Review of Climate Change Adaptation in the Canadian North

Identifying common themes, actions, and opportunities to improve access to adaptation knowledge

Northern Climate ExChange
YUKON RESEARCH CENTRE • Yukon College

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EXECUTIVE SUMMARY

Throughout northern Canada, a variety of documents speaking to climate change adaptation have been published. These range from peer review articles over presentations, websites, and reports to online tools. This project represents an effort to tie all these together. A literature review, including academic as well as grey literature, was conducted and organized into a database. The over 300 records were analyzed for common themes, adaptation enablers and barriers, project types, and geographical distribution. Additionally, online knowledge brokering platforms were reviewed and analyzed for their effectiveness.

Canada's North is changing rapidly. It is also unique in terms of its relatively strong representation of indigenous people, creating a culturally specific context. The three territories are represented relatively equally. Efforts are made to ensure adaptation is executed in a culturally relevant way. The representation of the northern parts of the provinces is more variable and generally decreases East to West.

Important topics across northern Canada are changing ecological, and in the eastern areas sea ice conditions, since these affect the game, fish, and berries that can be hunted and harvested, as well as the safety while traveling on the land. These are important components of food security to people in the North, since there is a stronger reliance on land-based food. The ability to access the land and execute activities such as hunting and harvesting is strongly tied in with traditional practices. Keeping these traditions is an important part of reconciliation. This is a significant consideration when creating climate change adaptation plans.

Common barriers and enablers very much reflect this. Adaptation works well when the communities are supportive of measures, or even better involved in it. Indigenous people have a long history of applying traditional knowledge (TK) to a changing environment. TK was found to be the top enabler of climate change adaptation. Difficulties arise from a lack of funding, baseline data, and long-term adaptations. Building capacity to increase equity and enable communities to adapt is key.

When analyzing the project types of records, 46% showed to distribute information, followed by 28% studying issues. Solution orientated documents are rare, with 16% suggesting solutions and only 10% applying solutions. However, climate change adaptation is a matter that calls for action.

Web-based platforms become increasingly important in the communication of climate change. They attempt to bridge the gap between science and end users. To deliver a successful product, developers must understand who the users and their needs are, build relationships with them, and organize the platform intuitively. This ensures the presented information is relevant, easy to navigate, and understandable to the end user.

KEY TERMS

Indigenous: is used to refer to the descendants of the original inhabitants of Turtle Island (Monchalin, 2016).

Project: is the work, research, or other endeavor described in a record. It may be described by multiple records, or a record may describe multiple projects.

Document: is the publicly available documentation of a project.

Publication: this can be any type of document, such as reports, websites, grey literature, or peer-review articles, that is publicly available.

Record: describes a unique entry in the database. Multiple records can describe the same project, however their source, a specific document, is unique.

ABBREVIATIONS

TK: Traditional Knowledge

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1 INTRODUCTION

Climate change has become an important consideration for a wide variety of government, private, and nonprofit organizations to consider in decision making. However, as with many applied sciences, climate change data is difficult to effectively communicate across different policy and scientific domains, which has resulted in limited uptake and duplicated research efforts (Hering, 2015; Karali & Mattern, 2017). As discussions on climate change have become increasingly concerned with adaptation, the communication gap between applied scientists and the end users of climate change data has become apparent once more (Dilling & Lemos, 2011; Hammill, Harvey, & Echeverria, 2013). For example, in 2002, the U.S Congress critiqued the U.S Global Change Research Program for being "less than successful at developing information that is useful to policy-makers and resource managers in making informed decisions" (Dilling & Lemos, 2011, p.681). In 2007, the U.S National Research Council echoed this sentiment by finding that "inadequate progress has been made in providing knowledge to support decision making and risk analysis" (Dilling & Lemos, 2011, p.681).

Throughout northern Canada, a variety of documents speaking to climate change adaptation have been published. These range from peer review articles over presentations, websites, and reports to online tools. However, there is a need to compile the various types of documents to gain an understanding of common topics, climate change adaptation enablers and barriers, and geographic distribution as well as gaps of adaptation projects.In an effort to make climate data more widely available, there has been an increase in the availability of climate data and information on web-based platforms called climate services. The World Meteorological Organization defines climate services as "the provision of one or more climate products or advice in such a way to assist decision-making by individuals or organizations" (Bell-Pasht & Krechowicz, 2017). Historically, climate services have focused on increasing access to climate change data.

In 2015, an Environmental Commissioner of Ontario (ECO) Roundtable found that available climate information in Ontario is a "patchwork of climate data based on different sets of climate models" and "raw scientific data that is not user-friendly" (Bell-Pasht & Krechowicz, 2017). Environment and Climate Change Canada (ECCC) is the main producer of climate science and projections in Canada, however, the roundtable report found that very few public stakeholders had the "ability to decipher and translate the (ECCC) raw data" (Bell-Pasht & Krechowicz, 2017, parenthesis added). One of the challenges noted in the Pan-Territorial Adaptation Strategy was the lack of both localized baseline data and localized climate change models and scenarios (Northwest Territories, Nunavut, & Yukon, 2012) . These trends have been reported across a larger scale, indicating that the knowledge landscape of climate change research is fragmented with limited interaction between producers and end users of climate change data and information (Karali & Mattern, 2017).

Decision makers in both the private and public sectors are interested in using climate knowledge, however, even when relevant climate information is available, end users have limited access, limited ability to interpret technical data, and limited experience in applying climate knowledge to policies or procedures (Donatti, Harvey, Martinez-Rodriguez, Vignola, & Rodriguez, 2017). End users of climate change information include decision makers in variety of sectors, such as, government, infrastructure, financing, conservation, energy, resource extraction, emergency response and assistance, insurance and health (Bell-Pasht & Krechowicz, 2017).

To address this, there has been a rise in the creation of climate knowledge brokering platforms which transform climate data into information that is usable for diverse audiences (Hammill et al., 2013). Knowledge brokering creates better connections between researchers and their audiences by identifying, localizing, redistribution, rescaling and transforming knowledge to enable the usability of climate data for decision-making (Meyer, 2010). Climate knowledge brokering platforms collect a wide assortment of climate knowledge in the forms of databases, libraries, and interactive maps, to provide a variety of end users with the usable climate knowledge they need in one space. Climate knowledge brokering platforms are funded and operated by a wide variety of actors, including provincial, territorial and federal governments, pan arctic organizations, international organizations (such as the United Nations and the World Bank), nonprofit organizations, and Indigenous groups. Despite the proliferation of climate knowledge brokering platforms, little evaluation has been done to determine whether climate knowledge brokering platforms promote better access and understanding of climate data and information for end users.

This project gathers the existing literature on climate change adaptation in northern Canada, and ties together common themes. Further, it puts it into the unique cultural context, and discusses the effectiveness of measures specific to the area. We report on successes and limitations of climate knowledge brokering platforms to determine best practices. This analysis evaluate climate knowledge brokering platforms focusing on the Canadian North, and the Arctic, as well as, prominent internationals climate knowledge brokering platforms with Canadian and/or Arctic data and information.

2 METHODOLOGY

The following section describes the methodology, strategy and analyzes of the literature and tool review. In the beginning of the project, a database was set up to facilitate the entering of records. Two students systematically searched for literature regarding climate change adaptation in the Canadian North and entered information about the recording using a variety of fields. Categoric fields were later analyzed to look for common themes, climate change adaptation enablers and barriers, project types, and geographic distribution of publications. Online knowledge brokering tools were research and captured by a third student. The tools were analyzed in terms of the effectiveness based on a variety of criteria.

2.1 LITERATURE SEARCH

2.1.1 Systematic search

The search terms and associated online databases or websites used in this project are shown in Table 2-1. Databases were selected based on the accessibility for the searcher. Typically, searches started in well known, large academic databases like Jstor and Academic Search Complete and moved to more topic specific databases later in the search process. Google Scholar was also used. The search terms were entered into each database with no boolean or logical operators.

In order to capture publications not appearing in peer-reviewed journals such as websites, posters, and other documents search terms were entered into Google. During this phase of the search when a publication was found that linked to other publications the links were followed. Publications on the first ten pages of search results were cursorily screened for database inclusion, and where possible downloaded and listed for more detailed screening prior to final database inclusion or rejection based on the criteria outlined in section 2.1.2 Additionally, each article in the portion of the catalog of the journal ARCTIC available online was considered for inclusion in this database.

Table 2-1 List of search terms, and database used with each search term. The first and second Search Term column were combined to create a single search term which was then used in each database listed.

First Search Terms	Additional Search Terms	Database
climate change	Response arctic	Academic Search Complete, Jstor, Google Scholar, Arctic & Antarctic Regions
	Mitigation north	Academic Search Complete, Jstor, Google Scholar, Arctic & Antarctic Regions
	Remote Ontario	Jstor, Academic Search Complete, Google
climate change, first nation	Arctic action	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Mitigation arctic	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Mitigation north	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Planning arctic	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Proactive north	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Western artic	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
	Yukon	Jstor, Arctic & Antarctic Regions, Academic Search Complete, Arctic & Antarctic Regions
climate change, adaptation	Boreal flooding	Jstor, Academic Search Complete, Arctic & Antarctic Regions, Google Scholar, Arctic Institute
	Boreal wildfire	Academic Search Complete
	Wildfire northern Canada	Academic Search Complete
	Remote	Academic Search Complete
	Yukon	Academic Search Complete, Jstor, Google Scholar, Arctic & Antarctic Regions, Climate Change
	Northwest Territories	Academic Search Complete, Arctic & Antarctic Regions, Jstor, Google Scholar, Climatic Change
	Nunavut	Academic Search Complete, Arctic & Antarctic Regions, Jstor, Google Scholar, Climatic Change

	Arctic	Academic Search Complete, Arctic & Antarctic Regions, Jstor, Google Scholar, Climatic Change, CSP: Environmental Review
	Canada	Academic Search Complete, Jstor, Google Scholar, Environmental Review, Arctic & Antarctic Regions, Climate Change, Science Direct, Arctic
	Labrador	Academic Search Complete; Arctic & Antarctic Regions, Jstor, Google Scholar, Climatic Change, Environmental Review
	North	Academic Search Complete, Arctic & Antarctic Regions, Jstor, Google Scholar
	Planning north	Academic Search Complete, Jstor, Google Scholar, Google, Arctic & Antarctic Regions
	Northern Canada	Academic Search Complete, Jstor, Google Scholar; Arctic & Antarctic Regions
	North Ontario	Academic Search Complete, Arctic & Antarctic Regions, Jstor, Google Scholar
	Northern Ontario	Jstor, Academic Search Complete, Google
	Northern Quebec	Jstor, Academic Search Complete, Google, Climatic Change
	Remote Quebec	Academic Search Complete; Arctic & Antarctic Regions, Jstor, Google Scholar, Climatic Change
	Ivujivik Quebec	Jstor, Academic Search Complete, Google
	Kangiqsualujjuaq	Jstor, Academic Search Complete, Google
	Nain	Jstor, Academic Search Complete, Google
		Jstor, Academic Search Complete, Google, Online Journal Archives, Arctic Institute
climate change, adaptation, first nation	Northern Canada	Google, Google Scholar, Academic Search Complete, Jstor, Arctic & Antarctic Regions
	Northwest Territories	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Nunavut	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Yukon	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern Quebec	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern Ontario	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions

	Northern Manitoba	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern Saskatchewan	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern British Columbia	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern Alberta	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Labrador	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Strategies Canadian North	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	North	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Northern Canada North	Google, Google Scholar, Academic Search Complete, Arctic & Antarctic Regions
	Canada	Google, Academic Search Complete, Arctic & Antarctic Regions
	Canada arctic	Google, Academic Search Complete, Arctic & Antarctic Regions
	Canadian arctic	Google, Academic Search Complete, Arctic & Antarctic Regions
	NWT	Google, Academic Search Complete, Arctic & Antarctic Regions
	Yukon plan	Google, Academic Search Complete, Arctic & Antarctic Regions
climate change, adaptation, Inuit	Labrador	Academic Search Complete, Arctic & Antarctic Regions
	Northern Quebec	Academic Search Complete, Arctic & Antarctic Regions
	Northern Ontario	Academic Search Complete, Arctic & Antarctic Regions
	Nunavut	Academic Search Complete, Arctic & Antarctic Regions
	Northwest Territories	Academic Search Complete, Arctic & Antarctic Regions
	Yukon	Academic Search Complete, Arctic & Antarctic Regions

2.1.2 **Inclusion criteria**

The criteria for including documents or projects in this database is based on the project context identified in the project proposal *Review of Climate Change Adaptation in the Canadian North: Identifying Common Themes, Actions and Opportunities to Improve Access to Adaptation Knowledge.* This project seeks to:

- Track and compile Northern focused publications to identify common themes, questions and solutions.
- Identify sub-regions where additional adaptation work may be needed.

Documents in academic databases were identified for consideration based on a series of search strings, associated with a particular database identified in Table 2-1.

For inclusion in this database, documents must focus on climate change adaptation or climate change impacts in a Northern context. Climate change adaption and climate change impacts can encompass a broad range of documents. Work that is not directly targeted at the North may have information that pertains to it. The following criteria were applied to each result of the searches applied in Table 2-1.

1. Documents that are not Canada based will be excluded.

2. In order to be included, the title, abstract or summary of each document must include the terms the same as or similar to:
   - Climate change adaptation, climate change impact(s), climate change mitigation, global warming, greenhouse gas effect, atmospheric warming, warming climate, change climate, temperature change or any other synonym for climate change.
   - North, northern, boreal, the Arctic, sub-arctic, permafrost, tundra, remote communities, the name of a Northern indigenous group/community or one of the territories (plus Labrador and the far north of Ontario/Quebec).

3. Documents without a summary were included if a simple electronic search of the document returns any of the above terms. Generally, speaking, in order to be considered documents in this category met criteria 1 (Canadian based) and/or the first part of criteria 2 (climate change or a synonym appeared in the title).

4. Documents and projects that met the above criteria were potentials for database inclusion. If at any point while extracting information the document or project is found to not in fact to meet inclusion criteria, it was rejected.

2.2 DATABASE STRUCTURE AND DATA ENTRY

2.2.1 Fields and categories

Information from publications was captured in fields in the database. Three general types of fields were implemented in the database. To freely describe varying information, text fields were used – *"Short Text"* for smaller amounts of information (up to 255 characters), and *"Long Text"* allowing for longer descriptions (exceeds 255 characters). To easily quantify information after data entry was completed, *"Categories"* were computed for certain fields. Here, a list of possible values were pre-determined for students to choose from. For example, for the field *"Project type"* the options were *"Applies solution"*, *"Distributes information"*, *"Studies issues"*, *"Suggests solution"*. Additionally, a binary *"Yes/No"* option was set up for the *"Tool check"* field. The section below shows all fields in the database, together with a description (unless self-explanatory) and the type of field that was used. When fields use categories, the categories are listed as well.

Title: title of publication [Long Text]

File name: name of documents saved to the literature folder [Short Text]

Author: all authors of the project [Short Text]

Date published: date the project was published [Short Text]

Start date of project: date the project started [Short Text]

End date of project: date the project ended [Short Text]

Calculated date: equal to the date published field, or if a document is unpublished equal to the end date of project field [Calculated Field]

Document Type: type of document the project was published as [Categories: Artwork, Audio recording, Blog Post, Book, Book section, Document, Film, Interview, Journal article, Magazine article, Map, Newspaper article, Podcast, Presentation, Radio Broadcast, Thesis, Website]

URL: web link to the project [Long Text]

DOI: doi link [Long Text]

: the attached document for a record [Attachment]

Scale: scale the project took place at [Categories: National, Region, Province/ Territory, Community]

Region: broad geographic region where the project took place [Categories: Atlantic region (NL, PEI, NS, NB), Central Canada (QC, ON), Northern Canada (NU, NT, YT), Prairie Provinces (MB, SK, AB), Western Canada (BC)]

Province/ Territory: [Categories: Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Northwest Territories, Nova Scotia, Nunavut, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon Territory]

Community: the community, or communities where the project took place [Categories: list of Canadian communities. This list was populated based on the value in the province/territory field]

Indigenous Group: [Categories: Abenaki, Acho Dene Koe, Ahousaht, Ahtna, Akaitcho, Algonquin, Anishinabek, Assiniboine, Athabaska, Atikamekw, Baffin Island Inuit, Beothuk, Blackfoot Confederacy, Carcross/Tagish, Cayuga, Central Coast Salish, Champagne and Aishihik, Coast Salish, Cree, Dakelh (Carrier), Dakota, Dane-zaa (Beaver), Dehcho Dene, Dene (Chipewyan), Dene Tha', Denesoline (Chipewyan), Ditidaht, Ehattesaht, Gitxsan (Gitksan), Gwich'in, Haida, Haisla (Kitamaat), Hän, Haudenosaunee (Six Nations or Iroquois), Heiltsuk, Hesquiaht, Hupacasath (Opetchesaht), Huron-Wendat, Huu-ay-aht, Iglulingmuit (Iglulik Inuit), Innu (Montagnais-Naskapi), Interior Salish, Inuinnait (Copper Inuit), Inuit, Inupiaq, Inuvialuit (Mackenzie Inuit), Kainai (Blood), K'asho Got'ine (Hare), Kaska Dena, Kivallirmiut (Caribou Inuit), Kluane, Ktunaxa (Kootenay), Kwakwaka'wakw (Kwakiutl), Kwanlin Dün, Kyuquot and Checleseht, Labradormiut (Labrador Inuit), Lilwat (Lillooet), Lingit (Tlingit), Little Salmon/Carmacks, Maliseet, Métis, Mi'kmaq, Mohawk (Kanien'kehá:ka), Moose Cree, Mowachaht-Muchalaht, Na-cho Nyäk Dun, Nahani, Naskapi, Netsilingmiut (Netsilik Inuit), Neutral Confederacy, Nicola-Similkameen, Nisga'a, Nlaka'pamux (Thompson), Northern Georgia Strait Coast Salish, Nuchatlaht, Nunatsiavut, Nunavik, Nunavimmiut (Ungava Inuit), Nunavut, Nuu-chah-nulth, Nuxalk (Bella Coola), Odawa, Ojibwa, Oneida, Onondaga, Pacheenaht, Passamaquoddy, Penobscot, Petun, Piikani (Peigan), Sahtu Dene and Metis, Sahtu Got'ine (Bearlake), Saldermiut Inuit, Secwepemc (Shuswap), Sekani, Selkirk, Seneca, Shuta Got'ine(Mountain), Siksika (Blackfoot), Slavey, Stoney-Nakoda, Syilx (Okanagan), Ta'an Kwäch'än, Tagish, Tahltan, Tetlit Gwich'in, Tla-o-qui-aht(Clayoquot), Tlicho , Tlingit, Toquaht,

Tr'ondëk Hwëch'in, Tseshaht (Sheshaht), Tsilhqot'in (Chilcotin), Tsimshian, Tsuut'ina (Sarcee), Tutchone, Uchucklesaht, Ucluelet (First Nation), Vuntut Gwitchin, Wabanaki, Weenusk, Wetal (Tsetsaut), White River, Wolastoqiyik (Maliseet), Yellowknives]

Broad Theme: [Categories: Atmosphere, Ecology, Human Health, Industries, Infrastructure, Natural Hazards, Snow and Ice, Social Issues, Water, Pollution]

Detailed Theme: [Categories: Agriculture, Air Quality, Air Temperature, Aquaculture, Biodiversity, Built Environment, Clean Technology, Communication, Connectivity, Conservation, Cumulative Effects, Diseases, Drought, Ecological Restoration, Ecology, Emissions, Fire, Fish, Flooding, Food Security, Forestry, Glacier Melt, Glaciers, Governance, Health and Temperature, Hunting and Harvesting, Industries, Inequities, Infrastructure, Landslides, Mental Health, Mining, Natural Hazards, Permafrost Thaw, Policy, Poverty, Protected Area, Public Safety, Renewable Energy, Sea Ice, Sea Level Rise, Shift in Species Distribution, Snow, Snow Melt, Social, Species Migration, Storms, Tornados, Traditional practices, Vegetation, Waste Management, Water, Water Management, Water Quality, Water Quantity, Water Temperature, Wildlife]

Project type: [Categories: Applies solution, Distributes information, Studies issues, Suggests solution]

Aim: Aim of the project [Short Text]

Method Category: [Categories: Case study, Community Engagement, Data analysis, Experiment, Field Investigation, Impact Assessment, Interviews, Literature Review, Mapping, Modeling, Monitoring, Remote sensing, Statistical analysis, Workshop]

Measured values: [Short Text]

Issues/ Impacts: Impacts and issues caused by climate change discussed in the publication [Short Text]

Solution: Solutions suggested or applied in the publication [Short Text]

Suggestions: Suggestions or further research questions posed in the publication [Short Text]

Adaptation barriers: [Short Text]

Adaptation Barriers Categories: [Categories: Climate change skepticism, Communication challenges, Conflicts of interest, Inaction by organizations, Inaction by the government, Inconsistent reporting, Inequity, Lack of awareness, Lack of baseline data, Lack of clear and consistent policy guidelines, Lack of community involvement, Lack of expertise, Lack of financial resources, Lack of knowledge, Lack of local autonomy, Lack of long term adaptations, Lack of personnel, Lack of qualitative information, Lack of time, Lack of trust, Legislation issues, Mainstreaming]

Adaptation enablers: [Short Text]

Adaptation Enablers Categories: [Categories: Collaboration, Community support Connections and networks, Economic resources, Education, Effective institutional support, Equity, Flexibility of resource use, Inclusion of vulnerable groups, Information sharing, Interdisciplinary approaches, Mainstreaming, Raising of awareness, Shared responsibility, Technology, Traditional knowledge, Training, Transboundary organization]

Summary: [Long Text]

Key words: [Long Text]

Comments: Comments and observations of the person entering the record [Long Text]

Tool check: Indicates if the publication was about a tool [Yes/No]

Tool Name: The name of tool used, if applicable. [Short text]

2.2.2 **Data Entry**

To provide a better understanding of the information in the database, considerations while entering data into the specific fields are described in the following section. The main types of fields that were used, text and categories, both have advantages and disadvantages. A text field allows for a high degree of freedom when entering material. However, the information within is difficult to quantify and analyze. Categorical fields allow for a quick and easy quantitative analysis, however it can sometimes be difficult to fit information from a publication into these categories. Fields were generally left blank if there was no information on it in the record, or categories did not apply to the record. Therefore, the following section talks about how these cases were dealt with. The considerations used to fit records into specific categories are

explained for those categories, which were non-intuitive or could be interpreted in different ways. Otherwise, the specific categories for each database field are listed in section 2.2.1.

2.2.2.1 Scale

Records were assigned a scale level of either community, territorial/provincial, regional or national. In many cases, records spanned multiple scales or were focused on a variety of locations within the same spatial scale. In order to classify records consistently throughout the database, they were assigned a scale category based on the following criteria:

Community scale:
Research or projects conducted in a single community, or in multiple communities with conclusions, results or outcomes limited to those communities or comparisons between those communities. Some limitations to classify records at this scale include: Study areas that were larger than communities but smaller than a territory/province like First Nation traditional territories, watershed drainages, etc. This was addressed on a case by case basis with scale level assigned based on what was most appropriate for each record. Typically, traditional territories were classified as community, or in some cases territorial/provincial while watersheds and drainages were classified as territorial/provincial or regional depending on the watershed. These are just two examples and there are other records within the database that don't exactly match scales in the database and were assigned a scale of best fit.

Territorial/ Provincial scale:
Projects conducted in and speaking to a single territory/province, or in many communities within a single province/territory. There are technical and classification limitations at this scale that were addressed upon database entry on a case by case best fit scenario. Records that spanned multiple provinces/territories with conclusions, results or outcomes limited to those provinces/territories or comparisons between them were typically classified at the Territorial/Provincial scale level, however if this was a poor fit the record was classified at the regional scale.

Regional scale:

Records in the database are divided into 5 broad geographic regions (Government of Canada, 2012):

- Atlantic (NL, PEI, NS, NB)
- Central (QC, ON)
- Northern Canada (NU, NT, YT)
- Prairie Provinces (MB, SK, AB)
- Western Canada (BC)

Records were assigned to this scale if the project spanned multiple territories/provinces, spoke to issues that encompassed broad geographic regions (The North), or didn't fit cleanly into the territorial/provincial scale.
National scale:

National scaled records have met the criteria for database inclusion described in 2.1.2. These are records that spanned multiple territories/provinces in different regions, did not fit into one region, addressed national level climate change adaptation measures relevant to the North, or don't specifically target the North but contain elements that pertain to the North. Publications were only included in the database if they addressed Northern issues or discussed Northern adaptations. For example, broad level municipal climate change adaptation planning strategies were included in the database at the national scale, as the content of the document was general and had relevance to climate change planning in the North. Municipal water strategy planning is another example of a document that would meet database inclusion criteria and be classified at a national scale. While northern communities may have unique conditions and requirements for municipal water systems, many of their broader planning needs are similar to those faced by communities nationwide.

2.2.2.2 Region

One of the five broad geographic regions of Canada, mentioned in 2.2.2.1, was assigned to each record.

2.2.2.3 Province/Territory

The province or territory where the work described in the record took place. Only one province or territory could be selected for each record, so this field was left blank for records that spanned multiple provinces/territories.

2.2.2.4 Communities

For community scaled records, all communities identified in each record were entered into the database. This included multiple studies conducted in multiple communities, across multiple regions in one document. No community was identified when the record was at a national, regional or, territorial/provincial scale level and did not include the name of specific northern communities. The database was designed in such a way that the Communities field was related to the Province/Territory field, which was in turn related to the Region field. Because of this it was possible to enter communities from multiple provinces/territories or regions, but it was not possible to classify a record with more than one province/territory or region value. In these cases, the Province/Territory or Region of best fit was used for the record, but all communities were entered.

2.2.2.5 Indigenous Groups

This field was initially populated with a list of Indigenous groups from the website https://native-land.ca (Temprano, 2018). This list was updated as records were entered; if an indigenous group appeared in a record but was not on the initial list, the list was updated to include that indigenous group. Each indigenous group identified in the record was entered in this database field. If an overarching and a more specific Indigenous group were identified in the record, both were entered in the database. For example, Nunatsiavut and Inuvialuit are sub-classifications of Inuit people so Nunatsiavut or Inuvialuit and Inuit would both be selected for that record. If a record identified multiple Indigenous groups, they were all entered in the database field.

2.2.2.6 Broad Theme:

The broad theme was used to capture the overarching idea(s) or subject of each record. This field was intended to answer the question, “What is the main subject of this record?”. The broad themes were developed by entering a portion of the records into the database and identifying recurring ideas and subjects in those records. As new broad themes were identified throughout data base entry, they were added as needed and existing records were reclassified as needed. Records can have multiple broad themes. The broad themes were very general, consisting of a single word or concept which in many cases made assigning them a case of identifying the theme that fit best. If it was not possible to identify a broad theme for a record it was left blank and the detailed themes category was used solely to classify the record thematically. Records were classified using the following broad themes:

Atmosphere: was used when the subject of a record was the atmosphere or atmospheric conditions. This could range from records exploring air pollution, or atmospheric temperature changes to changing wind regimes.

Ecology: was selected for records about the natural world, fish, wildlife, plants, etc. and their relationships. This theme was also used for records about how changes to the natural world were impacting human activities, human infrastructure, human culture or the natural world itself.

Human health: was used for records about changes to human health. Both mental and physical health were included here. It was often selected in conjunction with other broad themes that captured the cause of human health impacts.

Industries: was selected for records with industry as their subject. Industries could be mining or resource related, tourism, or local crafting. This theme was used for records that detailed climate change changes to existing industries, the creation of new industries, or the industries' impact on climate, people or the environment.

Infrastructure: was used for records about roads and structures built by people. It was also used for changes to access locations and travel.

Natural hazards: was used for records about natural hazards like flooding and landslides. It was also used for travel related issues such as increased risk associated with ice travel and river crossings due to climate change.

Snow and ice: was used for records about snow and ice related impacts and adaptations. Freshwater and marine ice, glaciers, permafrost and snow were included in this broad theme.

Social issues: was used for cultural and social challenges and issues associated with climate change. Climate change not only has an impact on individual health, it also may have a range of social and cultural impacts that are not health related. Some examples of social issues include changes to economic activities, economic hardships, and changing demographics in Northern communities.

Water: records that focused on water, and water related issues were assigned the water broad theme. This broad theme was not used for records focused on snow and ice. Water travel, shipping, water quantity and quality are examples of topics that were assigned the water broad theme.

Pollution: records that addressed pollution, or contamination of medium.

Planning: was applied to records that addressed planning and governance. Adaptation planning is a generalized process taking place across much of the North that touches on many of the broad themes used in the database. However, the planning theme was used for records specifically about planning, analyzing the efficacy of plans, and various climate change adaptation frameworks proposed and analyzed in database records.

2.2.2.7 Detailed Theme:

Detailed themes, just like broad themes, were developed by reviewing a portion of records in the database and identifying common ideas and subjects throughout these records. Detailed themes were reevaluated throughout database entry and more themes were added as they were identified. Multiple detailed themes could be assigned to a single record.

2.2.2.8 Project Type

The project type refers to the primary objective of the record. Multiple options could be chosen for each record. Four options were available:

Applies solution: was used if the record identified a specific issue or problem to which a solution was applied, and the results of that solution were detailed in the record. It is important to note that solutions varied widely in nature and may not solve a problem directly. Instead they allow adaptation measures to be more successful or provide a means to continue an activity despite climate change. Some examples include remote sensing technology to monitor ice thickness for trip planning and using video and online media to record and disperse traditional knowledge.

Distributes information: this project type was applicable to many records in the database. The main aim of the record is simply to synthesize and share information. Many literature reviews fall into this category, and it is often paired with other categories. This project type was applied to records that document climate change impacts, frameworks, and adaptation needs assessments.

Studies issues: An issue is identified and explored. Some examples include documenting permafrost impacts to infrastructure, or how changing sea ice conditions impact access for hunters.

Suggests solution: The record suggests solutions to identified climate change impacts or issues. The solutions suggested are not tested, explored or analyzed.

2.2.2.9 Aim

The aim field captured the specific goal of the record in one or two sentences. It was a succinct description of what the record accomplished or set out to accomplish. The nature of this field varied with the type of record. In some cases, the aim was a specific research goal, in others it was to distribute information on a topic or propose a policy/governance action or provide a solution to a problem.

2.2.2.10 Method Category:

The method category field broadly describes the research methodology or methodologies used in the record. In most cases, in our database, a method category value is associated with academic literature published in a peer-reviewed journal and the method category was extracted from a methods section. However, there are also examples of records in the database where a method category was gleaned from a website or non-academic literature. For these records a method category was still assigned. Multiple method categories could be selected.

2.2.2.11 Measured values

Any quantitative value measured in the record is briefly described in this database field only values measured directly in the record were noted in this field, so if pre-existing data was used in the record, this field was left blank.

2.2.2.12 Issues/ Impacts

The issues/impacts field was a non-categorical field in the database, used to briefly describe issues or impacts that appeared in the record. This field was used for both resolved and unresolved issues and impacts.

2.2.2.13 Solutions

The solution field was a non-categorical field used to provide a brief description of solutions to issues or impacts described, suggested or implemented in the record. A solution was entered in this field whether it was successful or not.

2.2.2.14 Suggestions:

The suggestions field was a non-categorical field where a short description of suggestions to issues or impacts is described, suggested or proposed. It was also used to capture other avenues of research proposed in the record. Suggestions and solutions are quite similar and often related. Solutions are or can be implemented, whereas suggestions are offered without any implementation consideration, or propose a different avenue of research or questioning.

2.2.2.15 Adaptation barriers

This categorical field lists categories of barriers to climate change adaptation. Some examples include financial or economic barriers, where it is possible to obtain project funding but the community cannot bear the long term financial burden of the project, or mainstreaming policy and planning decisions where research and planning conducted in the south doesn't apply to Northern situations, but that inserting climate change adaptation into planning and policy at a national level can accelerate adaptation in the North.

2.2.2.16 Adaptation enablers

This field was used to categorize climate change adaptation enablers identified in database records. Like adaptation barriers, only enablers explicitly identified in the record are entered, and no assumed enablers are entered.

2.2.2.17 Summary

A brief summary of the content of the record.

2.2.2.18 Use of dates in database record analysis

There are 4 date fields in the database, Date published, Start date of project, End date of project and Calculated date. For records that were not formally published the Date published field was left blank, but project start and end dates were recorded. In order to perform analysis using dates the Calculated Date field was created. The Calculated Date field was populated, where possible with the date from the Date Published field. If the Date Published was blank, the Calculated Date field was populated with the Project end date field.

2.2.3 Gap analyses

During record search and database entry potential gaps in northern climate change adaptation publications were observed. In order to determine if these gaps were in fact gaps in published material, rather than a reflection of the search technique used, summary queries of database records were ran at two points during data entry. Using these queries, it was possible to confirm whether the gaps observed were present and to adjust future search terms to possibly address gaps or dismiss them.

2.2.3.1 Geographic and regional gaps

The northern regions of Ontario, Quebec and the Prairie Provinces as well as Labrador were not well represented during database entry. This was confirmed by summary queries. Search terms specific to these regions were added to future searches and additional publications focused on

these regions were found, but number less than other Northern regions of Canada. The geographic distribution of publications is further discussed in section 3.1.

2.2.3.2 Project type gaps

Records were classified into four broad categories based on the intent of the record. These categories include, *"Applies solution"*, *"Distributes information"*, *"Studies issues"* and *"Suggests solution"*. During data entry the category "Applies solution" was thought to be largely under represented, with the purpose of most records to "*Distribute information"* or "*Studies Issues".* This pattern was most apparent in academic literature. This gap was also observable when assigning themes to records; the planning broad theme category was most frequently assigned to records. While planning indicates a potential intent to take action, it does not mean that any action was taken. It was also observed in the method field, where a large number of records were categorized as "*Literature Review"*, indicating that no original or novel action was taken.

In order to explore this potential gap, the search terms were modified to determine if this gap was in fact a gap, or a reflection of the search terms. Additionally, the search was expanded to include non-academic literature, and websites. The trend of minimal adaptation action was more apparent during initial record entry when searches were focused on academic databases and remained despite modifying search terms. As searches were broadened to include grey literature and websites, records described more action-based adaptation. It was observed that action is being taken to adapt to climate change more at grassroots or a community level. Section 4.1.1 explores this in more detail.

2.2.4 Different records referring to the same project, and one record referring to multiple projects

Based on the original research proposal for this project the purpose of this database is to compile and analyze northern climate change adaptation publications. As a database of publications if a project produces many publications (e.g. a journal article, a poster and a website) each publication is treated as an individual record. Whereas, if a single publication describes multiple projects only one record is entered into the database.

A series of records were drawn from website Climate Telling (http://www.ClimateTelling.info) (ClimateTelling, 2017). The climatetelling.org website was developed to highlight climate change impacts indigenous communities are facing and the efforts being undertaken to adapt. The website is intended as a resource "by communities for communities" to share tools, expertise and information. The website is organized thematically and by location, displaying projects in multiple phases that can be quite distinct. The reason for this is the nature of the funding for these projects. Funding for the website and associated projects is provided by the Department of Indigenous

Services Canada's Climate Change and Health Adaptation Program (CCHAP) (ClimateTelling, 2017). The CCHAP provides up to $200 000 for a single project per community in the North each year. The funding period is limited to one year, which is why many of the projects listed on the climatetelling.org website and described in this database are divided into multiple phases (Health Canada, 2011). While the phases could be seen as unique projects, the URL is still the same. The unique URLs were entered as unique records, meaning multiple phases are captured in one record.

The organization by unique publications over unique projects was based on the wording in the project proposal, which suggests gathering of climate change adaptation publications, not projects.

2.3 EVALUATION CRITERIA FOR CLIMATE KNOWLEDGE PLATFORMS

2.3.1 Tool search

Websites were compiled for analysis through a list provided by Indigenous and Northern Affairs (INAC), and subsequent website links associated. Websites were excluded from the analyses if they were incomplete, or did not load. Websites were also excluded if they only focused on southern climate issues that did not relate to climate change strategies in northern latitudes. Five main sections (purpose, simplicity, readability, navigation, and organization) were used to analyze 19 websites with northern and Canadian climate information. A point was assigned for one of five pf five parameters in each section if the expectation or goal was met. This would add up to a total score of 25 if every expectation or goal was met.

2.3.2 Evaluation Criteria

The parameters highlighted in the "purpose" section were; (1) a clear statement of the purpose, (2) whether or not the site met the visitors expectations, (3) organization (that meets the needs of the visitor), (4) whether or not the organization's information was accessible (i.e. for contacting), and, (5) if the information presented was useful and up-to-date.

The parameters highlighted in the "simplicity" section were; (1) transparency of information, (2) consistency in design throughout the website, (3) whether or not the website was easy to navigate, (4) if the website minimized redundant features (i.e. least amount of clicks to get to appropriate section), and (5) easily understandable functions (i.e. no confusing/out-of-context links).

The parameters highlighted in the "readability" section were; (1) easy to read (graphically), (2) well-written and grammatically correct, (3) appropriate amount of information/readable blocks, (4) appropriate reading level for audience, and (5) understandable/relatable to site content.

The parameters highlighted in the “navigation” section were; (1) salient menu/navigation bar, (2) aids for navigating (e.g. visible links), (3) consistency of layout, (4) search features (i.e. search bar), and (5) easy access to web pages (no excessive backtracking/clicks to reach, i.e. multiple/efficient pathways).

The parameters highlighted for the “organization” section were; (1) logical organization (i.e. broad to specific), (2) systematic arrangement and categorization (following a consistent pattern), (3) meaningful labels/headings/titles, (4) keywords, and (5) Sufficient amount of information to attract repeat visitors.

3 ANALYSES AND RESULTS

3.1 GEOGRAPHIC DISTRIBUTION OF PUBLICATIONS

“The North” of Canada was not clearly defined within this project to make sure not to exclude anyone. The review includes the territories, as well as the northern parts of provinces. On a community level, the number of publications range from zero to 16 (see Figure 3.1). Ulukhaktok, NWT and Rigolet, NL each have 16 hits and illustrate the largest number of adaptation publications in northern Canada. They are followed by Aklavik, NWT, Iqaluit, NU, and Igloolik, NU, with 14 publications.

Based on a territorial and provincial scale, the Northwest Territories have the strongest representation with 71 publication. The Yukon and Nunavut both have 59 hits. Out of the provinces, Newfoundland and Labrador contain the most publications with a total of 24. Ontario and Québec both have a total of 15 publications. Alberta and Manitoba are both represented by four, and British Columbia and Saskatchewan by one publication. In provincial documents, the northern parts of the provinces seem to be overshadowed by adaptation planning in the South. Often only a small section is reserved for the North. A similar observation can be made in national documents mainly focusing southern Canada, leaving only a short mention of the North.

Figure 3.1 Distribution of climate change adaptation publications per community in northern Canada.

3.2 COMMON TOPICS

In northern Canada, climate change induced temperature increase will allow grass, sedge and flowering plants to expand their range. Plant species specifically adapted to the far North may see a narrowing of their niche as the conditions they need to thrive change. Plant species that are limited by other conditions like latitude or photoperiod may have limited ability to respond to climate change. Predicting the large-scale response of northern systems to climate change is difficult. Some models predict that the boreal forest will replace as much as 50% of tundra systems, however other models suggest that increased disturbances like pests and fire will moderate the expansion of the boreal forest, or in fact drive a reduction and subsequent expansion of the tundra (Prowse et al., 2009). Increased shrub growth, and movement of the tree line northwards has been observed throughout the North (Barber et al., 2008; Cuerrier et al., 2015). Climate change is creating favourable conditions for deciduous shrubs such as birch (*Betula* spp.), willow (*Salix* spp.), and alder (*Alnus* spp.) farther and farther north. The shade these species offer will have negative impacts on lichens and mosses, sensitive to light, and important as food, particularly in the winter, for many northern species. Lichens are important to caribou, which are an important food species for many people living in the north (Barber et al., 2008).

Increased ocean temperatures, rising sea levels, reduction of seasonal ice extent, and decreased salinity of sea water are some of the climate change impacts that will affect Arctic marine ecosystems and people living in them. Contracting sea ice in particular drives changes in species range, abundance and ultimately recruitment (Ferguson, Stirling, & McLoughlin, 2005). Broad ecological shifts in the North can be understood by using populations of animals that are dependent on the sea ice such as Northern seals and walrus as indicators. Ringed seals rely on sea ice for both over winter survival and reproduction. By correlating recruitment and overwinter survival rates with environmental factors such as snow depth, precipitation, air temperature and the timing of spring ice break up, a picture of how environmental factors influence ringed seal populations can be drawn (Ferguson et al., 2005).
Arctic terrestrial and marine mammals and birds often inhabit thin ranges of habitat or occupy specific niches that make them particularly vulnerable to climate change. Many of these species live on the edges of their ecological ranges and are the first to experience climate change impacts (Prowse et al., 2009). Phenology, or the timing of events is particularly important in the north. The arrival of migratory birds to their northern breeding grounds is timed with particular environmental conditions. Climate change is modifying the onset of these conditions; birds arriving too late may fail to reproduce, whereas those arriving too early may face capricious weather conditions and possible food shortages. As a result, birds failing to adjust to the local

timing of breeding season can suffer drastically reduced reproductive success (Berteaux et al., 2004).

Shrub and tree line expansion has ecosystem ramifications and will pose challenges for northern residents to maintain travel routes. Climate change is impacting the distribution, abundance and presence of berries across the north, an important source of nutrition and culturally valuable to many people living in the north. Individuals also report that berries no longer taste as good (Cuerrier et al., 2015). Impacts to berry harvest can affect entire communities. Berries are typically harvested and processed by multiple generations of community members, providing an opportunity to spend time on the land, and building connections between generations (Cuerrier et al., 2015). Northern people are connected to marine birds using them as a source of eggs, meat and feathers. A long history of harvesting marine birds places northern people in a unique situation, possessing TK based insights that may not be known to science. Marine birds are leaving the arctic later in the year and arriving earlier. This has both ecosystems effects and impacts for harvesters.

Environmental changes affect the accessibility of traditional foods. Food security is defined by the Food and Agriculture Organization as the time “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (Food and Agriculture Organization, 1996) and by the Kluane First Nation as present “when all people at all times have enough access to affordable, nutritious, safe, and culturally appropriate foods” (Kluane First Nation, 2014). Noticeable is the specification of “culturally appropriate foods” in the latter definition. For indigenous people, secure access to culturally appropriate foods is strongly interwoven with their traditional heritage. The ability to hunt, gather, and fish is an important aspect to the livelihood of indigenous people. Food insecurity resulting from climate change can threaten cultural practices. Adapting to climate change might mean to adapt traditional practices to the changing conditions. Schuster defines two aspects of food insecurity. Moderate food insecurity describes people not being able to access the types and variety of foods they would like to eat (Schuster, Wein, Dickson, & Chan, 2011). For indigenous people this means access to traditional foods. The Vuntut Gwitchin for example understand themselves as caribou people. If the caribou herds were to disappear it would challenge this identity. Severe food insecurity on the other hand means that a person does not have enough to eat to sustain themselves (Schuster et al., 2011). Replacing traditional foods with market foods can be an adaptation strategy. However, this is challenging, as these are very expensive due to high transportation costs to remote locations. Market foods contain higher amounts of preservatives, sodium, carbohydrates and saturated fats. Hence, health concerns arise with the switch to market foods in regards to the development of chronic diseases like cardiovascular diseases, diabetes and obesity (Schuster et al., 2011). Because of the cultural relevance of traditional foods, many indigenous people see

the hunting and gathering of it as an important aspect of mental health and as a pathway to heal from colonial trauma (Selkirk First Nation, 2016).

Monitoring is particularly important to track and understand ecological changes. It is essential to ensure the long-term survival of species, natural systems, and the communities that depend on them. The Chipewyan Dene, or Denesoline have a long history of monitoring caribou populations to adapt to seasonal variability in caribou movement patterns. Herd of caribou occupy distinct ranges, but their distribution within these ranges, and travel pattern can vary dramatically from year to year. The Denesoline people, dependent on these caribou for survival employed a system of monitoring caribou at known water crossings to monitor and understand variations in temporal and spatial movement patterns. (Parlee et al., 2005) Marine birds in the arctic can be used as an indicator species. As a species that spends most of its time at sea but must visit the land in order to breed, often in large colonies, many individuals can be monitored at a single location. This “time on land” allows the monitoring and assessment of a mostly marine population. By studying these indicator species, broader research questions can be answered (Provencher, 2014).

In adapting to these changes, it is important for northerners to participate or oversee implementation of solutions. Self-governance is an important factor for indigenous groups in the sustainable management of their lands. Traditional knowledge has been used in the past to adapt to a changing environment. To continue to make this possible, the preservation of TK is an important factor. Part of adapting to climate change is to make it possible to continue land based and traditional activities. The cultural context needs to be considered in climate change policy. Mainstreaming measures from the South without considering the northern setting has been shown to be ineffective.

3.2.1 **Yukon**

The Yukon Territory is represented by a total of 59 records. The five most common topics, traditional practices with 26 hits, ecology with 17 hits, food security with 16 hits, and governance and hunting and harvesting with both 10 hits (see

Figure 3.2), are closely connected. Species such as caribou, moose, chinook salmon, lake trout, blueberry, salmonberry, blackberry, and low bush cranberry are important traditional food sources. The ecosystem is affected by changes in climate. Over the last 50 years, the annual temperature in the Yukon increased by 2°C and annual precipitation by 6%. Resulting permafrost thaw results in major alterations to ecology, as well as to the built environment. Concerns arise around the condition of the ecosystem and the resulting ability to maintain land based traditional activities such as hunting and harvesting. Reliance on these depends on the specific areas throughout the territory. The situation varies between communities in southern Yukon that are connected by highways, to the remote community of Old Crow, which is a fly in community. Remote communities were often able to maintain more of their traditional practices, and therefore tend to consume more traditional food. From a practical perspective, land-based food is more important in remote communities due to the higher costs of store foods. However, from a cultural perspective, the ability to consume land-based foods and exercise traditional practices matters throughout the Yukon. Governance and stewardship are the way forward in climate change adaptation. Specific actions include sustainable environmental management and the recording of traditional knowledge to increase food security, and the creation of hazard maps to prepare for the risk of permafrost thaw, flooding, and fire.

Traditional foods are important to Yukon First Nations for their nutritional and cultural value. Knowledge about hunting, fishing and gathering has been transferred from generation to generation. Ecosystems are affected by climate change induced glacier melt, drying up of streams and thawing of lake ice. Changing ecosystems affect traditional food sources such as game, fish, and plants (Kluane First Nation, 2014). First Nations communities throughout the Yukon rely on traditional foods and practices to varying degrees. Remote communities were able to maintain more of their traditional practices. As a result, the consumption of traditional foods is generally higher in these communities. Additionally, the high cost of groceries in

remote communities creates a higher need to rely on traditional foods (Schuster et al., 2011). “Market foods in Old Crow are two and a half to three times the price as in the Yukon capital of Whitehorse” (Schuster et al., 2011). The level of moderate food insecurity is 21% and severe food security is 11% in average across the Yukon (2001), and 33% for indigenous people off-reserve (Schuster et al., 2011).

Traditional food consumption is most dominant for the Vuntut Gwitchin and Teslin Tlingit First Nation. Popular foods in the Vuntut Gwitchin community of Old Crow are Caribou meat, blueberry, chinook (king, spring) salmon, salmonberry and low bush cranberry. Moose meat, lake trout, caribou meat, chinook salmon and blackberry are amongst the most commonly eaten traditional foods in Teslin (Schuster et al., 2011). With 48% food insecurity, Old Crow is comparable with communities in Nunavut with an average food insecurity of 56%. Adapting to food insecurity by supplementing traditional foods with market foods is more challenging in Old Crow than in Teslin. Teslin is connected through the Alaska Highway in Southern Yukon, while Old Crow is a fly in community in northern Yukon. This is reflected in transport costs and market prices of food.

The Selkirk First Nation stresses the importance of fish camps to their people. A decline of salmon at fish camps has been observed in Tutchone territory. The traditional knowledge of how to use a fish camp is very important to the Selkirk people. Even without fish, they can be used as teaching opportunities to keep traditions alive. The First Nation is pro-active about fish management and proposes to start its own fish hatcheries, clear creeks for spawning, build channels for the fish to pass through during low water levels, measure water quality, and create a salmon management plan (Selkirk First Nation, 2016). Limiting resource development in the area is seen as an important step to ensure appropriate water quality. The Selkirk First Nation is also looking to other local foods to increase their food security. The community started growing their own food in community gardens and greenhouses. Further it is suggested to extend harvesting to small game (Selkirk First Nation, 2016). Both strategies work around the issues of adapting by supplementing traditional foods with expensive market foods. It further increases the self-sufficiency of the communities.

An important adaptation strategy for First Nations is to safeguard the traditional knowledge carried by their elders. Today, an important way to capture this is the combination of traditional knowledge and Western science. The Tr’ondëk Hwëch’in interviewed elders about their knowledge of berries in permafrost areas. Science confirmed the nutritional values of berries, such as anthocyanins, vitamin C and antioxidants (Mackin, 2013). This knowledge is to be carried forward, and to be applied to the changing landscape. It is important to the First Nations to manage the environment in their territories appropriately to prepare for the changes ahead.

Increase of annual temperature in the Yukon by 2°C over the last 50 years, with winters experiencing most warming with an increase of 4°C. Annual Precipitation rose by 6% over the

past 50 years. The most significant rise in precipitation occurred in summer. Rising temperatures and changes in precipitation increase risk of permafrost thaw, mass wasting, flooding, and forest fires (Streiker, 2016). McCoy and Burn state that for the Dawson region, annual number of fires might double by 2069 driven by changes in temperature and precipitation (McCoy & Burn, 2005). Thawing permafrost greatly affects the infrastructure in the Yukon (Bonnaventure, Lewkowicz, Kremer, & Sawada, 2012). Further development in the North is foreseen. It is therefore important to understand the challenges of building in permafrost areas and know its distribution (Walsh & et al., 2009).

Hazard maps, which identify zones of risk are an important tool for planning ahead to cope with natural hazard occurrences. In the case of Old Crow, seismicity, mass wasting, flooding, and permafrost have been taken into account to create such maps (Benkert et al., 2016).

It is of significant value for the communities to be actively involved in the monitoring of environmental parameters. This enables communities to take stewardship in climate change adaptation.

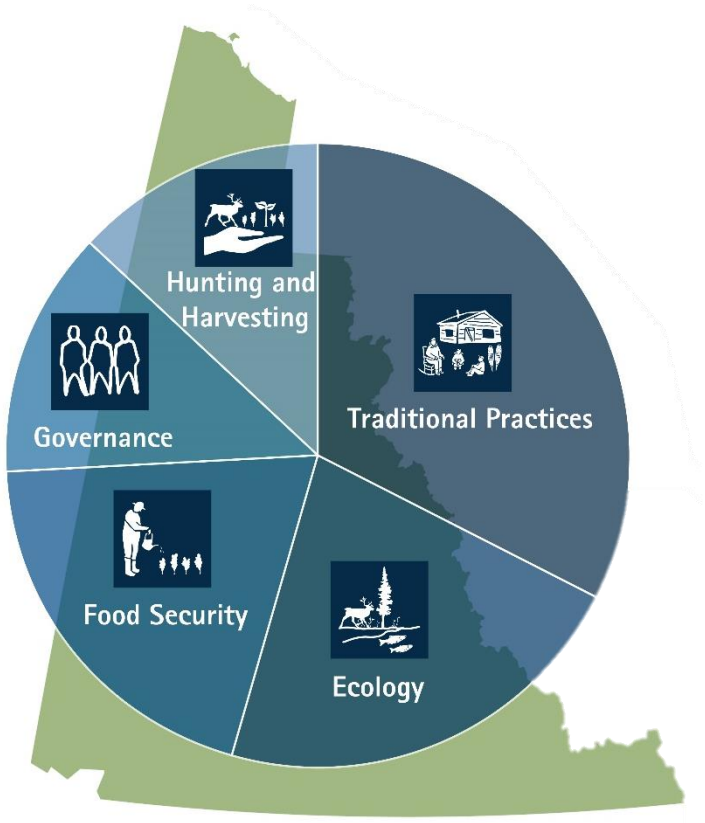

Figure 3.2 Top five themes in the Yukon Territory. The Yukon Territory is represented by a total of 59 records. The five most

common topics are traditional practices with 26 hits, ecology with 17 hits, food security with 16 hits, and governance and hunting and harvesting with both 10 hits.

3.2.2 **Northwest Territories**

In

Figure 3.3 the top detailed themes are shown, traditional practices and food security are the top detailed themes with governance, wildlife, policy, hunting and harvesting, and sea ice also appearing.

Traditional practices are one of the top climate change enablers, and a common theme as well. Indigenous people in the North believe that their traditional knowledge and skills are the best way to adapt to present and future climate change (Ecology North, 2017). To this end, many communities in NWT have prioritized the use, collection and transmission of traditional indigenous knowledge (Ecology North, 2017). Indigenous people of the North have a long history of association with their environment. Climate change not only threatens ecosystems, infrastructure and health, but culture and identity. Northern communities are looking to traditional methods of understanding and living with their environment to increase their resilience to climate change impacts (Ecology North, 2017). While these traditional practices are an important climate change adaptation enabler in NWT, there are many challenges associated with them.

Many communities identify a need to return to the land, yet social, economic and environmental conditions make accessing the land increasingly difficult and more communities are devoting resources and energy to re-enable access (Ecology North, 2017). In Inuit culture, learning and living were considered the same, yet in many cases the Inuit youth of today are educated in the Euro-Canadian education model, and have only experienced the lifestyle of contemporary Inuit who live in fixed settlements (Pearce et al., 2011). Transmission of traditional knowledge between elders and youth is complicated by a language barrier. In some cases, elders have not learned English, and youth are unable to speak the elder's language. This results in a breakdown of not only the transmission of traditional knowledge, but of the community itself (Parker, 2016).

For Indigenous youth in NWT commitments to school interrupt time spent on the land with elders and experienced harvesters which reduces the opportunity for them to learn traditional skills. Under equipped with land skills these youth may then seek to enter the wage economy, rather than live a more traditional lifestyle. As this trend continues over multiple generations, traditional knowledge becomes more dilute (Parker, 2016). Additionally, wage economy opportunities are limited, and youth must leave the community for post-secondary education, leaving them little opportunity to practice land skills. "The generations of Inuit who were born, grew up and went to school in communities have, for the most part, acquired neither a mastery of land skills nor the quality of education necessary to succeed in a Euro-centric world" (Pearce, Wright, et al., 2011).

Additionally, traditional knowledge as a climate change adaptation enabler is hampered by socio-economic factors, community members are unable to afford the equipment needed to engage in traditional practices (snowmobiles, gasoline, firearms, etc.) and are unable to practice the land skills they have managed to acquire despite time spent in school and language barriers, leaving youth frustrated and "stranded between the English and Inuit cultures" (Pearce, Wright, et al., 2011). To the Inuit in NWT, traditional knowledge or education does not consist only of hunting skills. It includes many other skills and abilities such as patience, observation, and control over emotional and physical reactions while under pressure, planning and strategy development, and how to face adversity. All of these are valuable skills for modern Inuit youth, who may also be experiencing or witnessing homelessness, dependence on social assistance, and poor health (Pearce et al., 2011).

The opportunity to practice traditional skills may be directly impacted by climate change induced environmental impacts. Sea ice and lake ice is thinner, less predictable, forming later and breaking up sooner, impeding the ability of people to travel safely. Weather changes like

increased fall precipitation cause newly frozen lakes and rivers to overflow, and further reduce ice predictability and safety (Parker, 2016; Guyot et al., 2006).

Food security is also a concern for communities in NWT. Migratory birds and animals are changing the timing, and routes of their movement patterns, which, compounded with the other difficulties associated with travel, make hunting success less predictable (Ecology North, 2017), (Guyot et al., 2006). In many communities, frozen storage is connected to food security, as the harvest of community members is limited by (cold) storage capacity. Since access to traditional food sources is seasonal, storage is a financial burden that some community members cannot bear. “Without a central cold storage facility in which to keep meat, harvesting is limited by how much freezer space a hunter has access to.” (Parker, 2016).

As the climate changes, the length of summer increases. Most harvesting activities take place during the summer months of May through September, coinciding with the time when there is the greatest need for storage (during the winter freezers are not needed) (Parker, 2016). This can increase the reliance of community members on expensive, often less nutritional, imported goods, or store foods. However, this reduces the self-reliance of a community who becomes more dependent on imported food with availability subject climate change induced environmental impacts and uncertainty (Parker, 2016). Low water on the MacKenzie River has disrupted traffic, and in some years community resupply barges were not able to reach communities forcing community members to purchase more expensive airlifted food. Additionally, thawing permafrost can damage highways and travel routes, and warmer winters mean shorter ice road seasons (Ecology North, 2017). Because of the high cost of store food many community members are unable to afford healthy foods such as fresh produce. Additionally, perishable products may be past their expiry date by the time they arrive in the community, or damaged further de-incentivizing the purchase of healthy foods (Parker, 2016). The purchase of store foods requires some participation in the wage economy. This is typically reserved for community members that have completed high school, who are community members who have spent less time learning the traditional skills that community members in the north depend on (Parker, 2016) weakening traditional land skills.
A food sharing network is a traditional system that northern communities use to improve food security. In a modern context a food sharing network can also reduce the burden of food storage; households with more freezer space will share what they are able to store with other community members, and community members with food to store will use the freezers of other community members (Parker, 2016). From Parker (2016) a community member stated, “I don’t get big portions of country food like the hunters do, like the main hunters. I just get a little portion that’ll maybe be good for a while and my mom has all the food so I don’t…maybe once

in a while I go to her house and get a little country food and bring it home but that's about it...She's got all the freezers."- Donna Akhiatak (Parker, 2016).

Food sharing networks are also used for equipment, parts and other resources. In many cases they are informal networks of community members, but are also formalized by the community. The costs of hunting are high, and the schedules of community members are often limited; in Ulukhaktok, NWT harvesters are hired by the local Hunters and Trappers Committee and the Ulukhaktok Community Corporation to hunt for the community, with elders and single mothers being a priority for food distribution (Parker, 2016). The Ulukhaktok Community Corporation also provides fuel subsidy for hunters and the Inuvialuit Regional Corporation has a hunter assistance program that will subsidize the cost of large equipment such as snowmobiles, boats, rifles, and fish nets (Parker, 2016). In some cases, the food sharing network can work to the detriment of more prepared community members. Households that had the forethought to purchase large quantities of staple food items when they were more affordable (i.e. when the barge was operating as opposed to purchasing food that arrived via airlift) are often treated as community stockpiles in the food sharing network (Parker, 2016).

In Northwest Territories, Community and Traditional Knowledge are the top enablers. Planning is the most common broad theme, with Human Health, Ecology and Social Issues also scoring in the top five. The top detailed themes are Traditional Practices, Food Security, Governance, Ecology, and Hunting and Harvesting. The most common barriers are Lack of Financial Resources, Inequity and communication challenges. Traditional knowledge and practices are considered to be crucial to adaptation in NWT communities. This is apparent both thematically and in the Enablers category. However, the utilization of Traditional Knowledge and practices as adaptation strategies is not straightforward. Socio-economic issues, and changing cultures make the practice and transfer of traditional knowledge challenging. Community members must balance learning traditional skills with time spent in a western style education. There are communication challenges between elders and youth. Travel, in order to practice traditional skills is more difficult, and requires resources such as fuel that may not be available to community members.

Figure 3.3: Top five themes in the Northwest Territories. With 71 total records, the Northwest Territories have the strongest representation among the territories. The top five topics on climate change adaptation are traditional practices with 40 hits, governance with 30 hits, food security with 26 hits, policy with 24 hits, and hunting and harvesting with 22 hits.

3.2.3 **Nunavut**

Out of 59 records speaking to climate change adaptation in Nunavut, traditional practices is the top theme with 27 hits, followed by food security with 19 hits, hunting and harvesting with 17 hits, governance with 16 hits, and sea ice with 14 hits (see Figure 3.4). In Nunavut, Traditional Knowledge and Community Support are the top climate change adaptation enablers, the Inuit believe that their traditional connection with the environment and associated cultural activities is integral to adaptation (Ford, Smit, & Wandel, 2006).

Traditional knowledge is transferred between generations of Inuit by experiencing time on the land and observing elders and experienced hunters. However, school, employment in the wage sector and limited financial resources restrict the amount of time available to spend on the land (Ford et al. 2006). Furthermore, as traditional knowledge and skills are lost, intergenerational

transfer of these skills is reduced between each generation, reducing the total institutional memory of these skills and knowledge (Ford et al. 2006). Inuit that practice traditional skills are generally physically and mentally healthier and more active than those that don't (Ford et al. 2014); to this end, projects that record, conserve and promote traditional knowledge are considered to be the foundation of Inuit climate change adaptation (Ford et al. 2006). Digital recording technology, web based knowledge repositories, film making and photography are being used in Nunavut to not only record and preserve traditional knowledge but as a way to maintain traditional languages (Ford et al. 2014).

The "erosion" (Ford et al. 2006) of traditional knowledge has implications for many facets of Inuit society. Historically, Inuit were able to adapt to a changing environment by being flexible about resource use, basing harvest strategies on what species were abundant at the time. As the transfer of traditional knowledge is reduced, or diluted and knowledge is lost, hunters become less flexible (Ford et al. 2006). In some cases skills and knowledge, such as a traditional navigation methods, have been all but lost, particularly among younger hunters. In other cases, knowledge transfer is incomplete and Inuit are not as well equipped to handle dangerous conditions, dress appropriately, prepare and identify hazards resulting in increased accidents (Ford et al. 2006; Ford et al. 2014). This increased risk may act as a barrier to spending time on the land, using traditional skills (Bunce, Ford, Harper, Edge, & IHACC Research Team, 2016). Technology, another top adaptation enabler, can to some degree offset a decline in traditional skills. However, GPS, radio, snow mobiles, powerboats, and access to Search and Rescue can also increase the risk taking behaviour of a hunter (Ford et al. 2006).

Many Inuit are travelling in conditions that would have been considered dangerous in the past (Ford et al. 2006). Limited time for harvesting traditional foods influences risk taking behaviours, as travel is constrained to particular times that may have to be organized in advance, forcing hunters to travel in substandard weather environmental conditions (Ford et al. 2006). Access to wildlife is becoming more challenging as its distribution and abundance changes in response to the climate, forcing community members to travel farther afield for food and again perhaps taking greater risks in order to obtain food (Dowsley, Gearheard, Johnson, & Inksetter, 2010).

Access to traditional food sources and practicing traditional skills are described by many community members as important, not only for food security but for their mental health (Bunce et al., 2016). In the past sewing was a traditional role of Inuit women, and their primary economic activity. Today Inuit women are the primary wage earner in home, leaving them little time to practice sewing (or other traditional skills) causing frustration and disappointment (Bunce et al., 2016).

Lack of Financial resources and inequity are top adaptation barriers identified in the database. These are effectively also barriers to traditional practices, driving a reduction in adaptation capacity. Access to resources such as boats, snow mobiles and ATVs determines a community member's ability to access the land, as much as time availability or risk (Government of Nunavut, 2012). The costs associated with purchasing and operating equipment must be balanced against other needs (Bunce et al., 2016). As the length of the open water season grows community members without access to boats are dependent on other community members to meet their harvest needs. This results in an economic stratification, which may be a source of conflict in the community (Ford et al., 2006) and impact the mental health of communities. This economic stratification, or inequity is apparent during the narwhal hunt in Nunavut. Historically, hunters waited for the narwhals to migrate close to communities to hunt them. However, hunters with access to snow mobiles, supplies, boats, GPS and other equipment travel long distances from the communities and harvest the quota of whales for the season (Ford et al. 2006).

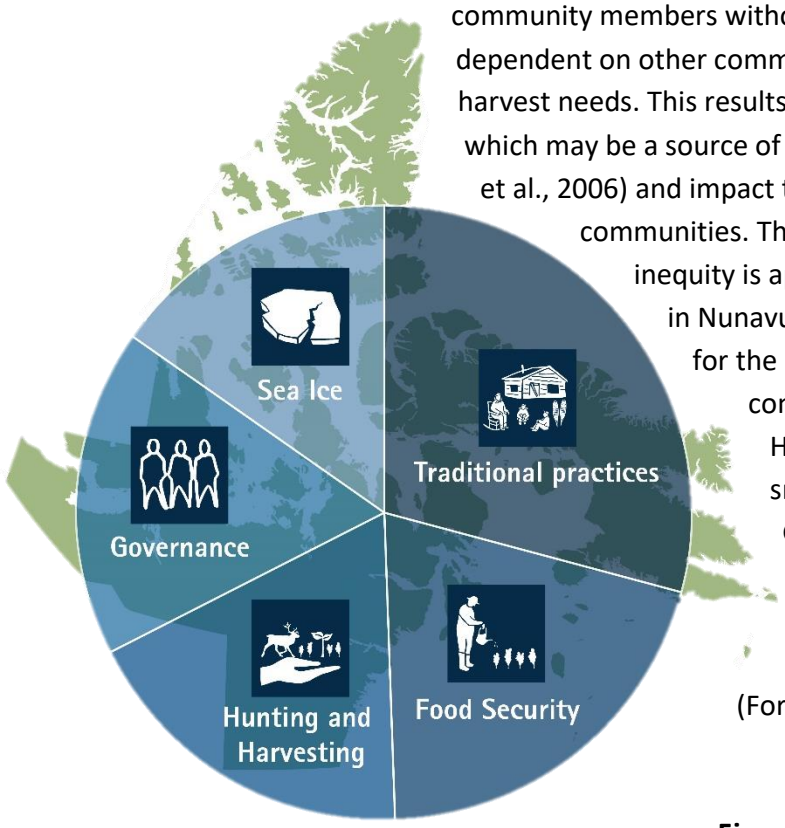

Figure 3.4: Top five themes in Nunavut. Out of 59 records speaking to climate change adaptation in Nunavut, traditional practices is the top theme with 27 hits, followed by food security with 19 hits, hunting and harvesting with 17 hits, governance with 16 hits, and sea ice with 14 hits.

3.2.4 **Ontario**

There are less records in the database that focus on northern Ontario, a total of 15. This was identified as a possible gap during record searches (see section 2.2.3.1). Despite updating search terms to target the northern regions of Ontario database records remain limited. This could indicate that climate change adaptation work is in fact taking place less often in northern Ontario, or work could be done but not be reported. It could also be a limitation of the record search methodology used in this project. Because of the limited number of records the impression of climate change adaptation in northern Ontario is not complete and more fragmented than in other regions. The general distribution of detailed themes is still similar compared with the territories. Ecology, foods security, hunting and harvesting, and traditional activities were all mentioned five times, while cumulative effects were mentioned four times (see figure Figure 3.5).

Community support and traditional knowledge are important climate change adaptation enablers in northern Ontario. The community of Weenusk has a mixed economy bolstering employment in the wage sector with traditional activities such as cutting wood, hunting, fishing and trapping. The unemployment rate of the community is 86%, so traditional activities are important to the well-being of the community (Lemelin et al., 2010). At least 70% of community members hunt and fish for subsistence purposes (Lemelin et al., 2010). However, changes in both the abundance and distribution of plant and animal species have led to reduced access to important traditional food sources (Hori, 2010) and ice conditions have changed, reducing access to traditional foods and increasing costs associated with access. Additionally, hunters are exposed to greater risk (Tam, Gough, Edwards, & J. S. Tsuji, 2013). The number of ice related search and rescue incidents in northern Ontario is increasing as the climate warms (Hori, 2010).

Winter roads allow for travel between some communities, making it possible for residents to travel despite snow and ice conditions not suitable for snow mobiles. It also allows for the purchase of store goods at lower cost. However, as the climate warms, the amount of time the road is navigable each year decreases (Tam et al., 2013). Ice formation is changing. There is less “blue ice”, ice that forms before it becomes snow covered. This ice is stronger, enabling safer winter travel earlier in the season. The reduction in “blue ice” impacts both traditional activities, and the formation of winter roads (Golden et al., 2015). Reduced ability to travel winter roads has large impacts on the price and availability of store foods, fuel, large goods, and equipment. Many of the items carried on winter roads are important for community members to maintain traditional life styles, already hampered by lack of “blue ice” (Golden et al., 2015).

However, for many residents store bought food is an imperfect solution and can leave community members frustrated and discouraged. Healthy foods are not available, prohibitively expensive, or expired and are felt to be a poor substitute for traditional land based foods (Tam et al., 2013). In order to improve access to nutritious store bought food, a fresh food not for profit organization in Fort Albany flies fresh produce and meant into the community on a regular basis for residents to purchase at reduced cost (Skinner et al., 2014). Community members in believe traditional practices are integral to not only the food security of people in Fort Albany but to their cultural identity (Tam et al., 2013), yet this is the last generation of elders to have lived a large portion of their lives in the traditional way and still hold traditional languages and skills (Lemelin et al., 2010) making traditional knowledge transfer difficult.

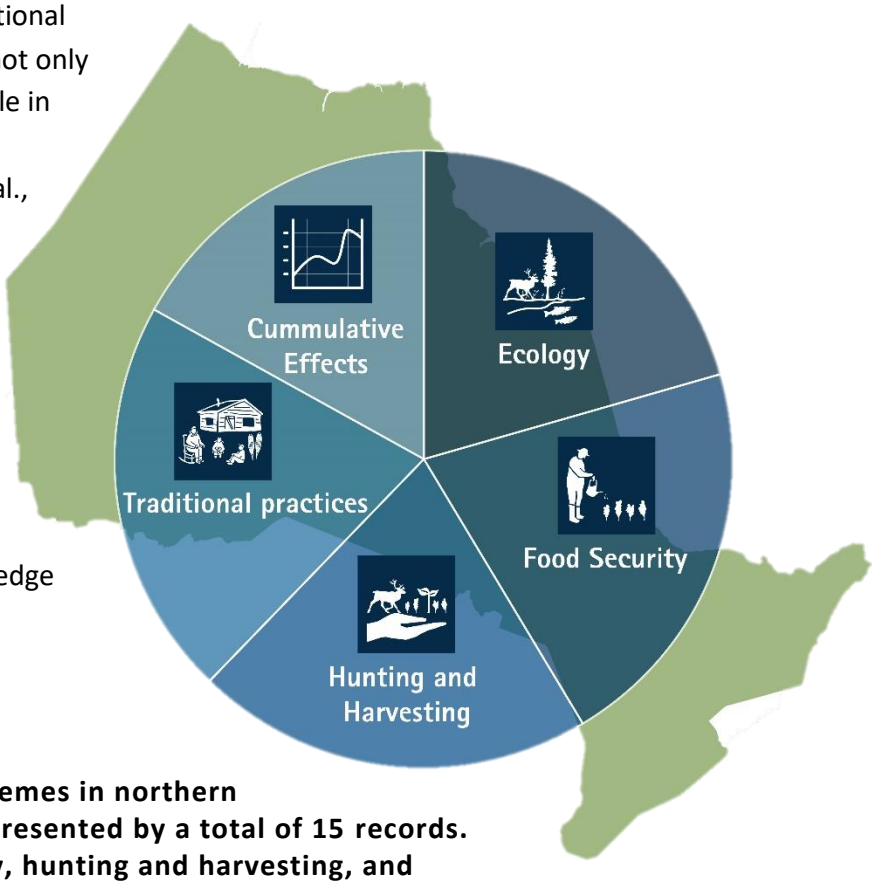

Figure 3.5 Tope five themes in northern Ontario. Ontario is represented by a total of 15 records. Ecology, foods security, hunting and harvesting, and traditional activities were all mentioned five times, while cumulative effects were mentioned four times

3.2.5 Northern Québec

Northern Québec is represented by a total of 15 records, with the top five themes being food security and hunting and harvesting with 7 hits each, traditional practices with 6 hits, and sea ice and wildlife 3 hits each (see Figure 3.6). Between 1960 and 2005, mean temperature in Québec rose by 0.2 to 0.4°C. While overall precipitation increased, snow decreased due to shortened winters. These trends are predicted to continue (Herrmann, Royer, & Cuciurean, 2012). By 2050, winter temperatures are projected to rise by 1.6°C to 2.8°C in northern Québec.

Precipitation is expected to increase by 16.8% to 29.4% by 2050 (Government of Quebec, 2012). These changes lead to permafrost thaw and changes in species distribution (Furgal & Tremblay, 2008). On the coast line of Québec, permafrost degradation leads to erosion and formation of new wetlands. Slumping, erosion and landslides present challenges to existing infrastructure (Government of Quebec, 2012). Permafrost degradation further results in changes in the ecosystem, affecting animals and plants traditionally hunted and gathered (Allard & Beaulieu, 2003). Nunavik and northern Québec contain important trail networks which connect communities and serve to support traditional practices such as hunting, fishing and trapping (Furgal & Tremblay, 2008). Thinning of sea ice due to climate change affects the safety of people travelling on it (Herrmann et al., 2012). While indigenous people have used traditional knowledge to adapt to changing climatic conditions, the intensity of current changes present challenges to this system (Furgal & Tremblay, 2008). Reduced opportunities for save travel make it difficult for indigenous people to visit other communities, access the land, and hunt (Lewis, 2011).

Hunters traveling out on the land can be an important source of information regarding environmental change. A variety of studies have tapped into local knowledge to understand change in data scarce areas (Cuerrier, Brunet, Gérin-Lajoie, Downing, & Lévesque, 2015; Furgal & Tremblay, 2008; Herrmann et al., 2012). Locals observed an increase in the quantity and size of shrubs, in particular willows. The shrubification impacts travel. Berries are of high cultural and nutritional value to indigenous people. Their growth and quality have also been observed to be impacted by climate change. Hunters observed a decline in caribou health. This may be related to an increase in mosquitos and parasites caused by warming (Cuerrier, Brunet, Gérin-Lajoie, Downing, & Lévesque, 2015). Changes were perceived for climatic conditions such as wind direction and ice thickness (Herrmann et al., 2012). Increases in wind speed and resulting lower snow depths, as well as stability of ice affect winter travel (Cuerrier, Brunet, Gérin-Lajoie, Downing, & Lévesque, 2015).

Herrmann et al. studied the use of community-based environmental monitoring (CBEM) initiatives, where local knowledge and observations are systematically recorded. Observation from Cree hunters on species distribution, population size change, environmental conditions, animal behavior and migration patterns were collected. The information can help to inform resource management and decision making. Knowledge captured through Cree hunters can provide important information where scientific monitoring data is missing. However, it is important not to directly compare or integrate local observations into scientific knowledge systems (Herrmann et al., 2012).
Some of the observations made include an increase of species migrating from the South, diminishing woodland caribou populations, polar bears travelling closer to villages, change in

flight path of Canada Geese and pioneer species such as the pelican and the white-tailed deer. The abundance of certain species is an important part of the food security of hunters in northern Québec. Hunters start to adapt their hunting strategies to different species, to accommodate for the change (Herrmann et al., 2012). A different strategy was used by the community of Quaqtaq. The community conducted an experiment using small scale hydroponic rotating gardens. First tests involved growing of lettuce. Further testing with other greens is planned (Deer, 2015).

Figure 3.6 Top five themes in northern Québec. Northern Québec is represented by a total of 15 records, with the top five themes being food security and hunting and harvesting with 7 hits each, traditional practices with 6 hits, and sea ice and wildlife 3 hits each.

3.2.6 Newfoundland and Labrador

Many of the records in the database describe projects that took place in Nain and Rigolet, Inuit communities on the coast of Labrador, within the Nunatsiavut region. In this region, traditional practices with 12 hits, mental health with ten hits, health and temperature with seven hits, and food security and sea ice with six hits each are important topics (see

Figure 3.7). The records in the database describe how, for the people of Labrador, traditional practices and skills are linked strongly to mental and physical health and well-being of community members. Traditional practices like hunting, fishing, trapping, foraging and living on the land are important to their culture, identity, and spirituality (Willox et al., 2013).

However, traditional practices are highly dependent on snow and ice cover for large portions of the year (Willox et al., 2013). Climate change is reducing the time period and amount of snow cover, reducing the ability of the people of Labrador the access the land. Rapid weather changes and unpredictable environmental variation can hinder land based activities like hunting, fishing, foraging, trapping and traveling to field camps (Cunsolo et al., 2012). Food and water security are issues faced by many households and communities in Labrador. Changes to wildlife patterns and abundance can reduce community member's food security if they are unable to obtain enough country food. This is compounded by less predictable weather and increased travel risks, especially sea ice conditions (Cunsolo et al., 2012). Limited access to food storage, typically freezers, can impact food security. Community members rely on predictable temperatures, and permanently frozen ground to store food. As temperatures increase, foods

may spoil, and traditional storage and preservation techniques may not be adequate. Another concern is that food arriving on barges may spoil prior to arrival if the barge is delayed (Harper et al., 2015). Due to a reduction in the availability of reliable water sources, residents may need to purchase water prior to travelling, increasing the financial burden of obtaining food. Because of escalating costs of hunting and traveling, community members feel pressured to have a successful harvest, which may increase the risks they take (Goldhar, Bell, & Wolf, 2014). A reduction in the availability of reliable water sources means some residents may need to purchase water prior to travelling, increasing the financial burden of obtaining food. In households without indoor plumbing water is gathered from land, however households without access to a vehicle, or with physical health issues can have trouble gathering enough water (Goldhar et al., 2013).

Powerful emotional response to inability to spend time on the land, and engage in traditional activities potentially leads to more stress at home; increases in drug and alcohol use; increase in suicidal tendencies; and compounding of previous mental health issues (Willox et al., 2013). Access to the land, mental health and traditional practices are intertwined with one each other; combined they can either bolster adaptive capacity or leave community members trapped and frustrated. Lack of country foods may link to increased diabetes, obesity and an overall reduction in health as community members may not be able to afford nutritious store bought food, or may choose unhealthy food over healthy food (Cunsolo et al., 2012; Harper et al., 2015).

Another important adaptation enabler is community support. The community, if healthy, can offer a support network, provide role models for youth, create a feeling of inclusion, and a sense of security. These are important for community members facing mental health challenges (MacDonald et al., 2015). In Nain, the community freezer program not only provides food for the community, it pairs hunters and experienced harvesters with community youth to teach them land based skills and community building skills such as building and maintaining equipment, building structures, preparing community dinners, preserving food, and distributing food. The food distribution component of this program has become a crucial link between youth and elders in the community, and also important for providing food to community members unable to access the freeze (Hirsch et al., 2016). Individuals with pre-existing mental illnesses/issues, other pervading social issues (colonialism, inequity, etc.), dependent on the environment for food, or living in regions with vulnerable to climate change are most likely to experience mental health impacts associated with climate change (Willox et al., 2013). Access to the land also impacts the mental health of workers in the health care field in Labrador communities. They suffer from many of the mental health related and access to land impacts of climate change the community does. This affects their ability to offer care to other community

members, particularly as climate change induced health impacts on the community increases their workload (Willox et al., 2013). Weather conditions can also hamper health care delivery. Unpredictable weather, increased rain and fog, can make travel difficult and risky making access to health care facilities difficult. Community members may have to travel by aircraft for advanced or emergency care, or health care providers may travel between communities via aircraft which are subject to weather concerns. Aircrafts are expensive to operate and delays and inability to plan can cause budget overruns reducing the quality of care available (Harper et al., 2015).

In essence, traditional practices and access to the land are important to the mental and physical health of community members in Labrador and are also important adaptation enablers. Yet direct and indirect climate change impacts make it difficult for community members to exercise these enablers. Additionally there is some concern that as the land changes traditional knowledge may become less relevant (Harper et al., 2015). Access to the land is also important for TK transfer to younger generations to occur. Finally, Housing is an issue for many community members. Housing is lacking in both quantity and quality resulting in overcrowding, and community members living in sub-standard conditions. As temperatures warm and precipitation increases, mold is becoming an issue. Community members are also concerned about instability and damage to buildings as permafrost melts and building may shift (Harper et al., 2015).

Figure 3.7 Tope five themes in Newfoundland and Labrador. Out of 24 records, 12 talked about traditional practices, ten about mental health, seven about health and temperature, and six about each food security and sea ice.

3.3 PROJECT TYPE

Documents about climate change adaptation started popping up in 1991. Figure 3.8 shows the number of publications for each year between 1991 and 2018. Depending on the document type, there are varying delays in the execution of a project and the publication of a document. In particular journal articles, which go through the peer-review process, show time lags. Each bar is divided into the four project type categories distributes information, studies issues, suggests solution, and applies solution. The studying of issues and distributing of information receives the most attention in the literature. In total 234 of 347 records are classified as distributing information, and 147 as studying issues. Climate change adaptation is a matter that is based on action. It is therefore surprising that the suggestion of solutions with a total of 82 records, and above all the application of solutions with 48 records are on the lower end. While the application of solutions rose

in 2009, it hasn't increased much since. For adaptation to happen, specific actions need to be implemented and the trend of applying solutions must go up.

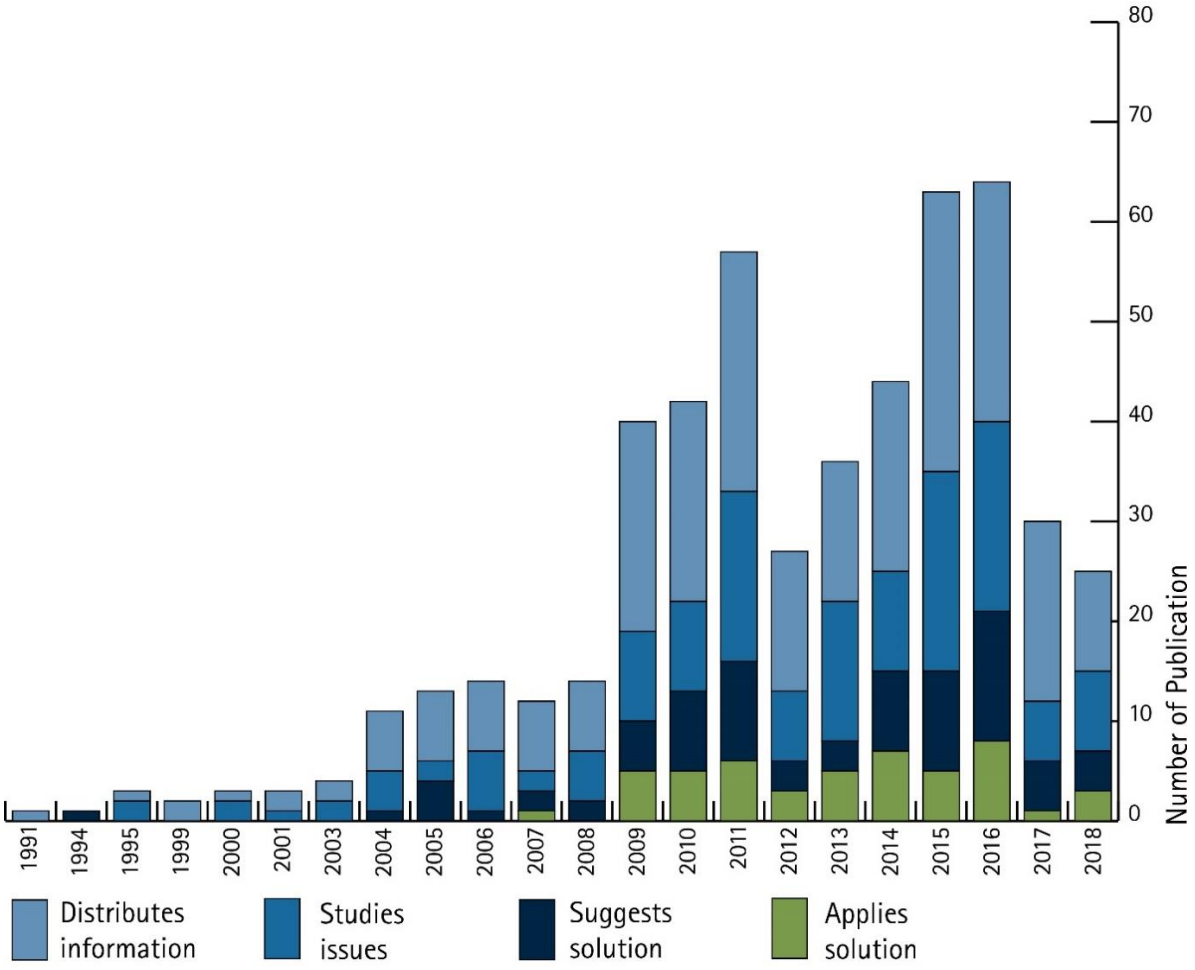

Figure 3.8 Number of publications per year. Each year is divided in four categories for the project type: distributes information, studies issues, suggests solution, and applies solution. These categories are represented in percentages per year.

3.4 ENABLERS AND BARRIERS TO CLIMATE CHANGE ADAPTATION

Enablers and barriers to climate change adaptation have been categories during data entry. We divided enablers into a total of 19 categories, and barriers into a total of 22 categories. Figure 3.9 shows the top ten enablers and barriers. The size of the symbol reflects their representation in the data base. **Error! Reference source not found.** shows the concrete numbers reflected in the graphic. The following sections talk in more detail about the most common enablers and barriers.

Figure 3.9 Top ten climate change adaptation enablers (blue) and barriers (red).

Barrier	Count	%	Enabler	Count	%
Lack of financial resources	58	10	Traditional knowledge	148	17
Inequity	52	9	Community support	131	15
Mainstreaming	46	8	Technology	82	9
Communication challenges	46	8	Raising of awareness	73	8
Lack of baseline data	39	6	Collaboration	62	7
Lack of awareness	36	6	Information sharing	59	7
Lack of knowledge	34	6	Education	55	6
Climate change sceptism	34	6	Shared responsibility	49	6
Lack of long-term adaptations	33	5	Flexibility of resource use	43	5
Lack of clear and consistent policy guidelines	31	5	Training	38	4
Conflicts of interest	26	4	Interdisciplinary approaches	36	4
Legislation issues	23	4	Effective institutional support	23	3
Inaction by the government	21	3	Connections and networks	22	3
Lack of expertise	21	3	Economic resources	18	2

Lack of time	17	3	**Inclusion of vulnerable groups**	17	2
Lack of personnel	17	3	**Mainstreaming**	12	1
Lack of community involvment	16	3	**Equity**	5	1
Inaction by organisations	16	3	**Transboundary organization**	2	0
Lack of trust	13	2			
Lack of local autonomy	12	2			
Inconsistent reporting	8	1			
Lack of qualitative information	7	1			

Table 3-1 Representation of climate change adaptation barriers and enablers in total and percent. The top ten are marked in grey.

3.4.1 Enablers

Traditional knowledge and community support were the top climate change adaptation enablers in the database. The importance and prevalence of traditional skills and practices, and community-based adaptation measures was observed throughout data entry and analysis. Traditional knowledge and practices have relevance to many aspects of adaptation. As a repository of intergenerational environmental understanding, TK gives people the ability to travel safely on the land, predict weather and travel conditions, and hunt and gather food as climate change modifies environmental conditions. It teaches flexible hunting and harvesting strategies, and knowledge of alternate prey species and travel routes giving hunters the ability to adapt hunting and travel strategies to a changing environment. However, TK provides not only hunting and travel skills, it also teaches patience, forethought, resilience and other abilities that are important for navigating the changing socio-economic and cultural landscapes of the north. Finally, it gives people cultural resilience, pride a history of connection and a sense of belonging despite environmental and social upheavals.

TK is often connected to community support. Many aspects of TK and traditional culture encourage community support. Throughout the north traditional food sharing networks support community members who are unable to hunt/harvest on their own or allow community members with surplus food to avoid wasting it. Freezers are a modern take on food sharing and incorporated into food sharing networks. In some cases, freezers are purchased for the community, in other cases community members with freezer spaces store food that is then available to the community a needed. Food sharing networks commonly only encompass traditional foods, or country foods, however they are growing to include store purchased staples in some communities. Community built and operated greenhouses are being tried out

in some northern communities in another community-based approach to improve access to food.

While in many cases TK and community support are identified as primary enablers in communities, technology helps to support these practices. Changing weather, environmental and ice conditions lead to more challenges accessing the land in order to carry out traditional activities. Time constraints, unpredictable weather, and other environmental conditions mean that people on the land may experience more risks than traditionally experienced. Technology can be used to offset risks experienced. Many communities have installed remote weather and ice monitoring stations. The data from these instruments is publicly available, allowing community members to plan travel routes in advance. More and more people are carrying GPS, and VHF radios when travelling and hunting, augmenting traditional navigation methods and enabling communication with other land users and perhaps the community. Another use of GPS is when hunting on sea ice, typically shore ice connected to the land, hunters can use GPS to determine if the ice they are on has separated from the mainland before they travel too far out to the ocean. Snowmobiles, ATVs, and powerboats are common tools used in northern communities. They are so crucial to hunting and harvesting and therefore food security that in many communities, gas and equipment purchases are subsidized by the community itself. This enables hunters and harvesters to find food, which is then shared via the community food sharing network.

Other top climate change adaptation enablers involve collecting, sharing and preserving information. Many communities are using novel media such as photo and video to share and preserve TK. There is a strong push to include TK in western science style projects in the north, to augment limited baseline and historical data. Information collected and preserved by northern communities is often not published in a traditional academic sense. As these communities are already seeing many climate change impacts, they are the fore front of practical, applied adaptation. In order to preserve and share their experiences, they are turning to the internet using wikis, blogs and other web-based technologies as knowledge repositories.

Training and education are other top enablers identified in the database. Remote northern communities tend to exist in a mixed economy, supplementing traditional foods with store purchased foods. This mixed economy requires cash inputs in order to support on the land activities and store purchases. By embracing adaptation measures that improve local opportunities to earn wages and improve the employability of community members, communities can improve their capacity for adaptation, while also maintaining a traditional lifestyle and culture. Training can also improve the adaptive capacity of communities by

improving local environmental monitoring capability, augmenting traditional skills, and opening new pathways for knowledge and experience transfer.

3.4.2 **Barriers**

The top two climate change adaptation barriers, lack of financial resources and inequity both deal with lack of resources needed for effective adaptation, or act to reduce the effectiveness of adaptation enablers. Many communities are dependent on access to the land for both the physical and mental health of community members. Since the land also provides a large portion of nutrition, lack of financial resources can hinder food security. Money is needed for fuel and ammunition, and lack of access to the land can have ramifications that resonate throughout a community and culture. Additionally, work in the wage economy to provide income for fuel forces community members to spend less time on the land carrying out traditional activities, reducing food security and connection to both their environment and culture. In many communities, store foods must be transported via aircraft or barge, and are expensive. Lack of financial resources affects community member's ability to make healthy food choices when purchasing store food. This can be compounded by inequity. Many community members only have access to at most a high school education without leaving the community. Many community members have limited budgeting skills. Effective adaptation is challenging. It is even more challenging when faced with inadequate food security, limited access to fresh water, poor housing, and a legacy of colonial impacts. Northern communities have high unemployment rates, low incomes and low education rates when compared with southern communities. Access to the land, and traditional practices are regarded as important adaptation measures, yet are limited by financial resources. Wage based jobs provide the resources to spend time on the land but may also act as a barrier taking away time available to be spent on the land.

Communication is another barrier. The loss of traditional languages, particularly in younger generations hampers effective transfer of TK between generations as may not be able to not speak English. Western science has a long history of reducing the value of TK based observations, hindering the ability of community to have a voice when discussing climate change, or other research even if that research is happening within the community. Adaptation information published in academic databases is often not available to the public and communities. Communities are moving to publish and share information via other mediums such as film and websites, however these resources are difficult to find and require access to a computer, and the internet which may or may not be available to communities. These non-academic sources are often considered less valuable than academic sources. Further, communication between researchers or adaptation planners and locals is crucial in

understanding which adaptation strategies will work and which won't. For example, residents of Pangnirtung are prone to aquatic risks. Researchers investigated why only a small number of people were using PFDs, which would increase safety while out on the water drastically. Apart from a lack of money to purchase PFDs, interviews showed that there are a number of cultural reasons why residents were not wearing them. PFDs are seen as a Euro-Canadian product. A lot of Inuit people don't identify with the product, think it looks stupid, inhibits movement, and doesn't fit their body types (Giles, Strachan, Doucette, & Stadig, 2013). Once effective communication allows for the identification of such issues, measures can be taken to make sure adaptation fits within the cultural context.

The North is changing rapidly, often much faster than other regions of Canada. Communities in the North are already facing and adapting to a changing climate, often ahead of research and understanding. This is complicated by limited or lack of baseline data. Some communities are even finding that their TK is losing relevancy in the face of rapid environmental change.

Adaptation actions are often linked to the availability of funding. However, this funding is often tied to political cycles or time limits, limiting the availability or effectiveness of funding. Lack of financial resources and inequity mean that infrastructure that is already in poor conditions, may be exposed to environmental changes, like permafrost melting, sea ice and coastline erosion that is not well understood.

Northern regions and communities are unique with strong connections to traditional life styles, and the environment, however they also experience a variety of stressors that make adaptation challenging. They are very remote with limited access, supplies and store food arrives via aircraft or barge. They have a history of colonialism, residential schools, and inequity that has left a legacy of mental health and social issues, and they utilize a form of mixed economy to sustain themselves. Climate change is an additional stressor, when their ability to adapt is already hampered. These factors, and many others mean that mainstreaming, or applying climate change adaptation methods and ideas from different regions are poor adaptation strategies for these communities. What works in the South may not work in the North. National and regional policy needs to include northern specific items. Southern Ontario and Quebec are densely populated and relatively rich when compared to their northern regions. Planning and policy often target southern regions, because they represent the largest portion of the population. These plans and policies can be of little relevance to the North, which faces dramatically different concerns.

3.5 NORTHERN CLIMATE KNOWLEDGE BROKERING PLATFORMS

3.5.1 **Limitations**

One of the primary limitations of climate knowledge brokering platforms is that they are largely supply driven. This means the platforms are built, operated and managed by the producers of climate change information to better support evidence-based policy and program decision making (Hammill et al., 2013). Since climate information producers are deciding on research topics and how their research is shared, supply-driven knowledge brokering can result in platforms that are organized for scientific experts with ineffective engagement and limited relevance for intended users (Hering, 2015; Swart et al., 2017). Though the intent is to connect to the end-users of climate information, often it is unclear who exactly these end-users are Therefore, their needs, priorities, and preferences are undefined (Hammill et al., 2013). Without a clear understanding of the users of climate knowledge brokering platforms it is difficult to address usability and gaps in knowledge, which can lead to duplication and inefficient use of resources (Hammill et al., 2013; Swart et al., 2017).

Access to internet, continued difficulties in translating climate knowledge into action, as well as, the specific context of many climate change adaptation responses are also limitations of climate knowledge brokering platforms (Hammill et al., 2013). For example, in 2015, the Canadian Radio and Television Commission found that 18% of Canadians do not have access to minimally sufficient internet speeds (controversially defined as 50/10 Mbps) and the majority lived in rural and remote locations, including northern Canada (Ruimy, 2018). It is estimated that closing the digital divide in Canada would cost over 7 billion dollars (Ruimy, 2018). In addition, examples of climate change adaptations are often very specific to a geophysical, cultural, and political context. This means that there are a wide variety of environmental, socio-economic, and political factors that could limit the transferability of a successful climate change adaptation from one location and context to a new one. Furthermore, climate knowledge brokering platforms experience practical issues, such as, project based funding that can restrict growth, maintenance, accessibility, design, monitoring and evaluation (Karali & Mattern, 2017). The project based nature of climate knowledge brokering platforms has also led to “portal proliferation”, which refers to the continual creation of new climate knowledge brokering platforms. This means an increasing number of climate knowledge brokering platforms are operating in isolation, duplicating efforts and inefficiently utilizing funding (Barnard, 2011). In addition, portal proliferation can overwhelm and discourage knowledge seekers, who may have to rely on multiple platforms to access all the information and tools they need (VanderMolen, Wall, & Daudert, 2019).

3.5.2 **Strengths**

Climate knowledge brokering platforms have been acknowledged as having the potential to enable and empower climate change adaptation by efficiently and effectively communicating accurate, comprehensive, and relevant climate change information (Karali & Mattern, 2017). These platforms have a much broader reach and require less development, maintenance and funding than traditional face-to-face methods of information brokering (Swart et al., 2017). Climate knowledge brokering platforms do more than enable access to relevant climate change information for decision makers and end users. Instead, the platforms attempt to create opportunities for end users to collaborate in the production of climate change knowledge since the creation of usable climate change information requires a "shared vision of what knowledge is usable" (Dilling & Lemos, 2011, p.681).

This collaboration is important because knowledge that is co-produced is more likely to fit user needs and to understand specific decision contexts (Dilling & Lemos, 2011). Co-producing climate change information also helps build community relationships and social capital which can be key to combatting distrust, misunderstanding and perceived irrelevance (Dilling & Lemos, 2011). For example, a study that interviewed the users of the climate change adaptation knowledge brokering platform AfricaAdapt found that users "associated trustworthiness with authenticity and information that 'matched' the realities they had witnessed on the ground as practitioners rather than its peer review or other approval from outside bodies" (Hammill et al., 2013, p.86). This quote further emphasizes the importance of localized information and the reoccurring theme 'For Africa, by African' reverberates with 'in the north, for the north, by the north'.

3.5.3 **Best Practices**

This section complies all reviewed literature on climate knowledge brokering to identify best practices, including practices to mitigate some of the limitations previously mentioned.

3.5.3.1 Understanding users

In order for climate knowledge brokering platforms to increase the usability of climate change data and information, it is important to understand who the potential and actual end-users of climate information are, in addition to their priorities and preferences (Hammill et al., 2013). Understanding user needs is necessary to enable the effective use of climate change information in decision-making and will enable the transition from a supply-driven to a demand-driven approach (Lourenco, Swart, Goosen, & Street, 2016). In addition, a better understanding

of user behavior will help improve site organization, structure and design, the identification and presentation of relevant information.

3.5.3.2 Building Relationships

Not only should climate knowledge brokering platforms know their users, but they should also strive to build relationships between climate knowledge producers and climate knowledge users to enable the usability of science through co-production (Swart et al., 2017). Usable scientific data was relevant, used appropriate spatial and temporal scales, and considered local decision frameworks (VanderMolen et al., 2019). Relationships to co-produce knowledge allows user communities to better situate scientific research in local conditions, and as previously discussed the lack of localized climate change information has been identified as a barrier to climate change adaptation in northern Canada (Northwest Territories et al., 2012; Swart et al., 2017). Furthermore, building relationships between climate change information producers and end users improves climate literacy and builds community capacity for climate change adaptation (Swart et al., 2017). In building relationships between climate knowledge producers and end users, end-users indicated 'offline' opportunities to connect were also greatly valued (Hammill et al., 2013).

3.5.3.3 Organization

Producing specific and localized climate change information may increase usability, however, it is also labor and resource intensive. To avoid duplicating efforts and to maximize funding, greater links between climate knowledge brokering platforms should be established to benefit from increasing 'portal proliferation'. Clear pathways from broad to specific climate change knowledge platforms will increase user navigability and provide regional and local climate information producers with a greater audience. The end users of climate data also emphasized the importance of learning supports within climate knowledge brokering platforms, including tutorials, hovers, and pop-ups to clarify terms, technical information, and acronyms (VanderMolen et al., 2019).

3.5.4 Climate Knowledge Brokering Platforms in Northern Canada

3.5.4.1 Platforms

There are multiple platforms that provide climate information about northern Canada. Territorial specific ones include the NWT Discovery Portal and the Nunavut Climate Change

Centre. Regional ones include the Pan-Territorial Adaptation Partnership, Climate Telling, and the Northern Contaminants Program. There are also national ones, including the Canadian Cyrospheric Information Network and the Canadian Centre for Climate Services. In addition to this, there are a couple of pan-Arctic platforms, like Polar Data Catalogue, the Arctic Portal and the Arctic Eider Society. The following section includes short descriptions of platforms relevant to northern Canada.

Canadian Centre for Climate Services

The Canadian Centre for Climate Services was launched in the fall of 2018 by the Canadian federal government. The site provides access to uninterpreted climate data in the form of downloadable datasets, but also hosts a library of climate resources. The library is extremely user friendly and allows users to filter by a wide variety of options including sector, region, hazard, and format, which includes options such as adaptation planning, case study, or educational awareness. The site also prominently features its Climate Service Support Desk which offers users assistance finding, interpreting and using climate data, as well as, a chance to offer suggestions and feedback.

Nunavut Climate Change Centre

The Nunavut Climate Change Centre (NC3) provides current climate change information relevant to Nunavummiut. One of the goals of the NC3 is to raise awareness of climate change impacts on Nunavut. This influences the website design to appeal to a general audience and attract the layperson, as well as the researcher. An overview of projects is provided of the projects taking place in Nunavut. The site is visually appealing, and the quick blurbs throughout the page banners in each page offer valuable insights in to the ideas being presented by the people of the region. There is also an interactive quiz “Tukisigiaqta” that provides information on how to prepare for climate change impacts around your home and on the land. This is visually appealing, and a fun way to attract a younger audience as well as those who may be searching for more formal documents and papers.

NWT Discovery Portal

The NWT Discovery Portal collects environmental monitoring knowledge across the Northwest Territories and enable users to access and share data, metadata, and reports. The Browse heading provides users with a starting point by displaying popular subject areas and keywords, and allows users to filter information by format, including categories like article, data, map, or graphic. The site includes qualitative information, quantitative information, traditional knowledge, baseline studies, regulatory, land-use planning and environmental assessment impacts. Though the site design is a little outdated, it is easily navigable.

UN Adaptation Knowledge Portal

The Adaptation Knowledge Portal was launched by the United Nations Framework Convention on Climate Change. The site supports the Framework Convention on Climate Change by providing access to adaptation knowledge resources including, case studies, methods, tools, publications, and technical documents. The site is well organized and visually appealing, however, certain headings overlap and it can be difficult for users to navigate if they are unfamiliar with the Framework Convention on Climate Change.

Climate Telling

Climate Telling offers a platform for northern Canadian Indigenous communities to promote resources, tools and case studies of adaptations to climate change impacts. The site is unique in that it focuses primarily on examples of implemented climate change adaptation projects, which can be difficult to find. The site has a few design issues, such as spacing between graphics and text, which are distracting to users. The site does not have any search or filter features; therefore, it can be time intensive for users to find specific resources.

Pan Territorial Adaptation Partnership

As the name suggests, the Pan Territorial Adaptation Partnership aims to connect climate change adaptation resources across all three Canadian territories. The site does not appear to be updated regularly, as the latest information comes from 2015. In addition, the site seems to focus on the activities and news from the Pan-Territorial Partnership, rather than providing access to climate change adaptation information.

Adaptation Library

The Adaptation Library is a database of community, forestry, and energy related adaptation products. The publications housed are easily accessible. The website is neatly organized into regions and is easily navigable. The design of the website and how the information is provided offers an overall guiding feel. This would appeal to many visitors, especially those who may not be as familiar with the topic content. This is optimal for the goal of the website, which is to connect community and industry users with relevant information related to climate change adaptation in Canada and abroad.

Canadian Cryospheric Information Network

The Canadian Cryospheric Information Network and the Polar Data Catalogue were developed by the University of Waterloo and other government, university, and private organizations. The Canadian Cryospheric Information Network is linked from the Polar Data Catalogue and contains data and information about the Arctic and Antarctic regions. The website design is effectively laid out, and has up-to-date information. Widgets along the side of the webpage provide quick

updates and social media connections, making the website feel more interactive and current. The publications for the site are easily accessible; however, the layout of the overview for the site publications is an image of the first page of the article. This makes it difficult to read what the title of the paper is, without opening the document after downloading.

Arctic Portal

The Arctic Portal functions as a directory for diverse topics of concern for the Arctic regions. These are organized in a menu consisting of broad topic headings such as: agriculture, atmosphere, biological classification, biosphere, climate indicators, cryosphere, human dimensions, land surface, oceans, paleoclimate, solid earth, spectral/engineering, sun-earth interactions, and terrestrial hydrosphere. This is an effective organization; however, there is a lot of whitespace on the page, the layout can be optimized to better fill up the large empty space. The hierarchy of topics leads a visitor to specifically what they are looking for. The search bar is always present, providing quick searching if keywords are known.

National Oceanic and Atmospheric Administration

The goals of the US National Oceanic and Atmospheric Administration are to promote public understanding of climate science and climate-related events, to make our data products and services easy to access and use, to provide climate-related support to the private sector and the Nation's economy, and to serve people making climate-related decisions with tools and resources that help them answer specific questions. There is a toolbox for teaching climate and energy available, and an informative yet not overwhelming dashboard of global climate trends.

European Climate Adaptation Platform -Climate ADAPT

The European Climate Adaptation Platform Climate-ADAPT supports climate change adaptation in Europe by provided access to and sharing data and information on climate change trends, vulnerability, strategies, actions, adaptation case studies and tools. The sheer amount of information on the site is quite overwhelming, despite clearly defined headings. Though not explicitly stated, the site seems to be aimed specifically at policy makers, as the home page focuses on the development of adaptation strategies and action plans.

Polar Data Catalogue

The Polar Data Catalogue is a repository of metadata and data from the Northern Canada region. Searching can be done using a keyword search as well as a mapping interface. Finding information by placing four dots on map is not very intuitive, however, it is a great way to find research for an area without having to search with keywords which can be either too vague, or too specific. The types of records include topics in health and social sciences, and policy and

natural sciences. The site is visually appealing, there is enough graphics to hold interest, but not so much that they would lead to unnecessary distraction. The data is up to date, with links to social media sites.

Arctic Biodiversity Data Service

The Arctic Biodiversity Data Service is an interoperable data management system operated by the Conservation of Arctic Flora and Fauna, and the biodiversity working group of the Arctic Council. It serves as a common platform for the Conservation of Arctic Flora and Fauna projects and circumpolar Arctic biodiversity information. One standout feature is a simple sticker placed beside completed data, to distinguish the information from incomplete data making it effective to find specifically what information is complete. Similarly, to the previous website analyses, a widgets section provides quick events and social media updates, keeping the webpage up-to-date. The webpage is very graphic-heavy. Each link has an accompanying image, it is visually appealing; however, the large images causes a lot of page scrolling to see all the information accessible.

LANDFIRE

LANDFIRE provides users with access to over 20 national geo-spatial layers, databases and ecological models that enable wildland fire management in the United States. The site layout, appearance, and navigation are all outdated, though the information and content seems to be updated regularly. Despite an overall disorganized appearance, the site does link to YouTube LANDFIRE learning tutorials, examples of the applications of LANDFIRE data, frequently asked questions, and contact us, which supports users learning.

Arctic Eider Society

The Arctic Eider Society aims to facilitate knowledge transfer, sea ice safety, participatory mapping, language preservation, education, training and environmental stewardship through a user friendly social media style interface. It is a registered Canadian charity that aims to address environmental change affecting sea ice ecosystems through research, education and outreach in the Hudson Bay area and across the Arctic. The website provides integration of Inuit language and culture, this is extremely useful for those that speak their traditional Inuit language. The site also promotes their charity work, for a mobile app and documentary film project. The app is not yet available, rendering this portion of the website useless; however, it will potentially offer a workable link of the app is developed.

Coastal Resilience

Coastal Resilience focuses on applying nature-based solutions to reduce and eliminate coastal flood risk. It has projects in the United States, Mexico, the Caribbean and Central America.

Coastal Resilience works with communities to assess hazard risks and community vulnerability, identifies nature-based solutions, implements solutions through conservation and restoration action and the evaluated effectiveness.

Climate Change Adaptation Community of Practice

The Climate Change Adaptation Community of Practice (CCACoP) is an interactive online community of people involved in the field of climate change adaptation. One main goal of the CCACoP is to support the Provinces and Territories in their efforts to incorporate climate change adaptation strategies into their climate change policies. The membership requirement allows for administrators to regulate the information that may get distributed throughout the website by ways of comments and knowledge sharing. This may deter some people from further accessing the website; however, once you have membership the content is highly useful, and updates are provided through email and through the website updates. There is a large library of news, articles, and webinars available.

Climate Change Knowledge Portal (CCKP)

The Climate Change Knowledge Portal (CCKP) is an online tool that provides access to comprehensive global, regional, and country data related to climate change and development. The portal offers climate projection models that are easily accessible. It has smooth navigation and appealing visuals. However, some links within the website do not work, or are not updated. Additionally, there is a "sliding" banner that is not optimal for reading through the available topics. One thing that the website does well is present a lot of information in a succinct and accessible manner for any visitor.

3.5.4.2 Evaluation

The above-mentioned websites represent a mix of climate services sites that provide uninterpreted climate data, and climate knowledge brokering sites that provide specific examples of climate change adaptation strategies for a variety of different audiences. As adaptation to climate change becomes increasingly important, many climate services are incorporating components of climate change knowledge brokering into their platforms, thus blurring the distinction between a climate services and a climate knowledge brokering platform. Despite both being territorial platforms, the NWT Discovery Portal and the Nunavut Climate Change Centre take very different approaches. The NWT Discovery Portal acts as more of a climate service provider, focusing on promoting access to and sharing raw data. The Nunavut Climate Change Centre is an excellent example of a climate knowledge brokering platform, as it

focuses on engaging users and encouraging their participation in the production of climate knowledge.

For this research project, 19 websites with climate information were collected, starting with a list provided by INAC and then expanding to other sites that focus on northern climate issues. Some of the sites function primarily as climate services, some operate as climate knowledge brokering platforms, and others fall somewhere in the middle. To determine usability for end-users outside of the scientific community these sites were evaluated on five main sections: purpose, simplicity, readability, navigation and organization. The evaluation of the northern climate brokering platforms focuses solely on platform usability, because it is not possible to evaluate the information on the sites without identifying users and understanding their needs. The complete evaluation criteria is attached as Annex 2, but for the purposes of this section, the Canadian and Pan-Arctic sites shown below in Table 3-2 will be discussed.

Site	Year	Purpose	Simplicity	Readability	Navigation	Organization	Total
NWT Discovery Portal	n.d.	5	5	5	5	5	25
Nunavut Climate Change Centre	n.d.	5	5	5	5	5	25
Canadian Centre for Climate Services	2018	5	5	5	5	5	25
Pan Territorial Adaptation Partnership	n.d.	3	5	5	5	4	22
Canadian Cryospheric Information Network	2018	5	4	4	5	4	22
Climate Telling	2017	5	5	3	4	5	22
Arctic Portal	n.d.	5	4	4	4	5	22
Adaptation Library	n.d.	5	5	5	3	4	22
Polar Data Catalogue	2017	5	4	5	4	3	21
Arctic Biodiversity Data Service	2018	4	3	4	5	4	20
Arctic Eider Society (SIKU)	n.d.	3	3	5	3	4	18

Table 3-2 Usability ranking of Canadian and Pan-Arctic Climate platforms.

4 DISCUSSION

4.1.1 The Community Based, "Grassroots" Nature, of Climate Change Adaptation

Communities in the North are directly experiencing the impacts of a changing climate more than other parts of the nation. This was noted throughout literature in the database. Northern people are adapting their lifestyles to a rapidly changing environment. Several trends in the database track the adaptations of Northerners.

A geographic scale value (community, territorial/provincial, regional, national) was assigned to each record in the database. Figure 4.1 shows the total count of records at each scale level in the database. There are 150 records, or 43% of total records in the database taking place in or considering climate change adaptation at the scale community level. While

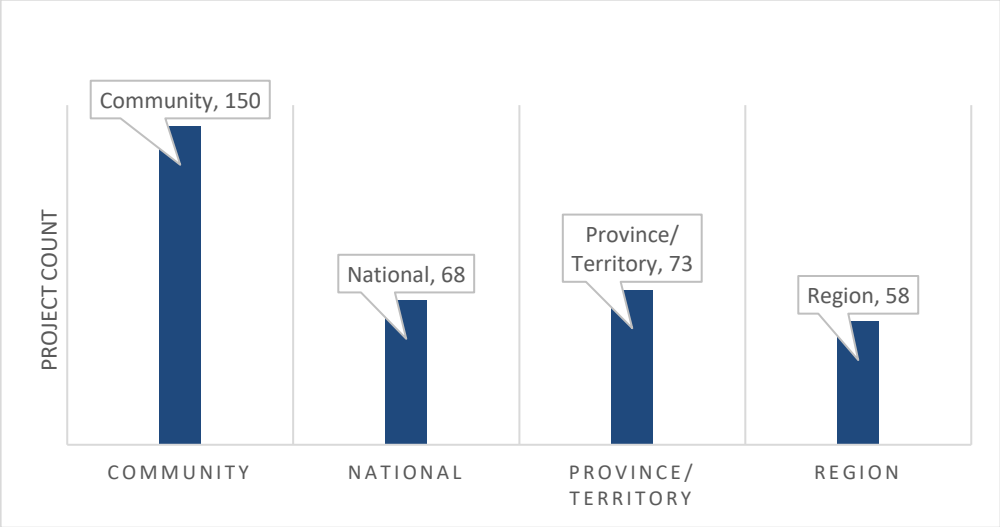

Figure 4.1 doesn't provide any insight into the type of adaptation projects taking place at the community scale, it does indicate that many more projects are taking place in and about communities than at other scales.

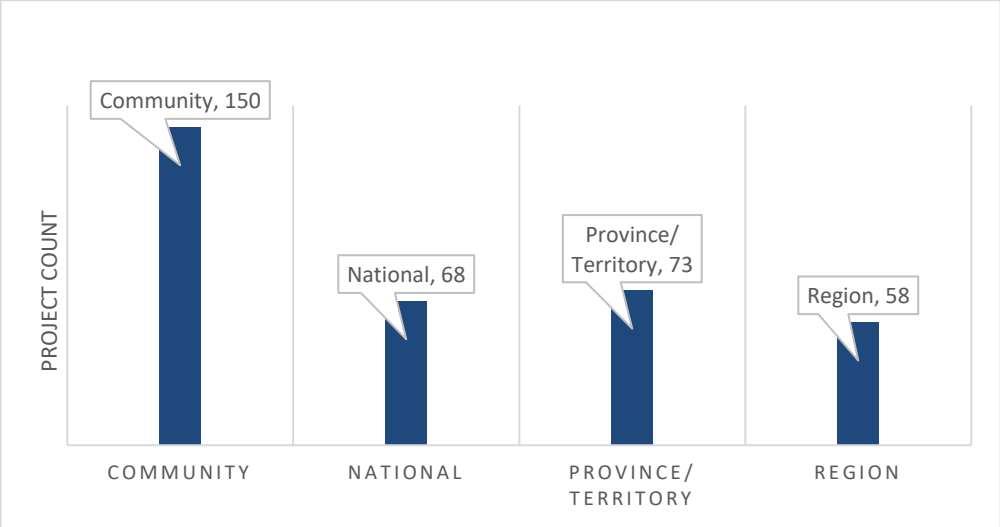

Figure 4.1 The total count of records classified at each scale level. There are 349 unique records in the database.

By combining the geographic scale of a record and the project type(s) of a record, it is possible to observe a trend of taking action, or seeking actions that can be taken, in records at a community

scale. Building on the idea that much of the climate change adaptation work being done happens at community scale, Figure 4.2 shows the percentage of each project type at each scale.

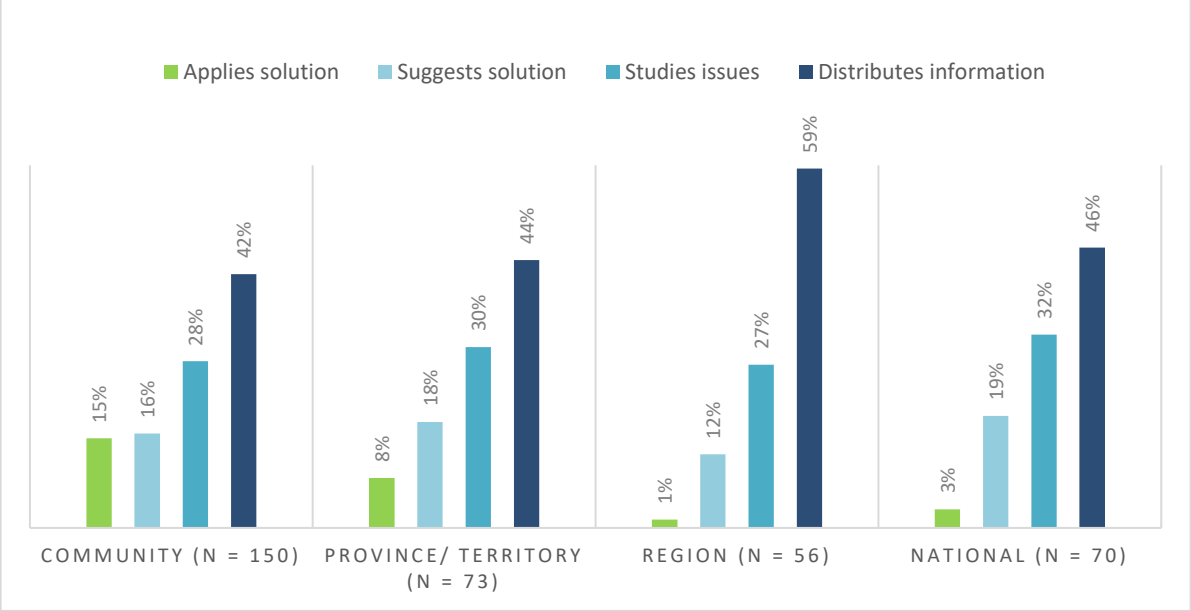

Figure 4.2 Project types for records at each scale.

The percentage of records that describe projects that *"Applies Solutions"* is much greater at the community scale. Not only are more projects taking place at the community scale, more of the projects seek to *"Apply Solutions",* or directly solve emerging problems and/or take steps to adapt to environmental and social changes associated with climate change.

In many cases the solutions applied at the community scale are not documented in academic literature or published in formal online repositories. Instead, projects are informally documented on community websites, in community plans and on various websites (such as the ClimateTelling.org website)(ClimateTelling, 2017). As described in section 4.1.2, access to resources can make adaptation measures difficult to locate. However, by sorting database records by Document Type (Website, Document, Journal, etc.) and Project Type, it allows the observation of another phenomena: climate change adaptation measures that take action are only captured in 7% of journal articles and 4% of documents, while websites capture 22% of

records with Project Type "Applies Solutions".

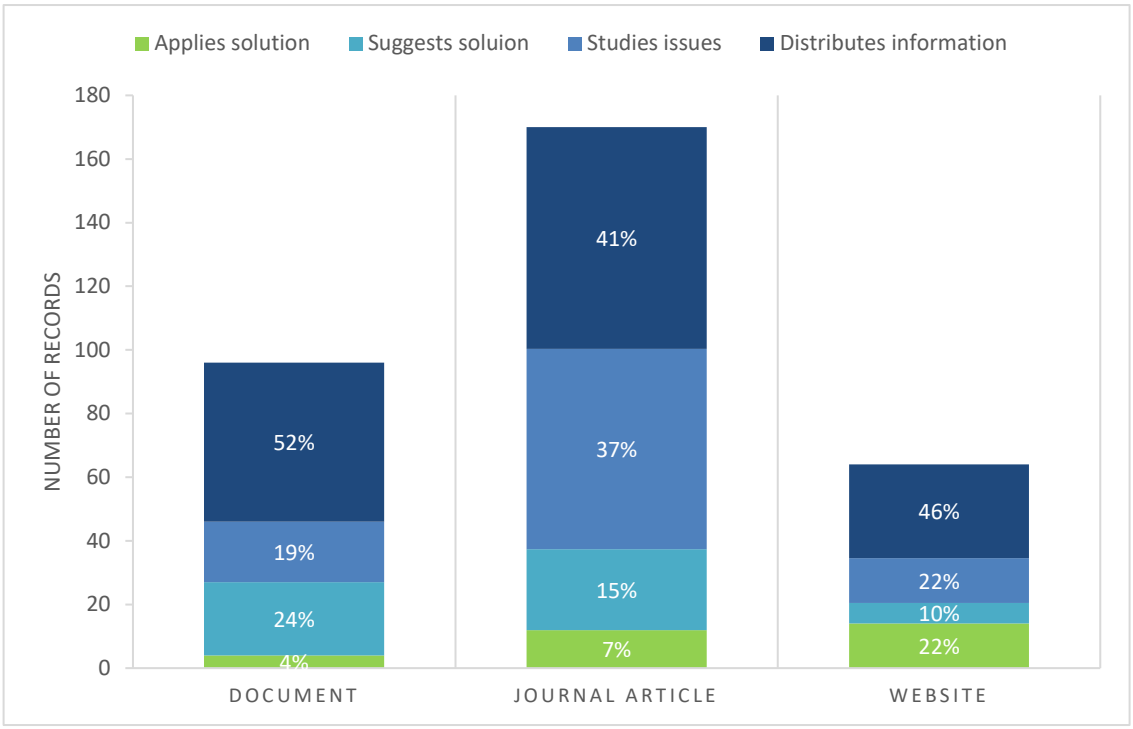

Figure 4.3 illustrates this.

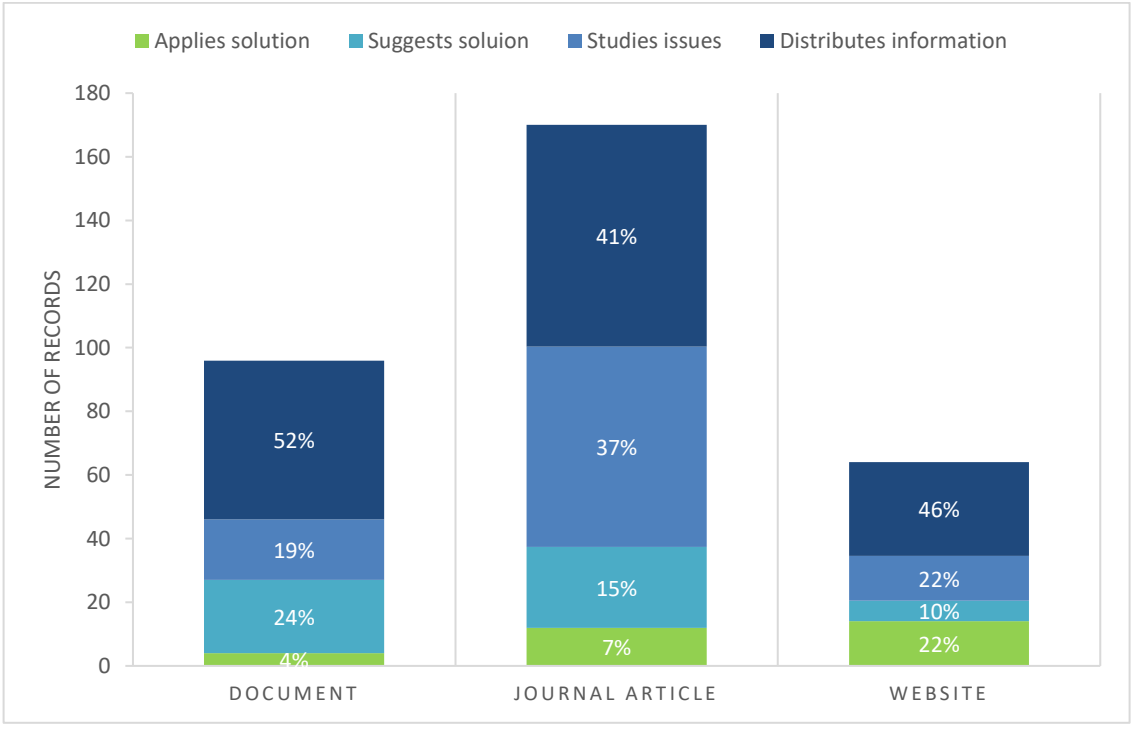

Figure 4.3 The top three document types found in the database with their project type proportions.

While there are more journal articles in the database (n = 170), compared to websites (n = 64), a much larger proportion of the projects recorded on websites describe the application of solutions compared to journal articles.

Many community scaled records in the database describe projects that allow communities to maintain traditional activities despite a changing climate. These practices are seen as important adaptation mechanisms for communities. By preserving and sharing these practices and connections, community members are better able to adapt (Hirsch et al., 2016). Traditional harvesting activities are important not only as a source of food, but as a source of connection, community and inter-generational knowledge transfer, as community members in the North are often dependent on and connected to the environment. Relying on it for both sustenance and well-being (Hirsch et al., 2016).

4.1.2 Access to Resources

Several in-depth and detailed repositories of climate change adaptation measures were found during searches. However, these sources of information were not found readily or on initial internet searches or were found by following links from other publications. It is apparent in the database that there is a broad range of climate change adaptation measures being tested and implemented, but often these measures are difficult to find. This suggests that access to information may become a barrier to adaptation, or that measures that are found to be effective in one publication may not be implemented in others simply because they are unknown. Inaccessible adaptation resources could prevent climate change adaptation for some communities.

5 RECOMMENDATIONS

5.1 RECOMMENDATION FOR CLIMATE CHANGE ADAPTATION PROJECTS IN NORTHERN CANADA

5.1.1 Consistent Funding

While funding is available for various projects and infrastructure, the funding is often available only for one year, linked to political cycles, or will not cover on-going operation and maintenance costs. Throughout this project, lack of funds was identified not only as a direct barrier to effective adaptation, but as an indirect barrier reducing the effectiveness of other adaptation enablers. For

example, food security is a common theme throughout records. Community freezers are one method identified in many records to improve food security, where long term funding is needed to build and maintain a freezer for many years. Traditional practices and knowledge are other themes that are repeated throughout the database and are regarded as crucial for adaptation. By providing on-going funding to improve the transfer, support, and recording of TK, the adaptive capacity of many northern communities could be improved.

Technology is available that can help people in the north to adapt. GPS, VHF, the internet, remote sensing, photography and video, and many others can improve access to the land, enabling traditional practices, improve the transfer and recording of TK, and reduce travel risks enhancing the adaptive capacity of the North. However, funding is needed to purchase equipment and train people to operate it. Training and education opportunities are limited in northern communities. In many locations, education beyond high school is not available locally, forcing community members to leave the community. While enhanced education can improve adaptation, leaving the community severs links with traditional practices, reduces traditional skills, and removes individuals from the communities, reducing adaptive capacity. With access to funds and technology, education could be delivered in person, or remotely to community members potentially giving them the best of both worlds.

Melting permafrost, thawing temperatures and changing coastlines are threatening infrastructure in the North. Some communities lack quality housing. Local roads are becoming less navigable reducing access to land, and changes to ice roads and reduced waterway access mean communities are isolated. Store food and equipment (often needed to for land-based activities) becomes more expensive, again reducing the ability of communities to adapt.

5.1.2 **Adaptation with Attention to the Northern Context**

Many communities are already experiencing climate change impacts and have been experiencing it for far longer than other places in the world. They have unique insights due to their recent climate change experience as well as the generational nature of TK and the time spent on the land. However, communities are experiencing many different stressors like food and water insecurity, which compound with climate change impacts and need to be considered when planning for and implementing adaptation. The traditional lifestyle and culture of northern people are crucial to their continued survival and must be maintained and supported by any adaptation process. Leaving the land, community and the North is not an option. Many northern people were once nomadic travelling on the land to adapt to changing environmental conditions. Contact has moved them into more sedentary, community-based living patterns. This drastic lifestyle change needs to be considered during adaption work. The north needs unique adaptation planning, policy, and action to reflect the culture uniqueness of its environment and its people. It is also experiencing a greater degree or rate of climate change than other regions, adaptation needs to reflect both the current changes as well as potential future changes.

5.1.3 Capacity Building

Community members often have unique perspectives and knowledge on environmental changes. Baseline data for northern systems is often lacking or missing. As the climate rapidly changes northern people are situated to act as environmental monitors, gathering and analyzing data. However, in order to effectively do this training and funding for wages is needed. Environmental monitoring duties are doubly beneficial as they allow individuals to spend time on the land while also earning a wage. By developing the capacity for communities to train and employ environmental monitors, and compile and analyze data communities can become focal points of climate change research.

Centralized food storage and production systems are another capacity building option. Several northern communities have successful community run green houses. The construction and operation of greenhouses is an opportunity for community members and can also improve food security by providing an alternative to expensive, often unhealthy, store foods. While store purchased food is not ideal because of expensive and cultural inadequacy, bulk purchasing options and education on preparation and nutrition of store foods can make it a viable food source, especially to augment traditional land-based foods. Dietary education aimed towards more "southern" diets is not adequate. Many communities report reduced access to fresh water, as streams, water courses and ice change. Tap water in many communities is often not a preferred water source. Locally operated water filtration plants can provide an alternative water source for community members removing this barrier. However, water filtration is often beyond many communities' capacity. Funding and training are needed to address water issues.

5.1.4 Integration of traditional knowledge

The rate of environmental changes in northern systems is difficult to understand because of limited baseline data. Environmental monitoring is sparse, making adaptation challenging. There are many examples where TK has been used to augment, improve and provide alternative understandings to scientific data. The two knowledge systems need to be integrated carefully, as they represent different types of information. Training of individuals and communities in the North to collect scientific data and utilize TK, is an opportunity to increase the understanding of northern systems and provide communities with a source of income that can be used to improve their adaptive capacity.

5.1.5 Improve access to the land

Access to the land is an important factor in conducting and maintaining traditional activities such as hunting and harvesting. Climate change, compounded with social and economic issues, can reduce the ability of individuals to access the land. Programs that support access to the land, such as providing money to hunters for fuel and ammunition. In some communities, funding is made

available for hunters to stock community freezers, increasing access to the land for the hunters and improving the food security of the community.

Many communities are using technology such as remote sensing, data loggers, and weather stations to monitor environmental conditions. When this data is available in the community, it can be used to plan travel routes and assess travel risks. However, the data needs to be accessible and, in a format, that community members can interpret and use.

5.1.6 Applying adaptation

The north is experiencing rapid climate change and communities already find it necessary to adapt. Yet, the records in our database are heavily weighted towards adaptation planning rather than implementation. Applying solutions to climate change means finding ways people in the North can adapt to environmental changes, while maintaining their unique cultures and lifestyle. Existing infrastructure needs to be protected from permafrost thaw and coastal erosion. The actions taken in communities should be supported at a national scale and funders should focus their funds on projects that actively improve adaptation such as community freezers and greenhouses, local capacity building and supporting traditional practices. Additionally, funding needs to allow long term adaptations. Alternative travel strategies are needed to manage changing ice conditions, waterways, and ice roads.

5.2 RECOMMENDATIONS FOR NORTHERN CLIMATE KNOWLEDGE BROKERING PLATFORMS

This section will explore how climate knowledge brokering best practices have been utilized and incorporated into northern platforms, then offer recommendations on how northern platforms can improve.

5.2.1 Understanding Users

As previously discussed, identifying users and their needs is necessary for creating and providing usable climate knowledge. Three northern climate knowledge brokering platforms do this well. Climate Telling clearly defines its audience: northern indigenous communities in Canada. By clearly defining its users, Climate Telling can provide examples of climate change adaptations that are more relevant and therefore more likely to be useful. In addition to this, understanding users, enables platforms to customize the presentation of their information. Therefore, Climate Telling uses a very qualitative approach with adaptation examples from across northern Canada. Similarly, the Arctic Eider Society has a clearly defined audience: the Inuit and Cree communities in Hudson Bay and across the Arctic. The site also hosts the award winning SIKU, an Inuit knowledge wiki and social mapping platform which collects sea ice information from satellites

and Inuit peoples to provide access to real time sea ice conditions. SIKU was under construction while the Arctic Eider Society platform was being assessed, which lowered the platform's usability score.

Recommendation #1: *Identify users.* Northern climate knowledge brokering platforms should clearly define intended users and continually identify actual users to address gaps between intended and actual users (Hammill et al., 2013). Information that is tailored to specific audiences, like SIKU, has greater usability (Dilling & Lemos, 2011).

Recommendation #2: *Produce user-driven climate information*. Northern climate knowledge brokering platforms should continue to shift from a supply to a user driven climate knowledge production which will be enabled by a deeper understanding of user needs and preferences (Hering, 2015; Swart et al., 2017).

Recommendation #3: *Prioritize co-production*. Usable climate knowledge requires a shared understanding of what is usable. Knowledge that is co-produced is more likely to fit user needs and understand specific decision contexts (Dilling & Lemos, 2011). The recommendations below in *Building Relationships* enable the co-production of knowledge.

5.2.2 **Building Relationships**

The Nunavut Climate Change Centre focuses very heavily on building relationships and empowering communities to participate in both the production of climate change knowledge and the implementation of climate change adaptation strategies. The Voices from the Land section collects IQ from Elders to encourages users to contribute to their communities' climate change IQ. The website also lists community research projects, has resources for educators, and connects users to other informative sites on climate change in northern Canada.

Recommendation #4: *Focus on local*. Climate knowledge brokering platforms should look to the Nunavut Climate Change Centre's examples on encouraging collaboration, and community participation on climate change issues at both a local and regional scale. The Voices from the Land section of the Nunavut Climate Change Centre demonstrates to community members that their knowledge and contributions are being valued. Climate information that is scalable to a community level is important because climate information that reflects local conditions is perceived to have more credibility and trustworthiness (Hammill et al., 2013).

Recommendation #5: *Prioritize iterative relationships.* Northern climate knowledge brokering platforms should prioritize building iterative relationships to combat distrust, misunderstanding,

and perceived irrelevance (Dilling & Lemos, 2011; Hammill et al., 2013). Collaborative processes encourage decision-makers to understand and prioritize the value of climate informed decisions.

Recommendation #6: *Capitalize on in person opportunities*. Online climate knowledge brokering is important to promote widespread access to usable climate knowledge, however, in person engagement opportunities have been identified as valuable by climate change information end-users. Translating climate information into action can be challenging, therefore climate knowledge brokering platforms should capitalize on opportunities to connect decision makers with each other, and climate science producers.

5.2.3 Organization

The Climate Services Support Desk feature of the Canadian Centre for Climate Services (CCCS) allows users to request specific information, submit feedback and seek guidance interpreting climate data. This feature fulfills several climate knowledge brokering best practices, the first being easy to access learning support. The Climate Services Support Desk also enables the CCCS to identify its users, while feedback is incorporated to encourage the production of user driven climate data. The Library of Climate Resources is extremely user-friendly and allows users to filter information by sector, hazard, jurisdiction, historical/ future, variables, resource type, source, data type, format type, spatial type and temporal resolution. The CCCS does a good job of connecting and enabling access to both raw and interpreted climate data, which is a difficulty for some of the other northern climate knowledge brokering sites. For example, Climate Telling, and the Pan Territorial Adaptation Partnership, focus on interpreted climate data and adaptation strategies that are easy for non-scientific users to understand. The NWT Discovery portal, the Adaption Library, and the Polar Data Catalogue focus providing increased access to raw, quantitative data.

Recommendation #7: *Streamline efficient access to online Canadian climate knowledge*. Canadian climate knowledge brokering platforms should be connected and reorganized to avoid user frustration over portal proliferation (VanderMolen et al., 2019). The Canadian Centre for Climate Services, should be a starting point that provides a road map through which users can access increasingly specific and localized climate information. The current northern climate knowledge brokering platforms create a fragmented and inefficient knowledge landscape, making it difficult for users to access and compare both raw and interpreted relevant climate change data.

Recommendation #8: *Bridge specialty sources of information.* Climate change conversations are increasingly focused on adaptation, however, there are few concrete examples of the successful implementation of climate change adaptions. Climate Telling collects examples of various Indigenous climate change adaptation projects, however, it is difficult to find and unlikely to appear in any of the other climate knowledge brokering platform databases. Climate knowledge brokering platforms should be actively working to bridge concrete examples of climate change adaptation to wider climate change resources.

Recommendation #9: *Expand learning tools*. Climate knowledge brokering platforms should expand interactive learning tools, including tips on how to effectively navigate platforms, the differences between types of resources, and examples of how climate change knowledge can be applied (Hering, 2015; VanderMolen et al., 2019).

Recommendation #10: *Avoid the creation of project based portals*. Climate knowledge brokering platforms that rely on project funding are often insufficiently maintained, updated, monitored and evaluated (Karali & Mattern, 2017; VanderMolen et al., 2019). For example, the Pan Territorial Adaptation Partnership doesn't seem to have been updated since 2015, and pan-territorial resources can be easily accessed by searching or filtering the Canadian Centre for Climate Services.

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ANNEX 1 DATA TABLES

ANNEX 1.1 CLIMATE CHANGE ADAPTATION ENABLERS

	All	YT	SK	QC	ON	NU	NWT	NL	MB	BC	AB
Traditional knowledge	148	26	-	6	3	36	42	14	-	-	-
Community support	131	23	-	4	4	31	42	11	1	1	1
Technology	82	10	-	7	2	17	16	9	-	-	1
Raising of awareness	73	14	-	1	3	15	22	5	-	-	-
Collaboration	62	7	-	3	3	10	21	3	1	1	1
Information sharing	59	9	-	3	1	8	17	7	-	-	1
Education	55	10	-	1	2	8	16	6	-	-	-
Shared responsibility	49	8	-	1	2	10	17	3	-	-	-
Flexibility of resource use	43	3	-	3	3	12	10	4	-	-	-
Training	38	8	-	1	2	8	9	5	-	-	-
Interdisciplinary approaches	36	6	-	-	1	7	9	4	-	-	-
Effective institutional support	23	-	-	-	-	6	4	3	-	-	1
Connections and networks	22	3	-	-	-	3	5	3	-	-	1
Economic resources	18	1	-	-	1	3	5	1	-	-	-
Inclusion of vulnerable groups	17	1	-	-	2	5	4	1	-	-	-
Mainstreaming	12	3	-	-	-	1	6	-	-	-	-
Equity	5	-	-	-	-	1	-	-	-	-	-
Transboundary organization	2	-	-	-	-	-	-	-	-	-	-

ANNEX 1.2 CLIMATE CHANGE ADAPTATION BARRIERS

	All	YT	SK	QC	ON	NU	NWT	NL	MB	BC	AB
Lack of financial resources	58	3	-	2	2	-	14	3	-	-	-
Inequity	52	2	-	2	4	17	13	2	-	-	-
Communication challenges	46	3	-	-	2	11	8	2	-	-	-
Mainstreaming	46	5	-	-	1	11	6	1	-	-	-
Lack of baseline data	39	9	-	-	2	9	6	2	-	-	-
Lack of awareness	36	5	-	1		6	7	3	-	-	1
Climate change skepticism	34	4	-	1	1	8	4	1	-	1	-
Lack of knowledge	33	2	-	-	-	7	7	-	1	-	-
Lack of long-term adaptations	33	3	-	-	1	4	9	2	-	1	1
Lack of clear and consistent policy guidelines	31	3	-	-	3	4	4	-	-	1	-
Conflicts of interest	26	4	-	-	4	6	2	1	-	-	
Legislation issues	23		-	1	1	5	2	-	-	-	1
Inaction by the government	21	3	-	-	1	6	2	-	-	-	-
Lack of expertise	21	2	-	1		3	8	1	-	1	-
Lack of personnel	17	2	-	2		1	6	1	-	1	-
Lack of time	17	1	-	1	1	4	4	-	-	-	-
Inaction by organizations	16	2	-	-	1	3	3	-	-	-	-
Lack of community involvement	16	2	-	-	1	3	8	-	-	-	-
Lack of trust	13	1	-	1	1	6	3	-	-	-	-
Lack of local autonomy	12	1	-	-		6	2	-	-	-	-

Inconsistent reporting	8	1	-	-	1	1	-	1	-	-	-
Lack of qualitative information	7	1	-	-	-	1	2	-	-	-	-

ANNEX 1.3 DETAILED THEMES

	All	YT	SK	QC	ON	NU	NWT	NL	MB	BC	AB
Traditional practices	133	26	-	6	5	27	40	12	1	-	1
Governance	110	10	-	2	1	16	30	5	3	1	-
Food Security	88	16	-	7	5	19	26	6	-	-	-
Policy	77	7	-	2	2	10	24	1	1	1	1
Hunting and Harvesting	71	10	-	7	5	17	22	5	-	-	-
Sea Ice	58	1	-	3	3	14	14	6	1	-	-
Ecology	56	17	-	2	5	5	14	1	-	-	1
Wildlife	51	10	-	3	3	4	17	1	1	-	3
Mental Health	37	2	-	-	1	8	7	10	-	-	-
Social	34	1	-	-	1	9	9	3	-	-	-
Health and Temperature	32	3	-	1	1	7	5	7	1	-	-
Permafrost Thaw	30	9	-	1	1	2	10	1	-	-	-
Infrastructure	29	2	-	-	-	7	4	2	-	-	-
Shift in Species Distribution	28	5	-	-	2	4	10	1	1	-	-
Communication	25	6	-	-	1	7	5	1	-	-	-
Vegetation	25	8	-	2	2	6	3	1	-	-	-
Water	24	3	-	1	2	4	5	-	-	-	-
Public Safety	21	2	-	-	1	5	7	2	-	-	-

Built Environment	19	2	-	-	-	7	2	1	-	-	-
Cumulative Effects	18	1	-	1	4	1	4	1	-	-	-
Forestry	18	6	1	1	1	-	-	-	-	-	2
Fish	16	5	-	-	1	2	3	-	-	-	-
Snow Melt	16	1	-	2	-	4	2	2	-	-	-
Natural Hazards	15	1	-	1	-	4	4	2	-	-	-
Snow	15	-	-	2	1	3	2	2	-	-	-
Air Temperature	13	2	-	-	1	4	1	1	-	-	-
Water Quality	12	2	-	1	-	2	2	2	-	-	-
Industries	11	-	-	1	-	-	1	-	-	-	-
Sea Level Rise	10	-	-	1	-	1	3	1	-	-	-
Water Management	9	1	-	2	1	1	1	-	-	-	-
Connectivity	8	-	-	1	1	1	1	-	-	-	-
Flooding	8	2	-	-	-	1	1	-	-	-	-
Glacier Melt	8	3	-	-	-	-	-	-	-	-	-
Inequities	8	-	-	-	1	3	1	1	-	-	-
Conservation	7	2	-	-	1	-	1	-	1	-	-
Species Migration	7	-	-	-	1	-	3	-	1	-	1
Water Quantity	7	-	-	-	-	-	3	1	-	-	-
Fire	6	3	-	1	-	-	1	-	-	-	-
Water Temperature	6	-	-	-	-	-	1	-	-	-	-
Biodiversity	5	-	-	-	-	-	-	-	-	-	1
Diseases	5	-	-	-	1	1	2	1	-	-	-
Poverty	5	-	-	-	-	1	2	1	-	-	-

Protected Area	5	-	-	-	1	-	-	-	1	-	-
Air Quality	3	-	-	-	-	1	-	1	-	-	-
Aquaculture	3	-	-	1	-	-	-	-	-	-	1
Clean Technology	3	1	-	-	1	-	-	-	-	-	-
Emissions	3	-	-	-	-	-	-	-	-	-	-
Glaciers	3	2	-	-	-	-	-	-	-	-	-
Agriculture	2	-	-	-	-	-	-	-	1	-	-
Ecological Restoration	2	-	-	-	-	-	1	-	-	-	-
Landslides	2	1	-	-	-	1	-	-	-	-	-
Mining	2	-	-	-	-	-	-	-	-	-	-
Renewable Energy	2	1	-	-	-	-	1	-	-	-	-
Waste Management	2	-	-	-	-	-	1	-	-	-	-
Drought	1	-	-	-	-	-	-	-	-	-	-
Storms	1	-	-	-	-	-	1	-	-	-	-
Tornados	1	-	-	-	-	1	-	-	-	-	-

ANNEX 1.4 BROAD THEMES

	All	YT	SK	QC	ON	NU	NWT	NL	MB	BC	AB
Planning	173	27	-	8	2	27	46	7	3	1	-
Human Health	104	18	-	2	6	20	26	16	1	-	-
Ecology	72	23	1	4	6	5	12	1	1	-	3
Social Issues	57	6	-	1	2	18	11	8	-	-	-
Snow and Ice	38	3	-	6	3	8	8	2	-	-	-
Water	24	4	-	1	1	5	3	1	-	-	-
Infrastructure	20	3	-	1	1	1	5	1	-	-	-
Natural Hazards	17	4	-	-	-	4	5	1	-	-	1
Industries	9		-	1	-	1	2	-	-	-	-
Pollution	4	2	-	-	-	-	-	-	-	-	-
Atmosphere	3	1	-	-	-	-	-	-	-	-	-

ANNEX 2 EVALUATION CRITERIA SCORING FOR CLIMATE KNOWLEDGE PLATFORMS

ANNEX 2.1 CANADIAN CENTRE FOR CLIMATE SERVICES

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	1	**5**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 25						

ANNEX 2.2 NUNAVUT CLIMATE CHANGE CENTRE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	1	**5**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 25						

ANNEX 2.3 NWT DISCOVERY PORTAL

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	1	**5**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 25						

ANNEX 2.4 UN ADAPTATION KNOWLEDGE PORTAL

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	0	1	0	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 23						

ANNEX 2.5 CLIMATE TELLING

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	1	**5**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	0	1	**3**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	0	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 22						

ANNEX 2.6 PAN TERRITORIAL ADAPTATION PARTNERSHIP

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	0	1	1	0	**3**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	1	**5**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	0	**4**
Total: 22						

ANNEX 2.7 ADAPTATION LIBRARY

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	0	1	0	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 23						

ANNEX 2.8 CANADIAN CRYOSPHERIC INFORMATION NETWORK

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	1	1	1	**4**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	1	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	0	1	1	**4**
Total: 22						

ANNEX 2.9 ARCTIC PORTAL

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	0	1	**4**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	0	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	0	1	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 22						

ANNEX 2.10 NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	0	1	0	**2**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	0	1	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 21						

ANNEX 2.11 EUROPEAN CLIMATE ADAPTATION PLATFORM - CLIMATE ADAPT

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	0	**4**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	0	1	**3**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	0	1	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 21						

ANNEX 2.12 POLAR DATA CATALOGUE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	1	1	0	**4**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	0	1	1	1	0	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	0	1	0	1	**3**
Total: 21						

ANNEX 2.13 ARCTIC BIODIVERSITY DATA SERVICE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	0	1	1	**4**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	0	1	1	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	1	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	1	1	**5**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	0	**4**
Total: 20						

ANNEX 2.14 LANDFIRE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	0	1	1	**4**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	0	1	1	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	1	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	0	1	1	1	1	**4**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	0	1	1	1	1	**4**
Total: 19						

ANNEX 2.15 ARCTIC EIDER SOCIETY

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	0	1	1	0	**3**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	1	0	1	0	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	1	1	**5**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	1	1	1	0	0	**3**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	0	1	**4**
Total: 18						

ANNEX 2.16 COASTAL RESILIENCE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	0	1	1	**4**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	0	1	1	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	1	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	0	1	1	1	0	**3**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	0	1	**4**
Total: 18						

ANNEX 2.17 CLIMATE CHANGE ADAPTATION COMMUNITY OF PRACTICE

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	1	1	1	**5**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	0	1	0	1	1	**3**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	0	1	1	0	1	**3**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	0	1	1	0	0	**2**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	1	1	1	1	1	**5**
Total: 18						

ANNEX 2.18 CLIMATE CHANGE KNOWLEDGE PORTAL (CCKP)

Purpose	Website clearly states purpose	Site meets expectations of visit	Website organized effectively	Organization information accessible/brand	Content utility/useful information & up-to-date	**Total**
	1	1	0	1	1	**4**
Simplicity	Transparency of information	Consistency in design throughout the website	Easy to navigate	Minimized redundant features	Easily understandable functions	**Total**
	1	0	0	1	0	**2**
Readability	Easy to read	Well-written	Understandable	Appropriate amount of content on page/readable blocks	Reading level appropriate content	**Total**
	1	1	1	0	1	**4**
Navigation	Easy-to-find menu/ navigation bar	Consistent navigation	Visible links/aids for navigation	Easy to access web pages/content	Search features	**Total**
	0	0	0	0	0	**0**
Organization	Logical organization	Systematic arrangement and categorization	Meaningful labels/heading/ titles	Keywords	Sufficient amount of information	**Total**
	0	1	1	0	1	**3**
Total: 13						