanding of diverse practices, safeguarding, and protecting contributed knowledge, and enabling control over the sharing of information and data.

Surveys were conducted to assess the requirements for an APS in different communities. In the first survey, carried out online in the beginning of 2022, respondents were asked about the key characteristics that an APS should have, as shown in Fig. 7.4a where nine different attributes are defined. There were fifty-two responses, 75% from academics and research facilities. The others came from government, NGOs and funded research projects.

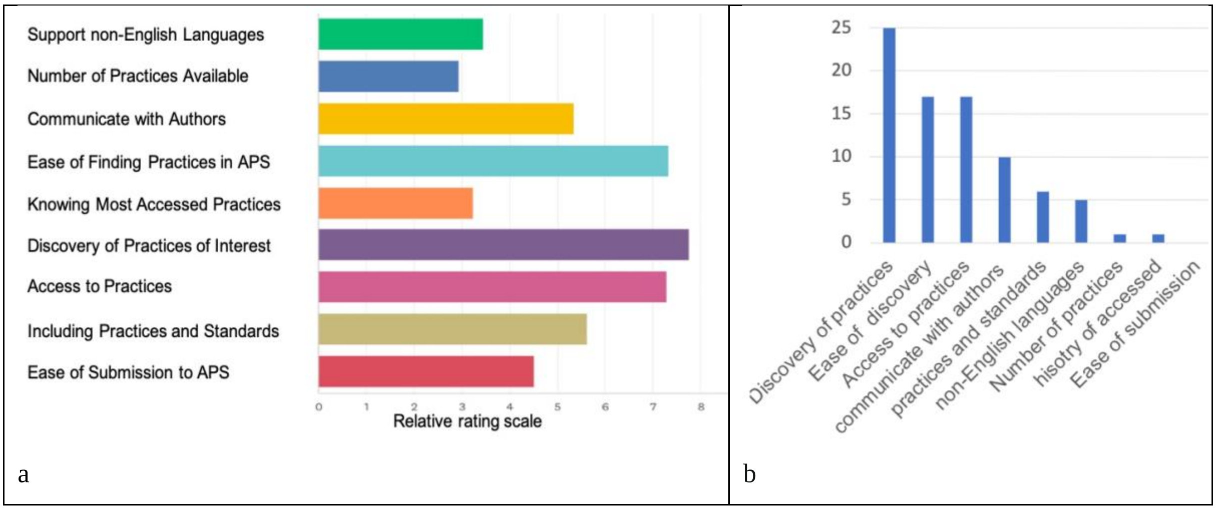

Figure 7.4 (a): Relative priority between nine APS attributes based on 52 responses. The respondents were asked to make a priority list of the nine attributes; (b) Distribution of priority # 1 and # 2.

The results of the survey indicated a strong interest in the creation of a sustainable repository where the three most important attributes are (1) Discovery of practices, (2) Ease of discovery, and (3) Access to practices (Fig. 7.4). When asked for a vision for three to five years ahead, the following responses were given:

"....that practices become generally accepted by relevant stakeholders"

"just having access to practices used across the Arctic with understanding that they may need to be flexibly adjusted to meet specific needs."

" better documentation and democratization", adding that "*having expertise limited to a number of individuals and their research groups makes it hard for new perspectives to contribute to the research community."*

" ...evaluation if the practices are being used in the ways Arctic local communities intended"

The participants were asked about their use of formal standards (such as ISO standards). Formal standards are developed through a consultation process in Standards Associations working groups. Thirty-one respondents replied that they use such standards in their work.

The second survey was conducted during the Svalbard workshop in August 2022, where the participants came from the cruise industry, the cultural heritage professionals and groups concerned with the sustainability of the Arctic environment. The results from this survey was quite similar to the first survey (Fig. 7.4), where discovery of practices and access to practices were the most important attributes.

Vision and core values of APS. In the design of the APS we have formulated a vision and described some anticipated core values of the system:

Vision:

An APS should provide multi-sectoral know-how on Arctic practices and ensure that it is safely preserved, rapidly accessible in understandable forms, responsibly managed, and collectively used to advance our understanding, protection, and sustainable development of the Arctic and its peoples.

The anticipated core values are:

- *Multilateralism:* Actors providing contributions to the APS may be interested in sharing methodological know-how to support dialogue, promote reciprocity of value, avoid conflict, and sustainably manage the Arctic for future generations.

- *Transparency and openness:* As far as possible and respecting the rights of all contributors, partners in the APS will facilitate the understanding of their methods to promote trust in their observations, decisions, and other outcomes of their practices.

- *Equity:* Recognising the diverse capacities across the Arctic, partners in the APS will co-design and co-develop mechanisms and resources to allow their methods to be understood and reused by as diverse and broad a user base as possible.

- *Responsibility & Ethics:* Methodologies and practices are valuable assets, and their responsible and ethical use is necessary for trust to flourish between all partners contributing to the APS. Contributions should clearly define conditions for reuse, and users should state how they met them. Further, partners in the APS have complete control over what they share, when and with whom

- *Etuaptmumk:* A Mi'kmaw term often translated as "Two-eyed seeing", is a concept championed by Mi'kmaq Elder Albert Marshall which promotes the linking and complementation of scientific traditions, systems, and methods of Indigenous and western knowledge to achieve innovative advancements (e.g. Yua et al. 2022).

During the requirement studies people from different scientific disciplines and different user groups were consulted. Many of them were not scientists but are professionals in public services or business and some are representatives from local communities. This means that language and terminology are important to define when the APS is described. Some of the most common terms used in the project are: ***stakeholders, knowledge-holders, standards, practices, guidelines, regulations, co-design, co-production, data, FAIR principles, ontologies and more***. We have attempted to explain these terms, with the goal to make the communication between different groups is as useful as possible.

A definition of Indigenous Knowledge has been provided by ICC (Fig. 7.5), but in the design document of the APS, the requirements from Indigenous Communities have not been included. During the project the authors have not been able to communicated with any the Indigenous Communities, although this was the original plan. The authors have only referred to literature and general ethical principles on how to deal with Arctic practices in a digital system.

ICC definition on Indigenous Knowledge

INUIT

Various challenges are faced on how to include IK in a meaningful way within Arctic work. One such challenge is the confusion of how to define and utilize IK, and how to employ both IK and science together. This paper will attempt to articulate and address these concerns, while outlining a process to ensure the application of IK within AC work.

Definition: With an understanding that there is a need to utilize both sources of knowledge, IK and science in Arctic research, to better inform decision-making, it is important to first come to a consensus on what IK is. To this extent, Inuit Circumpolar Council offers the following definition:

> Indigenous knowledge is a systematic way of thinking applied to phenomena across biological, physical, cultural and spiritual systems. It includes insights based on evidence acquired through direct and long-term experiences and extensive and multigenerational observations, lessons and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation.

Figure 7.5 Definition of Indigenous Knowledge (Kuupik Kleist's presentation, 22 February 2021)

Design principles for an APS are formulated based on experiences from OBPS (e.g. Pearlman et al., 2021). A refinement of these is listed below:

1. **Engagement-based co-design:** Broad stake- and knowledge-holders (including academic researchers, industry, local community organizations and others) should be engaged throughout the creation and evolution of APS and Arctic practices from initial concepts to implementation and use. It is imperative that such engagement does not perpetuate "parachute science" or other extractive, one-off, or shallow modes of consultation, but is based on sustained and meaningful participation of all those engaged.
2. **Mutual benefit**: Closely linked to reciprocity, the benefits realised by each contributor, user, or other participant in the APS (both in general and through each specific class of supported actions) must be clear to and deemed fair by them. In this pursuit, the acknowledging and harmonising of diverse value systems through consensus building will be key.
3. **Contextualisation**: The APS should be able to retain the context of the practices (as metadata) to understand if a practice is appropriate for another specific purpose.
4. **Open Access and Intellectual Property Rights**: An open-access policy must be balanced against community rights for information control (cf. the need for a system to respect Indigenous data sovereignty; e.g. Racine 2022; National Inuit Strategy on Research 2018; Kukutai & Taylor 2016).

5. **Multi-modality**: To achieve geographic and culturally attuned coverage, practices should be accessible in different languages, modalities (e.g., documents or videos or audio recordings) and sourced from all regions.
6. **Capacity sharing:** Educational tools should be integrated into the design of the APS to accelerate how new participants learn Arctic practices.

Additionally, we propose the following principles to ensure that the design of the APS (as it evolves) is able to accommodate novel opportunities and face unexpected challenges:

7. **Robustness**: An APS would federate independent resources, which would require a robust core infrastructure to be in place to weather the addition, change, or removal of components as Arctic observing and management systems evolve.
8. **Qualified simplicity**: From its user interfaces to its back-end implementation and foundational technologies, the APS should strive for simplicity and efficiency. Ease of use and maintenance should be prioritised, and any features which do not clearly contribute to achieving the vision of the APS deferred.
9. **Modularity**: Closely tied to robustness, the APS should be built as a collection of modules, each with defined inputs/outputs linking them together. In this manner, changes or accommodations of, e.g., digital sovereignty or regional regulatory frameworks (which may preclude certain technologies or capacities) can be nimbly implemented with minimal overhead.
10. **Relevance**: The informational value and user-friendliness as well as that of the APS should supersede the usage of Google, Youtube and ChatGPT in order to make it relevant for users.

The next step was to draw up an expected development path of the APS, which will primarily be a technical one, but guided by stakeholder input throughout. The technical development process includes several stages such as requirement gathering, system architecture design, user interface development, repository implementation, testing, and redesign. This roadmap identifies the need for repeated rounds of requirement setting and refinement, during which the implementation team will rely on surveys, interviews, and workshops with potential users to identify their specific needs and preferences for the APS.

Based on broad user requirements, the components and modules of the system are determined, with focus on a core set of modules identified in the case studies and user profiles. In brief, tailored user interfaces (UIs) and user experiences (UXs) will draw content from a secure database storing stakeholders either submitted directly to the APS or harvested from existing systems and filtered through a set of processing modules to identify, structure, and translate content to increase its value to users. User feedback modules will support iterative refinement and improvement, ensuring that the APS meets the needs of its intended users as they change in a rapidly changing Arctic.

In addition to the technical development, the implementation of an APS will require capacity-development efforts to ensure that users can effectively utilise and participate in the design of the platform. We recommend that training programs, workshops, and support materials should be developed to enhance users' understanding of the APS and its functionalities. This capacity-development component aims to empower stake- and knowledge-holders, particularly Indigenous People and local communities (IPLCs), to contribute their knowledge while maintain control and authority over it, while benefiting from the other knowledge hosted by APS.

A schematic of the Roadmap is shown in Fig. 7.6.

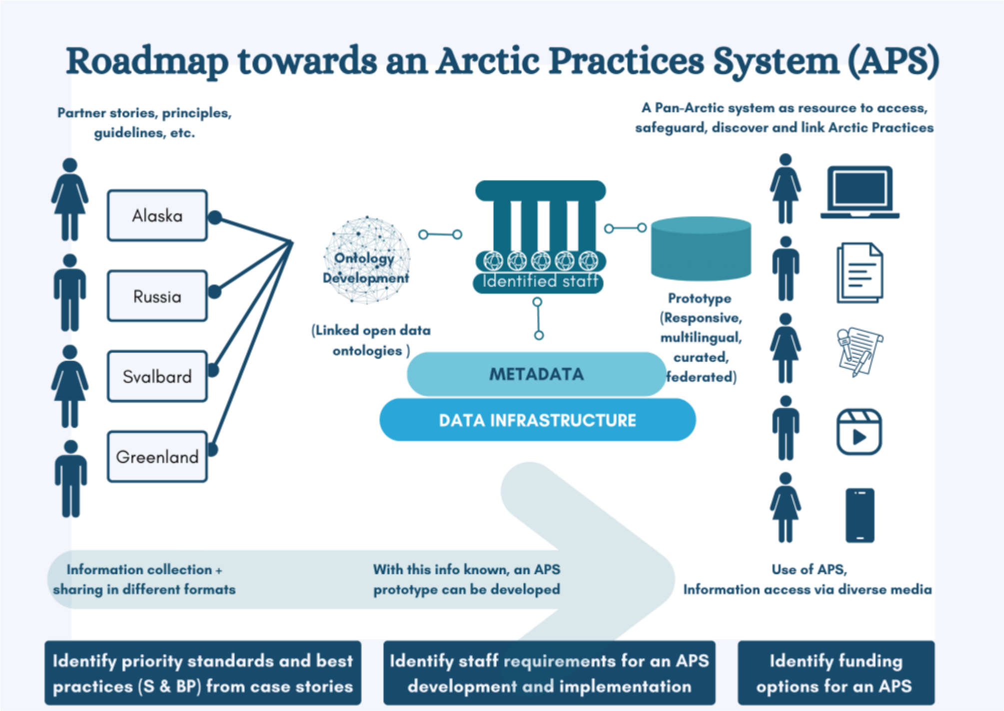

Figure 7.6 Schematic of an APS development process, resulting in a pan-Arctic practices system.

The architecture of an APS is described, including front-end elements, back-end elements, networked and trusted repositories as illustrated in Fig. 7.7. The description of the architecture and the implementation plan are given in the Roadmap document (D6.2).

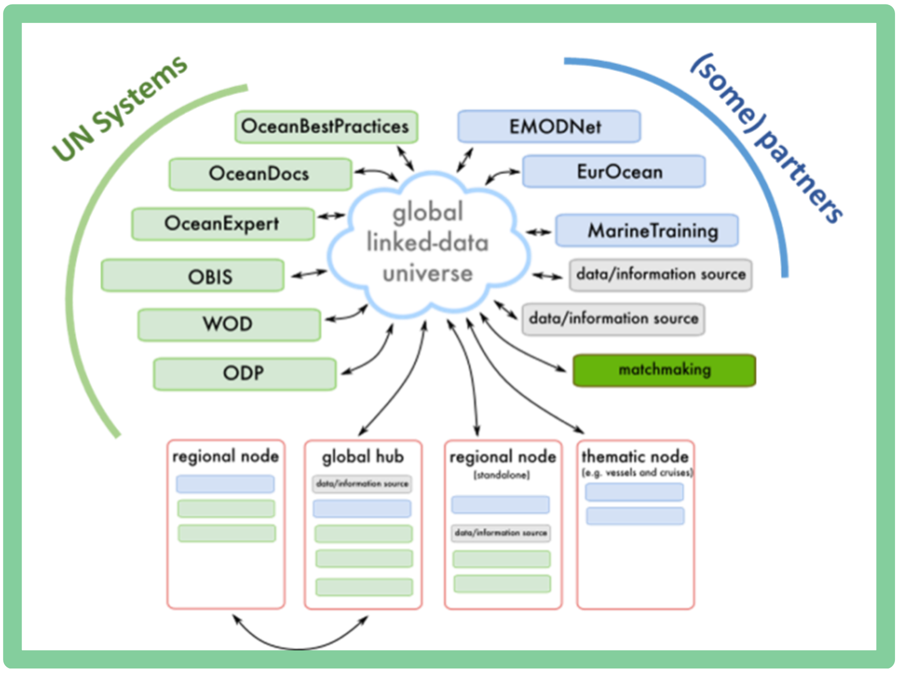

Figure 7.7. The interoperability approach employed by the [Ocean InfoHub] and [Ocean Data and Information System] (ODIS), within which the Ocean Best Practices System (OBPS) is embedded.

Potential use of machine translation in APS was briefly addressed in the Greenland case study as part of the test study to translate from Greenlandic to English. An APS can have great benefit of using machine translation since these tools are developing fast and Arctic practices will be documented in many languages.

An exciting project is Meta's No Language Left Behind (NLLB), which has developed a new technique for training language models based on limited datasets. It is using this to offer translations between 200 languages, including Fijian. No Arctic languages are included currently, but the development of the model is ongoing, and it has been made open source so that others can build on it. Current uses of the NLLB include a cooperation with Wikipedia to help editors develop translations of articles into their languages; perhaps a similar cooperation would be feasible with the APS. Another exciting realm of innovation is that of real-time speech-to-text or speech-to-speech translation, for videos, conference talks, or even fieldwork interviews.

Developers of APS should seek to work with technology companies such as Meta to encourage them to offer support for indigenous language translation. AI-tools are already important in building knowledge from large document repositories and APS development should benefit from this rapidly evolving technology.

User profiles from the case studies presented below show examples of various user requirements and recommendations for an APS. The description, which is extracted from D6.2, is based on replies from the respondents who worked directly with the user groups in the case studies.

Profile 1: Coastal hazards in Greenland. Potential APS users are developing approaches to respond to and build resilience for multiple, cascading coastal hazards. Such hazards are connected to rock avalanches into the ocean, leading to tsunami coastal settlements (Fig. 7.8). This phenomenon took place in West Greenland in 2017 and can potentially become more common as consequence of climate change. The users involved are: (1) public authorities/rescue agencies, (2) researchers, (3) citizens and evacuees.

Currently, public authorities rely on national and international science groups to 1) investigate the chain of events which leads to hazard impact, and 2) propose approaches for prevention, preparedness, and response to natural hazards. Often, however, the respondent noted that these authorities do not find the scientific results sufficient to inform their decisions. Citizens/evacuees rely on lived experience.

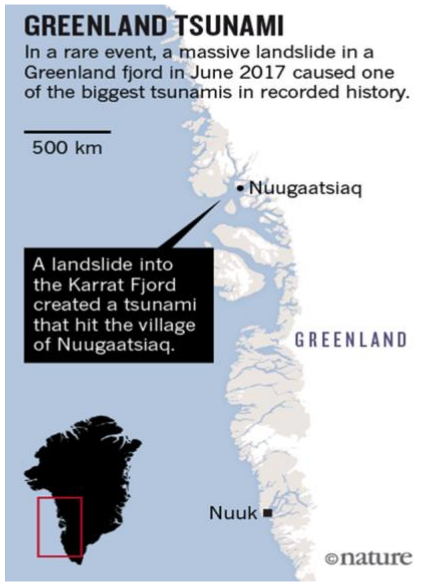

Fig. 7.8 Area where the tsunami on West Greenland occurred in June 2017

Public authorities transfer knowledge, guidance, and notices of decisions to citizens through press releases, outreach through social and other non-press media, and participation in public meetings. These communications occur prior to, during, and after the hazardous event.

The respondent noted that citizens want greater involvement in decision-making processes, especially those concerning possibilities of returning to flooded settlements and resuming public life. They maintain that authorities should rely more on citizen experiences and know-how, rather than solely on scientific research and recommendations. Citizens find that their knowledge and know-how is undervalued and underused by public authorities: Too few opportunities exist for them to participate in the processes that can effect change and/or take into account their experiences.

Profile 2: Fishers and hunters in Greenland. Potential APS users are custodians of traditional methods and developers of new approaches to fish and hunt in Greenland (Fig.7.9). Many of these communities are remote, and have unreliable access to the internet, with variable bandwidth.

Knowledge of the traditional methods is exchanged through word of mouth, television broadcast (Greenlandic and Danish languages), in-person training provided by co-practitioners, and generational transfer within families and larger social groups (e.g. via traditions). Where access to the internet is available, knowledge resources are found through web searches or media sharing platforms. Meta’s Facebook and Alphabet’s Google and YouTube services are mentioned explicitly. The respondent noted that a considerable amount of methodological knowledge is developed through trial and error.

The respondent felt that the knowledge and know-how their community possesses is not sufficiently taken into account by authorities, particularly regarding climatic and ecosystem changes, alongside their impacts on day-to-day life.

The respondent noted that the exchange of practices could be improved by both web-based and in-person measures. These included the availability of short instructional videos and more chances to meet and deepen social ties with other practitioners and exchange experiences. The major obstacles to sharing practices and know-how were identified as language barriers, limited access to WiFi, the high-cost of communication, and large geographic distances between potential partners.

Figure 7.9 Hunting seals in Disko Bay

Profile 3: Central and municipal governments in Greenland. Potential APS users are personnel working in both central and municipal governments in Greenland. These users exchange methodological know-how through directives (and further instruction) from superiors, email correspondence and/or phone conversations with knowledge holders, and occasionally web searches. Their primary reference material comes from information materials and instructions issued by the government, supported by knowledge transferred during meetings and conferences. The respondent noted that in-person attendance at national and international training courses, as well as exchange visits, would be desirable to increase methodological transfer. However, they noted that linguistic barriers, geographical distance, and cost are significant impediments.

Profile 4: Indigenous reindeer herders, hunters and fishermen in Sakha Republic Yakutia. Potential APS users are members of Indigenous communities in Yakutia, depending on traditional livelihoods (Fig. 7.10). These users exchange methodological know-how through human-to-human interaction, be it intergenerational, intra- and inter-familial, or within a community of practice (e.g. other herders).

Occasional use of telephony via Iridium satellites was also noted, as well as peer-to-peer messages and multimedia communication solutions such as Signal and WhatsApp. Traditional exchange of knowledge is key to structuring and maintaining this transfer, with trial and error driving cases where no knowledge is available. The respondent also identified the local Indigenous peoples organisations in the Sakha Republic Yakutia (CISPN) as a source of information.

Figure 7.10 Reindeer herders in Yakutia (Photo: CSIPN)

The respondent noted that an increased capacity to share experiences across the user types noted above is desirable, both within and beyond Yakutia. They also raised concerns of non-indigenous and extra-regional groups hunting, fishing, and extracting other resources from the local environment. The respondent noted that sharing of methods was hindered by language barriers, limited and costly access to the internet, and the present geo-political situation.

Profile 5: Cultural heritage research and management in Svalbard. Potential APS users are researchers, local community members, the Governor of Svalbard and National Directorate for Cultural Heritage.

These user types have well established channels of communication such as scientific publishing, research/policy consultations, as well as regulatory and licensing processes. The responded noted that these processes are supported by several existing systems, and interoperation with these systems would be necessary to engage with an APS. The respondent noted that methodological know-how in cultural heritage research is found in standard guidelines, both regionally and at the EU level, accessible to the users (Fig. 7.11).

Figure 7.11 The cable car system for transporting coal is a dominant cultural heritage feature in Longyearbyen (Photo: NIKU)

Knowledge is acquired primarily through the scientific literature and guidelines provided by regulatory authorities. Methodological knowledge is spread to other stakeholders through outreach activities by these user types, such as public-facing dissemination through museums, public distribution channels online (websites, social media, etc.).

The respondent noted that while the systems that are in place provide ample functionality, there is a lack of comprehensive discoverability, targeted information products, story maps/story-telling interfaces, and related user experiences. As an example, a virtual reality experience of a historic mine scheduled for demolition was proposed, to reconcile cultural preservation with natural restoration and erosion.

Regarding impediments to sharing methodology, the respondent noted that the financing of data and information resources to support comprehensive dissemination was the major obstacle. Additionally, directorates of cultural heritage occasionally have regulatory barriers to fully open sharing. Further, existing national repositories to support sharing of content generally preserve content which has been produced through opportunistic interests (e.g. films, documentaries) rather than through consolidated efforts to share practices.

Profile 6: Tourism in Svalbard. Potential APS users are a wide range of actors involved in tourism (Fig. 7.12). They include tourists, tourist operators, local service providers, researchers, and governing bodies in Svalbard and nationally.

These user types obtain information on permitted and recommended practice from the Governor's office (for regulations) and from the operators (e.g. Visit Svalbard) regarding all aspects of tourist activity, their guidelines, and approaches to develop sustainable tourism in the region. Researchers provide knowledge about tourism in general and its impact on the environment through seminars and presentations to the other actors.

Tourist-related information is distributed from several sources: the Governor's office, the operators, the Local Council, and researchers publishing articles through dedicated channels (e.g. through their websites, in journals and whitepapers). The tourist organisations (e.g. Visit Svalbard) provide extensive promotion and advertisement of expeditions and services via internet and other media.

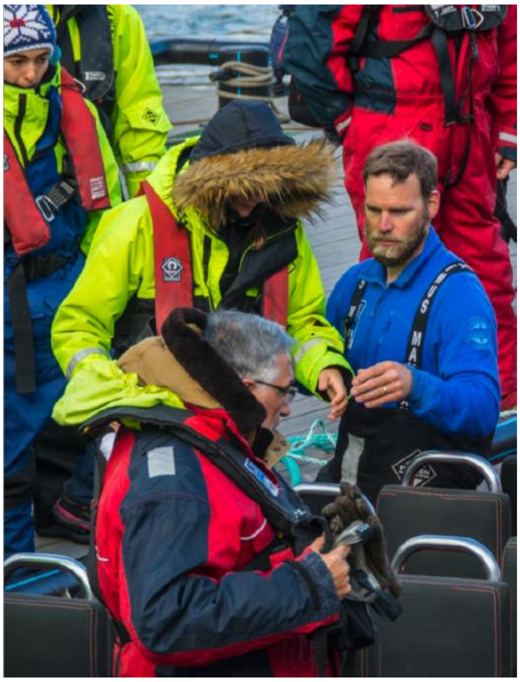

Figure 7.12 Organising tourist activities in Svalbard (Visit Svalbard).

The growth in tourism calls for more efficient and transparent sharing of information on all aspects of the tourist activities, because as not all actors are aware of changes to sustainable tourism practices, regulations, and recommendations in a timely and precise fashion. There is also a need to provide experiences and reports related to the safety of expeditions, which is a major issue for the tourists and the operators. This requires that an APS (or information system) for the tourist actors should include all the relevant aspects mentioned above.

A characteristic feature of this profile is the competitive context of the tourism sector. This means that there is business-related information that the actors do not want to share openly, or they want to share it within specific groups. This may reduce the motivation of the actors to allocate resources to share information. However, most of the tourist-related information should be openly available, because this is beneficial for all actors and will contribute to develop a more sustainable business in the Arctic.

8. Conclusions

Framework for Arctic standards

Standards can act as common language and practices among stakeholders when aiming to share and use observing systems, data, ensure safety, and many other activities in the Arctic. It is vital that the standards development process ensures that all interested parties work together in the context of openness and transparency. Standards are typically technical documents, while standardization is a human process that takes place in an ecosystem of interrelated and interdependent human actors, institutions, norms, and practices (including standards), technologies, information objects, and relationships. To enhance standards adoption, it is equally important to understand the ecosystem and its subsystems (general kinds of things, linkages and flows in the system) and the details of its interacting parts (e.g. the specific organizations, technologies, people and their needs). Standardization is a challenging and complex process and even defining the concept of standard can be difficult. As a geographically defined domain, the Arctic is highly complex and contains many knowledge systems, research disciplines, and operational activities to name a few. All of these elements need to be considered as part of any standardization effort. In CAPARDUS we have explored this complexity, but also found many opportunities to leverage existing nodes in the ecosystem to move the standardization process forward.

Regional case studies

In the regional case studies from Greenland Svalbard, Russia and Alaska we have been working closely with local communities, research groups, industries and governance bodies on four activities:

- Documentation of practices, guidelines and standards in the communities
- Support to community-based monitoring (CBM) and citizen science (CS) activities
- Development of Bayesian Belief Network for fisheries management
- Discuss requirements for an Arctic Practice System to serve different communities and user groups

The case studies had dialogue meetings and workshops in communities with different social, cultural, and economic background. The communities had common challenges connected to climate change and its impact on daily life, including food supply, transport, and economic perspectives. The case studies provided valuable input to the Framework for standardization and the requirements for an Arctic Practice System. Common for all was the need to build new knowledge to adapt to climate change and economic development in the Arctic, e.g, tourism, exploitation of renewable and non-renewable resources, and the new geopolitical situation. On this background, we found that practices, guidelines and standards are evolving in all the communities.

Arctic Practice System

The development of an APS is intended to address the lack of exchange and integration of practices and, more generally, knowledge between different communities and sectors in the Arctic. The proposed APS would serve as a platform for sharing and accessing diverse Arctic practices across disciplines and cultures. It aims to support capacity development, facilitate knowledge transfer, and promote inclusive participation, while protecting rights and ownership of knowledge. It is important to further develop the engagement with Indigenous People and other local communities, stake- and knowledge-holders to understand their needs and ensure the and APS can meet their requirements. Comparable to the OBPS for ocean-related practices, the goal of the APS is to improve the effectiveness, safety, and efficiency of Arctic-related knowledge-sharing activities in a scientifically sound and socially responsible manner. The APS can thus be useful for the Arctic by supporting: the sharing of practices, collaboration, capacity building, and policy development. Drawing on the results from the regional case studies, recommendations and requirements for an effective APS can be developed. An APS developed as suggested in the roadmap (D6.2) would not only support scientific observations but also document and preserve Arctic activities and heritage. Overall, the APS can therefore help to promote sustainable development and conservation in the Arctic by providing a platform for knowledge-sharing and collaboration among stakeholders in the region.

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