Examining Community Adaptation Readiness to Climate Change in the Inuvialuit Settlement Region, Northwest Territories

By

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Submitted in partial fulfillment of the requirements for the degree
of
Master of Marine Management

at

Dalhousie University
Halifax, Nova Scotia

November 2015

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List of Abbreviations

ACIA	Arctic Climate Impact Assessment
AIP	Agreement-in-Principle
CAVIAR	Community Adaptation and Vulnerability in Arctic Regions
CCCAP	Community Climate Change Adaptation Plan
DHVA	Dempster Highway Vulnerability Assessment
DOT	Department of Transportation
FJMC	Fisheries Joint Management Committee
GCM	Global Climate Models
IGC	Inuvialuit Game Council
ILA	Inuvialuit Land Administration
IRC	Inuvialuit Regional Corporation
IRC	Inuvialuit Regional Corporation
ISR	Inuvialuit Settlement Region
MLA	Member of the Legislative Assembly
NWT	Northwest Territories
WMAC	Wildlife Management Advisory Council

Abstract

M[ac]Donell, H., 2015. Examining community adaptation readiness to climate change in the Inuvialuit Settlement Region, Northwest Territories [graduate project]. Halifax, NS: Dalhousie University.

The current rate of anthropogenic driven climate change is unprecedented and threatening the social, cultural and ecological characteristics of many Arctic communities. The Government of the Northwest Territories, Inuit Organizations, and the scientific community have identified adaptation planning as a priority; however, no formal assessment of community readiness to adapt to climate change has been undertaken in the territory. This study aims to remedy this gap in the adaptation literature through an examination of community adaptation readiness in three communities in the Inuvialuit Settlement Region, Aklavik, Tuktoyaktuk, and Inuvik. This study is the first to examine community adaptation readiness in this region. Using an adaptation readiness framework, the existence of key factors important to adaptation evolution were assessed. The study findings provide needed insights on community adaptation readiness and identifies barriers constricting adaptation action. Recommendations were developed based on these findings to inform regional and local decision makers about proactive and practical efforts that can enhance community readiness. The outcomes of this research can contribute to planning and policy development in the ISR and provide insight on community climate change adaptation in the Canadian Arctic.

Key words: inuvialuit; climate change; adaptation; western arctic; vulnerability

Acknowledgements

I would like to extend a sincere thank you to Dr. James Ford, who agreed to be my academic supervisor. Your feedback and suggestions have improved the quality and fullness of this report.

To Ben Linaker and Shannon O'Hara, thank you for steering me through the many facets of governance and adaptation initiatives that exist throughout the Northwest Territories.

I would also like to thank the faculty of the Marine Affairs Program for their encouragement and guidance over the past 16 months. To my classmates, thank you for your support, whether in the form of laughter, food, or encouragement, I am extremely grateful we completed this journey together.

Finally, I would like to thank my family and friends for their words of encouragement and support. This project could not have been completed without you.

Chapter 1: The Climate Change Problem

1.1 Environmental Change in the North

The Arctic environmental is changing at an unprecedented rate due to climate change. The effects of which are altering not only natural systems, but the socio-economic characteristics of the North as well. Technical and indigenous observations of climate change in the Canadian Arctic have been well documented, such as warmer temperatures, changing weather patterns, reduced sea-ice extent, and shifting wildlife migration routes (e.g. Andrachuk & Smit, 2012; Community of Aklavik et al., 2005; Berkes & Jolly, 2001). Mean surface temperature warming at the poles continues to exceed the global average, a warming trend that is expected to continue despite global mitigation efforts (Larsen et al., 2014). The remote community of Inuvik, in the Inuvialuit Settlement Region (ISR) of the Western Canadian Arctic, has already experienced record rises in annual temperatures, recording a 3° C increase since the 1960's (Pearce et al., 2011; GNWT, 2008a; ACIA, 2005). This rate of warming is three times greater than the global average of 0.9° C.

Rising temperatures in the North are causing the degradation and disappearance of permafrost, the layer of soil that remains frozen throughout the year. Permafrost ground does provides a relatively stable building base for infrastructure development if ground temperatures remain below 0° C for the majority of the year (Couture et al., 2002). However, as temperatures rise, the stability of permafrost ground declines as it begins to transition into the more unstable active layer (Couture et al., 2002). The stability of the active layer is less so because it does not remain frozen throughout the year, subjected to freeze-thaw cycles. The loss of permafrost is causing ground slumpage and settlement, compromising the structural stability of infrastructure

across northern Canada (Couture et al., 2002). Permafrost temperatures have increased as much as 2° C since the late 1970s, increasing the thickness of the active layer by as much 0.5 m in areas of Northern Canada (Larsen et al., 2014; Romanovsky et al., 2013).

Infrastructure threatened by permafrost degradation across the Arctic includes roads, bridges, airstrips, buildings, sewage corridors and pipelines (Couture et al., 2002). The foundation of these structures along with the stability of the surrounding landscape, are at risk as the permafrost layer thins and coastal and riverbank slopes become more susceptible to erosion and landslides (Couture et al., 2002). The severity of these impacts will, however, vary across the Canadian Arctic, depending on soil type, magnitude of temperature change, and permafrost condition (Couture et al., 2002). In regions where permafrost temperatures are just below the freezing mark naturally, such as the Mackenzie Valley, even small changes in air temperatures will affect the stability of the soil and existing infrastructure (Couture et al., 2002

Coastal areas in particular are sensitive to the impacts of climate change as sea-level rises due to the combined effects of melting land ice and thermal expansion of sea water. Warming ocean temperatures are causing sea-levels to rise globally, an average of 3.2 mm each year (Gregory, 2013). It is almost certain that sea level rise will continue beyond this century, making coastal adaptation, retreat and eventual relocation all but unavoidable (Gregory, 2013)

Global Climate Models (GCM) have predicted that the Arctic Ocean could be ice-free during the summer months before the end of the century (Larsen et al., 2013). Sea-ice serves multiple purposes to northern communities; as a transportation route, hunting grounds, protection from wave exposure, erosion, and coastal flooding. A longer open water season also means an increase in the intensity of storm surges and stronger waves along the coast (Manson et al.,

2005). Without the presence of the sea-ice to act as a barrier, coastal infrastructure, homes and cultural sites will be more susceptible to erosion.

Climate change is also threatening community water supply, transportation routes, and the health of wildlife (Ford et al., 2014; Arctic Council, 2013; Pearce et al., 2011). Unpredictable and extreme weather events, such as shifts in precipitation patterns, more frequent blizzard events, and thinning sea-ice are impacting the ability of Inuit to hunt and gather country foods and provide for their families (Pearce et al., 2011; Berkes & Jolly, 2001). The most recent report released by the Intergovernmental Panel on Climate Change (IPCC), confirms with high confidence that climate change is enhancing community vulnerability in northern communities (Larsen et al., 2014). For example, impacts on food security, subsistence-based economies, and Inuit health and well-being, are all projected, with high confidence, to increase as the climate continues to change (Larsen et al., 2014).

In a region where culture and livelihood are firmly coupled to the natural environment, the impacts of climate change threaten a culture and way of life that has existed for millennia. While some of these changes present opportunity for economic growth and diversification, there is no doubt that the lifestyle and livelihood of residents will be greatly affected. The magnitude of these impacts will depend on the capacity, readiness and rate at which social systems in the north can adapt to them.

1.2 Initiatives and Assessments

The first comprehensive evaluation of Arctic climate change was the Arctic Climate Impact Assessment (ACIA), completed in 2004 following a request from the Ministers of the Arctic Council (ACIA, 2005). The Arctic Council was established in 1996 and serves as an intergovernmental forum with representation from the eight states with Arctic sovereignty,

Arctic indigenous communities, and non-indigenous residents (Arctic Council, 2015). Six research working groups were established under the the Arctic Council and mandated to provide reliable information on various issues of concern to Arctic stakeholders; such as contaminants, pollutants, emergency preparedness, and sustainable development (Arctic Council, 2015).

Canada served as the inaugural chair of the Council after its formation and again as chair from 2013-2015, during which time the Iqaluit Declaration was signed by the representatives of the Arctic Council. The Iqaluit Declaration reaffirmed the Council's commitment to the protection of the Arctic environment and sustainable use of natural resources and acknowledged that global and national action is needed to "reduce climate risks, increase prospects for effective adaptation, and reduce the costs and challenges of mitigation in the long term" (Arctic Council, 2015:1).

The Government of Canada has recognized adaptation as an important component of northern climate policy for over a decade, resulting in the development of a number of Community Climate Change Adaptation Plans (CCCAP) for northern communities. However, many of these plans have not been formally evaluated for effectiveness and some northern communities still lack long-term plans or strategies to address climate change impacts (Ford et al., 2014; Pearce et al., 2011). In 2010, the Pan-Territorial Adaptation Strategy was released, signaling a commitment from territorial governments to tackle the risks of climate change through intergovernmental collaboration and information sharing. Each of the territories have developed territorially focused adaptation reports, outlining the current and future impacts of climate change coupled with adaptation responses (GNWT, 2008a). While these territorial adaptation reports do provide general details on adaptation initiatives at the territorial level, they are lacking in community focused adaptation initiatives and strategies.

The Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) research program (2008) was instrumental in advancing knowledge on how community vulnerability is shaped and the factors that influence community capacity to adapt. Such information provides a valuable foundation for examining and investigating the actual preparedness of communities to adapt. Despite large research efforts, less research has been conducted on the relationship between policy response to climate change and community capacity to adapt. In 2014, the development and nature of adaptation actions in the Arctic were documented by Ford et al. (2014) via a systematic literature review of 117 peer-reviewed articles. The authors concluded that adaptation is still in its infancy in the Arctic, a finding that is concerning given the rate at which climate change is occurring.

1.3 Project Rational and Objectives

Given the heterogeneous nature of climatic changes and subsequent impacts, a one-size fits all approach to adaptation would be ineffective at addressing the local impacts of climate change. Thus, a community-based approach has been championed in the literature (e.g. Ford et al., 2008; Berkes & Jolly, 2001) as an appropriate method for characterizing northern vulnerability and adaptive strategies. Understanding the community specific conditions, vulnerabilities and local capacity to adapt is imperative when attempting to formulate proactive adaptation strategies or plans (Andrachuk & Smit, 2012; Pearce et al., 2011; Ford & Smit 2004; Berkes & Jolly, 2001).

The purpose of this study is to examine community readiness 'to do' adaptation in three communities in the Inuvialuit Settlement Region, Northwest Territories; Aklavik, Inuvik, and Tuktoyaktuk (Tuk). The Government of the Northwest Territories (GNWT) has identified

climate change adaptation as a priority in its *NWT Climate Change Impacts and Adaptation Report*, released in 2008 (GNWT, 2008). Seeing as the ISR has already experience some of the greatest recorded temperature increases globally it is concerning that our understanding community adaptation readiness presently is quite limited. Thus, the objectives of this study are, to summarize existing community vulnerabilities to climate change and assess the readiness of these communities to adapt. The findings will provide insights and recommendations for decision makers and community leaders regarding community preparedness to adapt and what can be done to enhance it.

Chapter 2: Conceptual Frameworks

2.1 Human Dimension of Climate Change

The capacity of individuals, communities and societies to response and adapt to climate change fits within a newly developed realm of the climate change literature, the human dimension. The emergence of this concept, over a decade ago, has led to a shift in the understanding of how human systems respond to climate change. Whereas impacts to the natural or physical environment have long been the focus of climate change studies, over the past decade, more and more studies are focusing more attention on the impacts climate change is having on human systems (e.g.; AHDR, 2015; Ford et al., 2012a; Smit & Wandel, 2006; ACIA, 2005). Human systems can be examined at various scales, ranging from an individual level to issues of a global scale with numerous stakeholders involved. Regardless of the scale, adaptation and vulnerability approaches have widely been adopted by academics as the method by which to study the impacts of climate change on human systems (Cameron, 2012; Smit & Wandel, 2006). This approach to understanding climate change impacts places adaptation in the context of

human development and risk management (Christoplos, 2009). Climate change impacts and the risks and opportunities associated with them, will be investigated within this context throughout this study.

2.2 Vulnerability

The concept of vulnerability has been explored extensively in the literature (e.g. Brooks, 2003; Allen, 2003; Ford & Smit, 2004; Jones & Boer, 2003;). Defining the concept, however, remains challenging given its use and broad application by various disciplines. Conceptual frameworks of vulnerability have therefore been developed by researchers in an attempt to organize and simplify the multiple components of the concept and to attempt to clarify conflicting nomenclature. For my study, I will frame the concept of vulnerability predominately using studies that investigate the concept as it relates to the human dimension of climate change. Generally, vulnerability has been defined in such studies as a state that exists within a system before it encounters a hazard event (Allen, 2003), the amount of potential damage caused to a system by a particular climate-related event or hazard (Jones & Boer, 2003), and the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change (IPCC, 2007).

Biophysical as well as social factors, such as poverty, health, social networks, access to resources and social status, will play a role in determining the degree to which a community or individual is vulnerable to climatic hazards (Ford & Smit, 2004; Brooks, 2003). The most widely accepted conceptual model of community vulnerability defines it as a function of community exposure to climate change effects and its adaptive capacity to deal with the exposure (Smit & Pilifosova, 2003; Ford & Smit, 2004). However, in the latest IPCC Assessment Report (2014), vulnerability is conceptualized as a function of sensitivity and

adaptive capacity, with exposure deemed to be more appropriately associated with risk (Nobel, 2014). Sensitivity is defined by the IPCC as "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli" (IPCC, 2007). This definition is also the one which has been integrated into various conceptual frameworks developed to assess community vulnerability to climate change in the Canadian Arctic (e.g. Ford & Smit, 2004; Pearce et al., 2009; Andrachuk & Smit, 2012). A comprehensive adaptation assessment is one that examines both the risks and vulnerabilities associated with climate change (Nobel, 2014), however, a risk analysis is beyond the scope of this study and thus vulnerability will be conceptualized as a function of exposure-sensitivity and the adaptive capacity of communities to cope with current stresses.

2.3 Adaptation, Adaptive Capacity and Adaptation Readiness

Adaptation and adaptive capacity, while related, are two distinct concepts. Adaptive capacity refers to the ability of a system to change its behaviour in response to existing or anticipated stresses, thereby reflecting the *potential* of the system to adapt (Ford & King, 2015; Brooks, 2003). While adaptation refers to the *actual* adjustments made in the system's behaviour that allow it to cope better with external stresses (Brooks, 2003). These two concepts, adaptation and adaptive capacity, have gained considerable attention in the literature particularly in relation to climate change and the capacity of societies to adapt (e.g. Berrang-Ford et al. 2014; Adger et al. 2005; Brooks et al., 2005; Berkes & Jolly, 2001).

Adaptive capacity, however, is not a strong proxy for assessing adaptation readiness as it does not take into account many factors that influence whether adaptation is likely to take place (Ford & King, 2015). Thus, a system may display a high adaptive capacity, but it may not translate into adaptation action. This has created a gap in our understanding of adaptation

processes and uncertainty surrounding the factors that influence existence of adaptation actions..

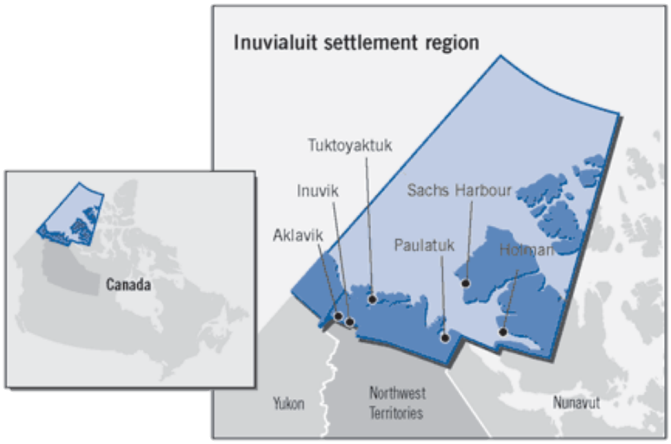
Adaptation readiness is a recently defined concept in the adaptation literature and is a function of 6 key factors affecting a system's readiness to adapt: political leadership, public support, funding, usable science, adaptation decision making & stakeholder engagement, and institutional organization (Ford & King, 2015). It presents a framework through which actual adaptive planning actions and experiences can be assessed to determine the extent to which a system is prepared to adapt (Ford & King, 2015). Ultimately providing a more complete picture of the adaptation processes.

Chapter 3: Inuvialuit Settlement Region

3.1 Geography

The ISR stretches east from the Alaskan border, along the southern coast of the Beaufort Sea to the Amundsen Gulf. It includes the western portion of Banks and Victoria Islands, covering an area of 906,403 km^2 (Fast et al., 2005; Pearce et al., 2011). The Settlement Region is comprised of six remote communities, two of which are located on the Mackenzie Delta (Inuvik and Aklavik) and four situated along the coast (Figure 1). The ISR has a population of 5,777, over 50% of whom are indigenous (Statistics Canada, 2012). The lifestyle and livelihood of the Inuvialuit is closely connected to the marine environment and thus very sensitive to the impacts of climate change, including sea-level rise, coastal erosion and reduced sea-ice extent.

Figure 1. Figure 1. The Inuvialuit Settlement Region (Auditor General of Canada, 2007)



2.2 Governance

The Inuvialuit have ownership over 10% of the land, including surface rights on 77,694 km^2 and both surface and sub-surface rights on 12,949 km^2 (Pearce et al., 2011; Fast et al., 2005). The land and sea-bed ownership were terms included in the Inuvialuit Final Agreement, signed in 1984 between the six communities and the Government of Canada (Pearce et al., 2011). The goals of the Agreement are "to preserve Inuvialuit culture identity and values within a changing northern society; to enable Inuvialuit to be equal and meaningful participants in the northern and national economy and society; and to protect and preserve the Arctic wildlife, environment and biological productivity" (Government of Canada, 1984:). Following the Agreement, various wildlife management and land-use bodies were formed and given responsibility for representing collective Inuvialuit interests, including upholding the goals of the Agreement (Fast et al., 2005).

The Inuvialuit Regional Corporation (IRC) was established and given responsibility for managing the $152 million in capital transfer payments the Inuvialuit received from the Government of Canada. These funds have been used by the IRC to develop economic and

political bodies in each of the six ISR communities (Pearce et al., 2011). The Inuvialuit Game Council (IGC) represents the collective Inuvialuit interest in wildlife and wildlife management and the Fisheries Joint Management Committee (FJMC) is responsible for administering the rights and obligations relating to fisheries and mammal management under the Agreement, including providing advice to the Minister of Fisheries and Oceans Canada (Community of Inuvik et al., 2008; Fast et al., 2005). All matters relating to wildlife management and policy, including the management of habitat and harvesting in the ISR, are handled by the Wildlife Management Advisory Council (WMAC) (Fast et al., 2005). The WMAC includes members representing the Government of Canada, the Government of the Northwest Territories and the Inuvialuit (Fast et al., 2005). Successful adaptation will require horizontal and vertical sector integration across multiple levels of government and co-management bodies.

The creation of these co-management bodies gives the Inuvialuit power to influence land-use and resource management decisions in the ISR, however, the majority of control over resource management decisions in the ISR rests with territorial and federal elected officials (Gjørv et al., 2013). The Inuvialuit have long sought to move towards a process of aboriginal self-government, an inherent right under section 35 of the *Constitution Act* (1982) (IRC, 2015). An Inuvialuit Government would grant the Inuvialuit more decision making power and authority over activities in the ISR and give them the authority to create and enforce their own laws and design their own social services and programs (IRC, 2015). On July 21, 2015 the Inuvialuit Self-Government Agreement-in-Principle (AIP) was signed in Inuvik by representatives from the federal and territorial governments and the Inuvialuit Regional Corporation (IRC, 2015). The signing of the AIP towards the development of the Inuvialuit Self-Government Agreement and the creation of an Inuvialuit government in the Northwest Territories.

2.3 Community Profiles

2.3.1 Inuvik

Located on the Mackenzie River Delta, within the northern most reaches of the tree line, the community of Inuvik is one of only two inland communities in the ISR. The community was established in 1958 when the Canadian Government moved its regional offices from Aklavik to Inuvik (Community of Inuvik et al., 2008). At that time, it was intended that Inuvik would replace Aklavik, but many in Aklavik refused to leave when the time came (Community of Inuvik et al. 2008). The new location of the town was chosen in part due to its close proximity to a gravel source, an invaluable resource for infrastructure development on permafrost ground (Borsy, 2009).

The Mackenzie Delta-Beaufort region was also rich in hydrocarbons and oil patch development interest began in Inuvik in the late 1960s (Fast et al., 2005). By the 1980s the oil patch was at its busiest and the community flourished (Community of Inuvik et al., 2008; Fast et al., 2005). A pipeline from the Mackenzie Delta was proposed in the 1970s but a federal inquiry to assess the ecological and social impacts recommended that, among other concerns, a ten-year moratorium on pipeline construction in the Mackenzie Valley to allow for time to settle ongoing land claim negotiations (Fast et al., 2005). Oil exploration activities in the region eventually ceased but the community remains an active center for commerce, research and government services (Gareis & Mercer, 2015; Fast et al., 2005). In Inuvik, there appears to be a significant shift from dependence on country foods compared to the other communities. Less than 25% of households in Inuvik continue to rely on country foods whereas dependence in Aklavik and Tuktoyaktuk is more than twice that amount (Table 1) (NWT Bureau of Statistics, 2014). This is

perhaps due in large part to the 'urbanization' and commercialization of the community. The community itself acknowledges that it has experience many changes during its history and has adapted well (Community of Inuvik et al., 2008).

Table 1. Population, employment, % of households consuming 50% or more country foods, and % of Aboriginals that speak an aboriginal language (all have been rounded to the nearest percent) (StatsNWT, 2014)

	Inuvik	Aklavik	Tuktoyaktuk
Population	3396	691	962
Employment	69%	42%	42%
Consuming country food	23%	72%	61%
Aboriginal language	21%	12%	25%

2.3.2 Aklavik

Aklavik is located 55 km west of Inuvik, along the Peel Channel on the Mackenzie Delta. The hamlet was established in 1912 as a Hudson's Bay trading post and quickly became an important trading center for a thriving trapping economy (Pearce et al., 2009; Rawluk et al., 2010). Overtime, the community expanded and eventually became the administrative and trading center of the ISR, housing the RCMP headquarters in the Western Arctic (Rawluk et al., 2010; Pearce et al., 2009). By the 1950's the population of the community had grown to over 1600 inhabitants, making it the largest sedentary community in the region (Rawluk et al., 2010; Pearce et al., 2009). The location of the community in a flood plain, coupled with its growing population, was placing strain on local infrastructure and prompted the Federal government's decision to relocate the community across the Delta (Rawluk et al., 2010).

Many community members resisted the move to Inuvik and chose to remain in Aklavik (Rawluk et al., 2010). Today, Aklavik's population is less than 700 people (691) (GNWT Bureau of Statistics, 2014), the majority of which are of Gwitch'in or Inuvialuit descent. The

economy of the town is supported by local tourism, hunting and trapping, infrastructure support and retail services (Pearce et al., 2009). Over over half (59.8%) of individuals in the community continue to hunt and fish (GNWT Bureau of Statistics, 2014). The community is accessible by air year-round, by boat in the summer and via an ice road in the winter linking it to Inuvik and Tuktoyaktuk (Pearce et al., 2009).

2.3.3 Tuktoyaktuk

The hamlet of Tuktoyaktuk (Tuk) is located on the southern coast of the Beaufort Sea, east of the Mackenzie Delta. The community is concentrated on a small peninsula along the eastern shore of Kugmallit Bay (Solomon, 2001). In 2014, the population of Tuk was 962 people, over 90% of which are of Inuvialuit descent (GNWT Bureau of Statistics, 2014). The community is located north of the northern limit of the tree-line, placing it in the tundra ecoregion, where the primary vegetation consists of mosses, shrubs and lichens (Department of Environment and Natural Resources, 2012; Couture et al., 2002).

Known in the 1930s as the 'caribou crossing' for its good fishing and trapping, a Hudson Bay Company Post was constructed in the community in 1934 (Couture et al., 2002). The growth and development of the community was aided by its close proximity to Tuktoyaktuk Harbour, one of the best harbors (20-30 m deep in places) in the region (Couture et al., 2002). Oil and gas exploration began in the Tuktoyaktuk Peninsula in the 1960s, followed by the discovery of oil in 1970, just 60 miles northeast of the community (Couture et al., 2002). Tuk was chosen by industry as the base for supply and staging operations and hundreds of workers lived in camps near the community (Couture et al., 2002). By 1982, 38 wells had been drilled offshore in the Beaufort Sea, resulting in the discovery of several oil and gas fields (Couture et

al., 2002). Unfortunately, the discoveries coincided with falling global oil prices and oil exploration in the region stopped (Couture et al., 2002).

Interest in hydrocarbon exploration and extraction in the Beaufort Sea has increased in recent years as supply diminishes elsewhere, but for the time being however, residents in the area depend primarily on tourism and traditional activities for economic revenues (Couture et al., 2002).

Infrastructure in Tuk is highly vulnerable to coastal erosion and permafrost degradation (Andrachuk & Pearce, 2010). The mainland coast of the Beaufort Sea is prone to erosion, with average retreat rates of one meter per year, but erosion of several meters has been recorded after individual storms (Andrachuck & Pearce, 2010; Carmack & MacDonald, 2002; Couture et al., 2002; Manson et al., 2005; Hamlet of Tuktoyaktuk, 1984; Reimnitz & Maurer, 1979; Solomon & Hart, 2000; Solomon et al., 1993). It is also important to note that the community has the administrative means to control land development in the shoreline erosion risk area (Johnson et al., 2003).

Chapter 4: Research Approach

4.1 Identifying Current Vulnerabilities and Adaptation Strategies

A traditional literature review of peer-reviewed and gray literature was conducted to determine current community vulnerabilities to climate change in each of the study communities. Six documents were reviewed, four from the peer-reviewed literature and three gray literature articles (GNWT, 2014; Andrachuk & Smit, 2012; Pearce et al., 2009; Andrachuk & Pearce, 2010; Pearce et al., 2011; Communities of Aklavik et al., 2005). The study conducted by Pearce et al. (2009) identified and reviewed 420 documents published between 1990-2009 that pertained to

climate change vulnerability in the ISR; this systematic review provided the baseline for my literature search. A literature search was thus conducted to seek-out articles published after 2010, that may provide additional vulnerabilities or adaptation strategies not captured in the research conducted by Pearce et al., 2009. Only geographically relevant documents were reviewed and only those vulnerabilities explicitly identified as affecting the study communities were recorded.

4.2 Assessing Community Adaptation Readiness

4.2.1 Systematic Reviews

Considering the growing body of literature on the subject of climate change adaptation and vulnerability in northern communities, conducting a systematic review of the literature presents a rigorous and transparent method of document collection and analysis (Ford et al., 2011; Ford et al., 2012b). The application of systematic reviews in climate change research has quickly grown in popularity to examine the impacts of climate change from the local to national scale (e.g. Berrang-Ford et al., 2014; Lesnikowski et al., 2013; Ford et al., 2012b; Pearce et al., 2011; Ford & Pearce, 2010). Systematic reviews differ from traditional literature searches in that they involve using specific search criteria and methods to select documents for inclusion in the study (Ford et al. 2011). Systematic reviews require the reporting of inclusion and exclusion criteria, including those publications excluded along with those included, and the search terms and databases used. This methodology allows for search replicability and an evaluation of study comprehensiveness (Ford et al., 2011).

4.2.2 Literature Search

A systematic methodology was developed to identify potentially relevant documents in the peer-reviewed literature, guided by the approach and framework developed by Ford and King (2015) and the systematic review approach followed by Ford et al. (2012). Three databases were used to search the peer-reviewed literature: Novanet, Web of Science, and Google Scholar. Search terms consisted of geographically relevant place names as well as thematically relevant key words, with four qualifier terms were used to reduce the possibility of unrelated search results (Table 2).

Table 2. Search terms used to identify potentially relevant literature

Search terms	
Geographic	"Inuvialuit Settlement Region"; "Aklavik"; "Inuvik"; "Tuktoyaktuk"; "Western Arctic";
Key words	"Vulnerability"; "Environmental change"; "Adaptation readiness"; "Traditional knowledge"
Qualifier	"Canadian Arctic" OR "Adaptation" OR "Climate change" OR "Inuvialuit"

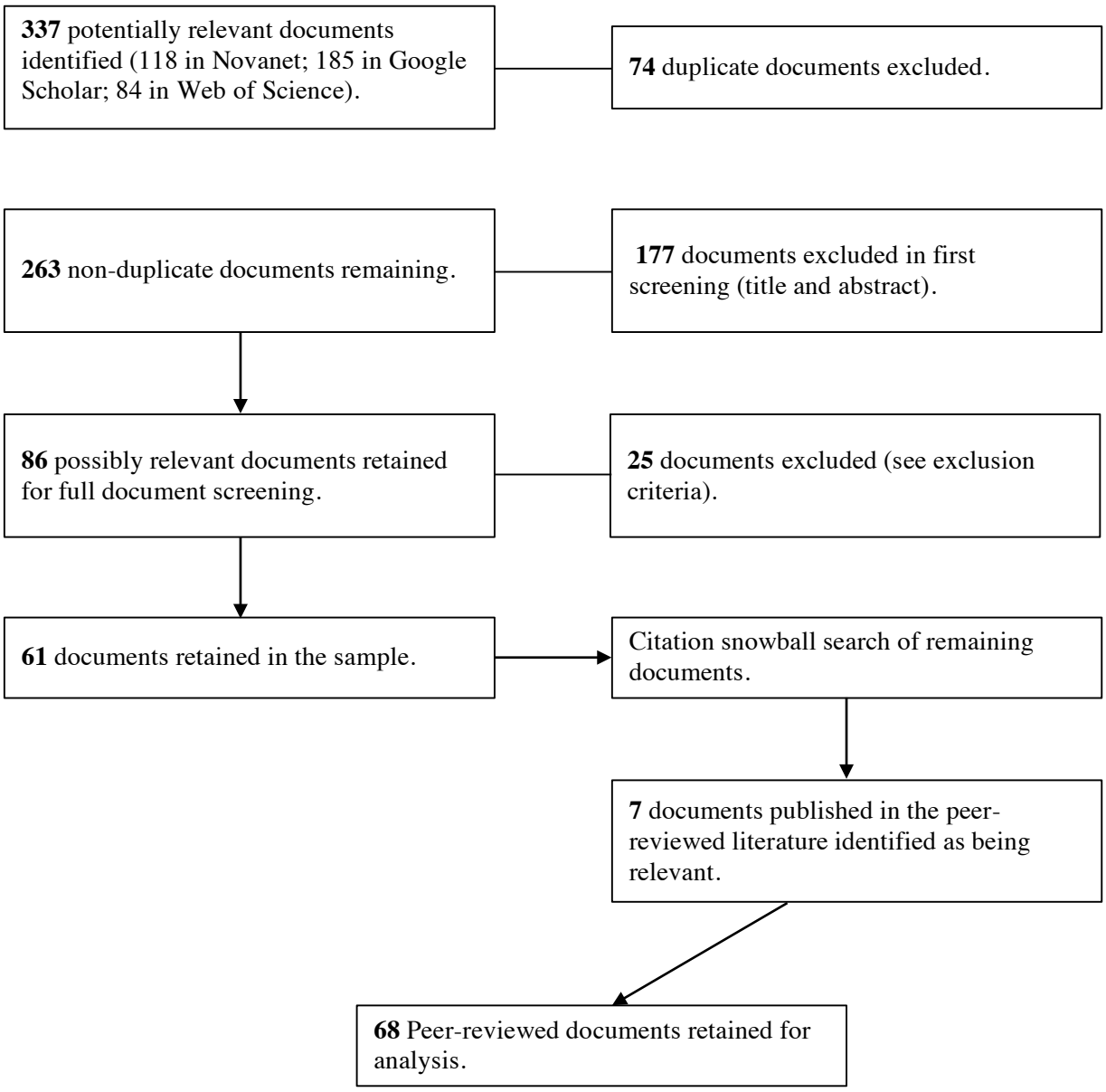
The title and abstract of each non-duplicate article was screened according to the inclusion criteria (Table 3), those documents that failed to meet the inclusion criteria were removed (Appendix 2). The remaining 86 documents were then read in full for relevancy, of which 25 were removed for failing to meet the inclusion criteria (Appendix 2).

Table 3. Criteria used to select relevant literature to be retained in the study

Inclusion criteria	Exclusion criteria
Relevancy: must be concerned with the community *adaptation* response to climate change.	Articles that do not meet the relevancy criteria, i.e. documents relating to climate change mitigation.
Overarching focus is on the human dimension of climate change.	Focus is explicitly on the response of biophysical systems to climate change.
Minimum level of information: information must pertain to the six readiness factors.	Conceptual adaptation documents, i.e. those that do not address or include actual adaptation initiatives, etc.
Involvement: Adaptation actions must be conducted either exclusively by the study community, or in conjunction with the ISR or territorial government.	Actions conducted exclusively by territorial or federal governments, without local involvement or engagement.
Literature will only be included in the review if the content is geographically relevant.	Literature unrelated to the study region.
Government documents and webpages, peer-reviewed articles, adaptation plans and assessments, community/municipal/territorial reports.	Conference papers or abstracts (unless community authorship).
Timeframe: 2000-2015	Documents dated prior to 2000.
Both positive and negative impacts of climate change will be included in the dataset	
Is in English.	Is not in English.

Following the second screening, a 'snowball' search was conducted whereby an additional seven publications were identified. This step involved reviewing all of the cited references in selected articles and retaining those that were missed by the database search. In total, 68 articles were retained for analysis (Figure 2).

Figure 2. Flowchart describing the process followed to identify relevant peer-reviewed articles (adapted from Ford et al., 2012b)



4.2.3 Criteria and Indicators

While the readiness framework developed by Ford and King (2015) identified the general factors that have been shown to influence adaptation readiness, a method for assessing each factor needed to be developed in order to analyze the retained literature to assess factor comprehensiveness in each community. A review of the adaptation literature was conducted to identify criteria (and potential indicators) shown to facilitate or constrain adaptation planning and implementation. The following is a summary of the components identified in the peer-reviewed literature as instrumental in the facilitation of effective adaptation actions. The review was not restricted to local scale studies and thus represents an overview of the criteria important for adaptation development across various scales.

Political leadership for adaptation

The role of leadership in moving climate change adaptation forward has been well supported in the literature (Ford & King, 2015; Ford et al., 2013; Measham et al., 2011; Brown, 2005). Leadership conducive to adaptation action can come from individuals spanning multiple levels of government, including local council members and elected representatives, who enable adaptation through initiating, mainstreaming and sustaining momentum for adaptation action (Pachauri et al., 2014; Brown 2005). When climate change is identified as a priority issue by individuals in a leadership position, the momentum it creates then has the potential to cascade throughout the organization. As a result, individuals working in supportive governance positions will often consider climate change a priority issue when it has been addressed as one by those in higher positions (Measham et al. 2011). Statements identifying climate change as a priority issue is therefore one of the criteria by which the political leadership factor will be assessed.

A lack of political will has also been identified in the literature as one of the major challenges hindering effective adaptation evolution at a local level (Ford et al. 2011). In the absence of regional and local political support for adaptation, inconsistencies may arise between national priorities or statements of action and the actual action that takes place locally (Ford et al. 2011). Support for adaptation by local leaders plays an important role in advancing adaptation action forward, and therefore it is an appropriate criterion by which the comprehensiveness of political leadership in each community can be assessed. In this analysis local statements will be assessed for fullness, where those statements that lead to or result in adaptation action will be scored higher than statements that fail to promote adaptation action. failed to bridge the gap between national or territorial statements and actual local action.

Access to financial assets is frequently cited in the literature as imperative to the evolution of adaptation planning and implementation. A lack of funding for adaptation is commonly cited as a constraining factor when attempting to develop effective adaption strategies (Pachauri et al., 2014; Measham et al., 2011; Smith et al., 2009). Limited financial resources can hinder adaptation effectiveness by reducing the scale of investment in adaptation policies and actions; ultimately hindering their effectiveness (Pachauri et al., 2014). Local lobbying by community leaders has been identified as one avenue through which community funding for adaptation activities can be secured (Measham et al. 2011). Community leader who have demonstrated an ability to successfully secure or lobby for adaptation funding is the third criterion by which the political leadership factor is assessed.

Political and community actors who display a strong willingness to coordination with various stakeholders, government officials, agencies and the private sector can enhance the momentum created by the prioritization of adaptation efforts through increased efficiency,

representation across multiple platforms, while cultivating support for climate adaptation (Pachauri et al., 2014). Such coordination and mainstreaming of adaptation activities and knowledge has been identified in the literature as essential to carrying-out effective adaptation (Smith et al., 2009). A study conducted by Measham et al. (2011) found that when climate change and adaptation were considered issues of importance by local leaders, the necessary resources tended to be available and information needs were often addressed. Strong leadership is thus crucial when addressing a complex problem such as climate change that requires political support, access to resources, and cross-sectorial collaboration (Smith et al., 2009). Communities where such leaders exist, i.e. leaders who have displayed an ability to work collaboratively with various stakeholders and agencies to tackle complex problems, will be more successful at creating and implementing effective adaptation strategies. Therefore, this is an appropriate criterion by which political leadership for adaptation can be assessed. The ability of community actors to coordinate adaptation strategies can, however, be hinder if not supported by strong institutional structures (Pachauri et al., 2014; Measham et al. 2011).

Institutional organization & administrative structure for adaptation

Strong institutional structures can enhance the ability of community actors to carryout adaptation through enhanced coordination of adaptation policies and actions, improve long-term planning capacity, and generate strong adaptation networks. Robust institutional structures allow for the integration of adaptation into planning processes, including policy design and decision-making, which can promote cross-departmental collaboration (Pachauri et al., 2014). Such institutional efforts to mainstream adaptation efforts into everyday decision-making processes have been identified in the literature as 'significant' when attempting to adequately address adaptation needs (Pachauri et al. 2014; Smith et al. 2009). When these efforts are absent or

lacking in a local institutional structure, they can be improved via enhanced governance coordination and cooperation, both within community departments and across levels of government. This has been shown to help organizations overcome the regional constraints associated with actually doing adaptation (Pachauri et al., 2014).

It is well recognized that adaptation planning and implementation can be enhanced through complementary actions and coordination across levels, from individuals to governments (Pachauri et al., 2014). Given the complexity and interconnectedness of climate change impacts, effective efforts to adapt to climate change will require strong coordination and cooperation at multiple scales (Pachauri et al., 2014)). The coordination and cross-departmental collaboration within governance structures has been identified as essential in order for institutions to adequately address adaptation and could promote the develop dual-benefit adaptation strategies (Pachauri et al., 2014; Smith et al., 2009). Evidence of cross-sectorial collaboration within community governance structures should thus be considered as a strong indication of institutional organization.

In the absence of strong institutional organization, however, the occurrence of poor adaptation planning or implementation rises, as overemphasis is placed on short-term outcomes due, in part, to inadequate institutional capacity for long-term adaptation planning (Pachauri et al., 2014). In the absence of long-term planning efforts, communities run the risk of promoting maladaptation which could inadvertently increase community vulnerability or exposure to climatic threats (Pachauri et al., 2014). Taking a longer-term perspective, has been shown to increase the likelihood that the implementation of immediate adaptation actions will also enhance future actions and preparedness (Pachauri et al., 2014). Evidence of long-term planning capacity within a community will therefore serve as an indication that community actors are

prepared to plan for and implement effective adaptation actions; facilitated by strong institutional support. In some cases, new institutional arrangements that span multiple scales may need to be developed before this criterion can fully be met. A coordinating body or individual responsible for initiating adaptation coordination and communication across scales should also be considered as an asset to effective adaptation planning and implementation. As such a body could ensure that adaptation is acknowledged and incorporated in the decision-making process, promote cross-institutional collaboration, and ensure communities are aware of funding opportunities. Ultimately, strengthening the readiness of an institution and communities to adapt.

Adaptation decision making and stakeholder engagement

Stakeholder involvement in the decision making process is necessary to ensure that the needs and concerns of those being affected by climate change impacts are considered in the planning process. The likelihood of adaptation taking place will depend largely on the practicality of developed plans given the resources and governance capacity of the region. Community participation during the development of adaptation plans will not only improve the practicality of developed strategies but also enhance community buy-in and local compliance with adaptive actions. Thus, the inclusion of stakeholders in decision-making processes will ultimately strengthen the likelihood of adaptation evolution, implementation and effectiveness.

Given the uncertain and unpredictable nature of climate change, enacting and implementing effective adaptation requires flexible decision-making structures. When decision-making processes fail to accommodate and account for the uncertain nature of vulnerability inducing impacts, this often translates to stalled or abandoned adaptation attempts (Ford et al., 2015). Participatory involvement in decision making can strengthen the evolution of adaptation through the recognition of external forces beyond climate change influencing community

vulnerability (Smit & Wandel, 2006). The ability of an institution to carry-out adaptive decision-making hinges largely on institutional capacity and organizational structure, interdependencies among the readiness factors. What is vulnerable in one time period may not be vulnerable in the next, or may not be vulnerable in the same way (Smit & Wandel, 2006). Adaptive decision making allows for the consideration and development of responses that can be changed as sensitivities and adaptive capacities evolve over time (Smit & Wandel, 2006). This is especially pertinent for coastal systems and low-lying communities where the impacts and rate of change are enhanced. Indicators of adaptive planning include the existence of adaptive plans or documents to address climate change, such community climate change plans, innovative strategies, or evidence of flexible management decisions.

Availability of usable science

Successful community adaptation requires an understanding of who and what are vulnerable, its capacity to adapt, the associated costs, benefits, and risks of available options (Pachauri et al., 2014; Ford & Smit, 2004). The utility, however, of many academic studies in promoting adaptation varies depending on a number of factors. Studies must produce information that is relevant, timely, and addresses community needs (Amundsen et al., 2010; Measham et al., 2011). If climate change and adaptation research is to stimulate a change in policy development or governance structures, it must also offer practical recommendations that are relevant to decision makers (Nobel et al., 2015; Smith et al. 2009). Thus, in this analysis, usable science is defined as, information that enhances the awareness or understanding of climatic risks and impacts, adaptation costs, community capacity to adapt, and community vulnerabilities.

The integration traditional knowledge into planning and policy practices has also been shown to increase the effectiveness of adaptation (Pachauri et al., 2014). In addition to content, the availability, language, and format of studies needs to be considered when assessing its usability. The utility of research findings will be greater if those findings are communicated directly to community members, or at the very least present in a format that is user-friendly, such as the use of tables or charts to summarize study findings. This is not to say that a study must meet all these criteria in order to be considered usable and so it is important to note that each criterion utilized in this analysis is considered to be of equal value. Each criterion, however, will need to be present throughout the existing literature in order for this factor is to be considered fully met during the analysis.

Funding for adaptation

A lack of financial capacity and resources at a local level is frequently cited as a constraint to implementing adaptation strategies and often hinders long-term planning attempts (Measham et al., 2011; Smith et al., 2009). Additional funding dedicated to supporting adaptation policy development or adaptation actions is usually required before strategies can be developed or implemented (Smith et al., 2009). As noted previously, this is strongly tied to political will and the capacity of local officials or community councils to secure adequate funding for adaptation. The availability of funding is thus strongly tied to the platforms of elected officials, who have the power to enable or hinder adaptation (Measham et al., 2011). There is thus a strong connection between political leadership for adaptation and availability of funding for adaptation actions. This is reflected in the criteria that was developed to assess this factor, whereby specific funding dedicated to adaptation initiatives, the availability of multi-year funding, and community capability to secure funding are all considered necessary. Building

individual and community adaptive capacity is also essential for effective development and implementation of adaptation options (Pachauri et al., 2014), thus while funding aimed at enhancing adaptive capacity is being incorporated in this assessment of adaptation readiness.

Public Support

Social acceptability of climate change adaptation is an essential factor of successful adaptation implementation, especially at a local scale. Gaining public support for climate adaptation actions can be a challenging tasks, specifically when a change in lifestyle or behaviour is required, however, failing to do so could jeopardize or stall the adaptation process. Public support for adaptation or concern about climate change can also be a powerful tool for mobilizing political leaders to take action on this issue, thus promoting readiness through various avenues.

Community support for adaptation can be assessed by exploring community acceptance of developed adaptation plans, and evidence of community concern regarding current or future impacts associated with climate change. Given that the social acceptability, and ultimately the effectiveness of climate policies, is influenced by the extent to which they incentivize, or the degree of lifestyle or behavioural change required (Pachauri et al., 2014). Enhancing community awareness and understanding of climate change impacts and the need for adaptation can improve readiness by raising social capital, an important component when adaptation requires a change of behaviour or way of life. It is important to note that observations of climate change impacts does not translate to concern, community concern about climate change impacts must be explicated stated.

4.2.4 Limitations of approach

Due to time constraints, no primary data could be collected for the analysis, and as a result the research approach includes only publicly available information. Original thoughts or opinions of the residents, leaders or figureheads living in the study region have not been incorporated into the analysis and therefore had no influence on the findings. This should be noted as an acute limitation to the study approach given that a participatory assessment may have uncovered evidence that was not apparent in the publicly reviewed literature. Such information may have altered the findings of this study and most certainty would have improved the fullness of the author's recommendations.

4.2.5 Assessment of Readiness Factors

A qualitative content analysis was conducted using the retained literature to assess community readiness using the readiness factors using a predetermined typology. Each article was read in-depth and manually coded using predetermined criteria and indicators. The criteria and indicators used were developed based on repeating characteristics and themes supported in the literature as important for cultivating adaptation actions (Table 4).

Table 4. Criteria, indicators and sources of information used to assess readiness factors in each community

Readiness factor	Criteria	Indicators	Sources of Information
1. Political leadership for adaptation	a. Adaptation actions initiated by a community figurehead or adaptation champion. b. Climate change identified as an important issue. c. Figurehead who can acquire resources. d. Ability to work collaboratively with multiple stakeholders to promote adaptive action & build partnerships.	• Statements identifying adaptation as a policy or community priority. • Statements describing climate change impacts or calls for action. • Support the implementation of community adaptation plans or strategies (i.e. lobbying, secure funding, etc.). • Engagement in climate change workshops or planning events; evidence of partnership building.	Legislative Assembly transcripts Community council minutes Speeches from elected and community officials
2. Institutional organization & administrative structure	a. A coordination committee or person who promotes and oversee adaptation activities. b. Capable of long term planning to address climate change impacts c. Promotes horizontal and vertical coordination of adaptation actions.	• A coordinating body or committee responsible for climate change adaptation. • Implementation of long-term plans or actions to address climatic risks. • Collaboration within communities, across sectors and/or levels of government.	Community management plans and adaptation strategies Territorial climate change coordinator
3. Adaptation decision making and stakeholder engagement	a. Stakeholder concerns are considered. b. Flexible decision making processes, i.e. evidence of adaptive management.	• Adaptation plans or strategies that incorporate stakeholder concerns. • Stakeholders included in climate change events or workshops. • Existence of adaptive management plans or documents	Community adaptation plans Resource management documents Government and community websites
4. Availability of usable science	a. Should enhance existing knowledge of climate change impacts, costs of action, community vulnerability, and/or adaptive capacity. b. Incorporate TEK with scientific knowledge. c. Assess risks and costs of climate change. d. Contribute to decision making processes (produces information relevant for policy development).	• Existence of community impact, vulnerability, adaptation, or cost-benefit assessments. • Community participation in studies; integration of TEK. • Existence of community-based risk & cost assessments. • Adaptation policy or decision-making recommendations are provided.	Peer-reviewed literature
5. Funding for adaptation planning, implementation and evaluation	a. Specific funding for adaptation activities. b. Multi-year funding. c. Individual(s) at the community level responsible for securing adaption funding.	• Assigned funding for community adaptation plans or strategies. • Employed funding coordinator.	Federal, territorial, municipal budgets Government websites Legislative Assembly transcripts
6. Public support for adaptation	a. Community acceptance of developed adaptation plans or strategies. b. Participation in opportunities to build awareness or adaptive capacity of residents. c. Community concern over climate change impacts.	• Community member involvement in the planning or implementation of adaptive strategies. • Participation in community meetings. • Statements of concern from residents.	Community adaptation plans Government websites (e.g. MACA) Northwest Territories Association of Communities documents and websites Community council minutes

A continuous quantitative scoring scheme was then assigned to each indicator, based on the adaptation literature (Table 5). This approach presents a robust assessment of adaptation readiness because the quality, i.e. the potential of each indicator to strengthen readiness, can now be incorporated in the readiness score. The resulting scores were converted to scores out of ten (10) and averaged to produce a score for each readiness factor. The factor scores were then summed and averaged to produce a community readiness score. This approach allowed for standardized comparisons between each community readiness score.

Table 5. Indicator scoring scheme

Readiness factor	Indicator Scores
1. Political leadership for adaptation	
1a)	Statements identifying adaptation as a policy or community priority. Leads to action? A score from 0-2, where 0 means no statement, 1 indicates statements made and 2 means statements were made, followed by action.
1b)	Statements describing climate change impacts or calls for action. A score from 0-1, where 0 means no statement, 1 indicates leaders have acknowledged climate change as a serious issue.
1c)	Support the implementation of community adaptation plans or strategies through lobbying or secure funding. A score from 0-2, where 0 means no evidence, 1 means statements requesting funding were made and 2 means funding for adaptation activities has been acquired.
1d)	Engagement in climate change workshops or planning events; evidence of partnership building. A score from 0-2, where 0 means no engagement, 1 indicates collaboration within the community scale and 2 indicates collaboration by community actors across multiple levels of government.
2. Institutional organization & administrative structure	
2a)	A coordinating body or committee responsible for climate change adaptation. Score from 0-1, where a score of 0 means no coordinating body and 1 means an active body exists.
2b)	Implementation of long-term plans or actions to address climatic risks. Score from 0-1, where a score of 0 means no evidence of long-term planning and a score of 1 indicates long-term plans to address climate change impacts exist.
2c)	Collaboration within and across sectors and levels of government. Score from 0-2, where a score of 0 means no collaboration, a score of 1 means only one (vertical or horizontal) is evident, and 2 means both are present.
3. Adaptation decision making and stakeholder engagement	
3a)	Adaptation plans that incorporate stakeholder concerns. Score from 0-1 (absent or present). Stakeholders included in climate change events or workshops. Score 0-1 (absent or present).
3b)	Existence of adaptive management plans or documents. Score from 0-1, where 0 means no plans, and 1 means adaptive management plans exist and. Score of 1.5 if plans or decisions have been evaluated or revised?
4. Availability of usable science	
4a)	Existence of community impact, vulnerability, and adaptation assessments. Score 0-3, where 0 means no assessments have been completed and 3 means there is evidence that all 3 forms of assessments exist in the literature.
4b)	Community participation in studies; integration of TEK. Score 0-1, where TEK either is (1) or is not included (0) in studies.
4c)	Existence of community-based cost & risk assessments. Score 0-2, where 0 means no assessments, 1 means only one sector has been assessed, and 2 means various sectors have been assessed.
4d)	Adaptation policy/decision-making recommendations are provided. Score 0-2, 0 means no relevant recommendations made, and 1 means adaptation recommendations have been made in the literature, 2 means results were communicated with community members.
5. Funding for adaptation	
5a)	Assigned funding for community adaptation plans or strategies. Score 0-2.5, where 0 means no funding has been assigned, 0.5 funding to improve adaptive capacity is achieved, 1.5 means short-term funding dedicated to adaption has been assigned, and 2.5 means multi-year funding for adaptation has been secured.
5b)	Employed funding coordinator. A score from 0-1, where 0 means no funding coordinator is employed and 1 means a coordinator is employed.
6. Public support for adaptation	
6a)	Community member participation in the planning or implementation of adaptive strategies. A score from 0-1, were 0 means no community participation and 1 means there is evidence of participation.
6b)	Participation in community meetings. A score from 0-1 where 0 means no participation and 1 means community members have attended climate change workshops.
6c)	Statements of concern from residents. A score from 0-1 where 0 means no statements of concern have been issued by residents and 1 means resident concerns are evident.[1]

[1] Resident *concern* of climate change impacts was not considered synonymous with resident *observations* of climate change impacts.

Chapter 5: Current Community Vulnerability Summary

This chapter presents the findings of the traditional literature review on existing community vulnerabilities, adaptive capacities and existing adaptive strategies. The findings for each community have been categorized into the following sectors: harvesting & food security, infrastructure, health & well-being, and economy.

Tuktoyaktuk

Harvesting & Food Security

The ability of community members in Tuk to hunt and provide country foods for themselves and their families is being affected by climate change. Hunters have reported that unpredictable weather conditions are making it increasingly difficult to predict when conditions are safe and suitable for travelling to hunting grounds (Andrachuk & Pearce, 2010, Community of Tuktoyaktuk, 2005). Changes in vegetation type and abundance (i.e. more shrubbery) is hindering the ability of residents to move across the land and find game like they use to (Community of Tuktoyaktuk, 2005). The abundance and location of traditionally harvested species are also shifting due to hanging temperatures, weather patterns and vegetation growth. This is making it more challenging for hunters to locate wildlife, such as caribou, gamebirds, and whales, as the range and migration route of these species changes (Andrachuk & Pearce, 2010; Andrachuk, 2008; Pearce et al., 2009; Community of Aklavik et al., 2005). Beluga whales for example, have been sighted less frequently in Kugmallit Bay due to stronger winds, and as a consequence the ability of residents to harvest enough meat to feed themselves and their families is put in jeopardy (Andrachuk, 2008).

Community members have adapted to these challenges by enacting reactive strategies to address the challenges. Hunting regulations have been put in place to protect the declining caribou herds (Andrachuk & Pearce, 2010). Community Polar Bear Management Agreements and community by-laws were established following concerns that sport hunting was resulting in overharvesting (Andrachuk, 2008). Management initiatives include not killing females with cubs less than a year old, hunting is only allowed between December 1st and May 31st, and the protection of important habitat (Andrachuk, 2008). These initiatives are completely voluntary and indicate that the community is capable of implementing long-term strategic adaptive strategies that require collaboration among harvesters and co-management organizations (Andrachuk, 2008). Those residents with the financial capacity to do so, have invested in new technologies to increase harvesting efficiency, such as skidoos, firearms and GPS devices (Andrachuk & Smit, 2012).

The behaviour and timing of harvests have had to change in order for hunters to continue accessing traditional foods. Residents have started harvesting more abundant species, such as fish and musk-ox when numbers of more traditional species, such as when caribou are down (Andrachuk & Pearce, 2010; Andrachuk & Smit, 2012). The timing of species harvests is being altered to better match new wildlife migration patterns (Andrachuk & Smit, 2012). The way in which traditional foods are prepared and preserved has also changed in order to prevent spoiling as temperatures increase (Andrachuk & Smit, 2012).

Infrastructure and Transportation

Like many northern communities, permafrost melt in Tuk has caused infrastructure and roadway degradation (Andrachuk & Pearce, 2010; Andrachuk & Smit, 2012). Given that the community is underlain by large amounts of ground ice, rising temperatures pose a significant

risk to community infrastructure. As the ice melts, the once stable permafrost layer transitions to an unstable active layer, threatening the integrity of those buildings that rely on stable permafrost ground for structural support (GNWT, 2008). Permafrost melt has also increased the frequency of landslides and promoted ground slumpage (Pearce et al., 2009; French, 2008; Dyke et al., 1997). General circulation models (GCM) predict that the region could experience a 4 °C to 5 °C increase in mean annual air temperatures by 2050, if atmospheric CO_2 levels are allowed to double (Couture et al., 2002). Suggesting that active layer thickening will continue for years to come.

Due to the community's location on the coast of the Beaufort Sea, the future of Tuk is also extremely vulnerable to coastal erosion and sea-level rise. Events of rapid coastal retreat tend to occur in late August and September when strong storm events are more frequent (Andrachuk & Pearce, 2010; Couture et al., 2002; Johnson et al., 2003; Manson et al., 2005; Reimnitz & Maurer, 1979). During a strong storm event in August 2015, several meters of coastline were lost to the sea (MacFadden, 2015).

Adaptations to to reduce the impacts of climate change impacts on coastal infrastructure have been ongoing in Tuk since the mid-1970s, focusing predominantly on shoreline protection (Andrachuk & Pearce, 2010; Johnson et al., 2003). At the request of the Government of the Northwest Territories, the federal Department of Public Works conducted a study to determine the causes of erosion and advise the community on how shoreline protect should be used to protect at risk infrastructure (Solomon, 2001). The results of the study indicated that most of the community is underlain by a massive lens of ice, up to 4 meters thick in some places (Solomon, 2001; Kolberg & Shah, 1976). Thaw subsidence associated with melting of the ice sheet was identified as the main cause of rapid erosion rates, prompting the installation of protection

measures to prevent further melting (Solomon, 2001). Longard tubes and groins were installed in front of the school in 1976, which was located on the coastline, underlain by ice and thus at risk from erosion (Solomon, 2001). The protection measures were successful at slowing erosion rates, however, vandalism in the area compromised their effectiveness and by 1981 the longard tubes had been destroyed (Solomon et al., 1993; Shah, 1978).

In 1987, a shoreline reclamation project was undertaken by the community where sand was dredged offshore, place on the beach and protected from removal using sandbags (Solomon, 2001). This effort was successful for a short period of time, until a strong storm in 1993 removed over half of the sandbags, ultimately undermining their effectiveness (Solomon, 2001). Following the loss of the sandbags, up to 8 m of shoreline was lost to erosion along most of the coast (Solomon, 2001). This prompted a study the following year by the GNWT to determine the best options for the community moving forward, the study concluded that gradual withdrawal from the peninsula would be the most cost-effective option (UMA Engineering Ltd., 1994). This recommendation was unfavorable among residents, and the community has continued to fight coastal erosion despite these findings.

More recently, shoreline protection measures, such as the installation of concrete slabs and rip-rap, have been successful at reducing the rate of shoreline erosion (Andrachuk & Smit, 2012), however it is difficult to predict how successful these measures will continue to be in the long-term as erosion rates and sea-levels continue to increases. The community has enacted long-term adaptive strategies, such as relocating coastal buildings deemed to at immediate risk to erosion coastal (Andrachuk & Smit, 2012; Andrachuk & Pearce, 2010), unfortunately even these measures may be ineffective given long-range projections of sea-level rise have predicted that it

is very likely that sea-level could rise by 0.31 m by 2015 and up to 0.76 m before the end of the century (Manson & Solomon, 2007).

Health and Well-being

Cultural erosion and the loss of traditional ecological knowledge (TEK) is perhaps one of the most distressing issues associated with the impacts climate change. Granted, climate change itself may be better defined as a facilitating factor of cultural erosion as oppose to the direct cause. There has been shift from a subsistence based economy to a wage dependent economy as the community and its (natural) resources become more accessible for the development (Andrachuk & Smit, 2012). The diversification of the local economy means employed residents tend to spend less time on the land because they are employed in hourly jobs (Carmack 2008). With this economic shift, the value of traditional knowledge may depreciate, and many residents fear the intergenerational transmission of TEK will be lost as the north opens to Western investment and development (Andrachuk & Smit, 2012).

Adaptive measures to reduce impacts on the harvesting sector, such as the development of hunting regulations, have been blamed for impeding traditional hunting practices and the ability of residents to 'connect with the land' (Andrachuk, 2008; Pearce et al., 2009). While the regulations are in place to ensure the long-term viability of species for future generations, they appear to be indirectly limiting the ability of harvesters to provide nutritionally adequate foods to the community and their families (Andrachuk & Smit, 2012). In the absence of such traditional foods, community members rely on store foods, many of which have less nutritional value than country foods, and are more expensive (Andrachuk & Smit, 2012). Community members who are unable to hunt, have adapted by purchasing traditional foods from full-time harvesters when available (Andrachuk & Pearce, 2010). Food sharing is an important part of Inuvialuit culture

and community members have described having a lessened sense of wellbeing when their diet does not consist, at least in part, of country foods (Andrachuk, 2008).

Species shifts and changing temperatures are causing community anxiety and stress, but, residents are also taking advantage of early ice break-up and warmer temperatures by spending more time participating in outdoor activities (Community of Tuktoyaktuk 2006; Pearce et al. 2009).

Economy

The community of Tuk has displayed entrepreneurial spirit in the face of changing socio-economic and natural conditions, such as the establishment of local tour operations and artisanal craft markets (Andrachuk & Smit, 2012). Sport hunters have adapted to altered snow quality by carrying-out hunting expeditions by dog sled instead of using skidoos (Andrachuk, 2008). The construction of an all-weather road connecting Tuktoyaktuk to Inuvik, brings with it the hope of increased jobs, tourism, and cheaper supplies.

Tuktoyaktuk's flexible economy is credited with enhancing its adaptive capacity to cope with changing climatic conditions (Andrachuk & Smit, 2012). However, the economy of the community is still sensitive to the impacts of climate change. The listing of polar bears in 2008 as threatened by the U.S. *Endangered Species Act* has impacting the livelihood of hunters and the economy of the community (Andrachuk & Smit, 2012). A decline in the abundance of traditional species has also contributed to a loss of income for harvesters and has prompted some to search for a more stable source of income (Andrachuk, 2008).

Positive aspects of climate change for the community include tourism and increased shipping opportunities. The potential social and economic impacts of such developments are not

expected to be substantial in the near future (Andrachuk & Smit, 2012).

Inuvik

Harvesting

In Inuvik, harvesters have observed that above average water temperatures are causing fish caught in nets to spoil faster, affecting the quality and viability of the meat (Nickels et al., 2005). Fishers have responded to this change by adapting their fishing practices (e.g. checking nets more frequently) to limit the amount of time their catch stays in the water. Earlier ice break-up and later freeze-up of inland waters are thought to be forcing caribou herds to spend more time near the coast where it is also hypothesized that higher winds give them relief from mosquitoes (Community of Aklavik et al., 2005). This shift in herd migration means hunters must travel further distances, increasing travel time and risk as weather conditions become more unpredictable (Community of Aklavik et al., 2005). This shift, coupled with reports that the health of the animals is declining and in some cases the meat is inedible and infected with parasites, has resulted in fewer hunters participating in hunting expeditions and general community wariness of caribou meat (Community of Aklavik et al., 2005). Given that caribou is considered a traditional food of the Inuvialuit (Community of Aklavik et al., 2005), poor animal health is likely also threaten community health and well-being.

Infrastructure and Transportation

Climate change is threatening one of the main points of entry into the community, the Dempster Highway, an all-weather road connecting Inuvik to the Klondike Highway in the Yukon and a major gateway for the community. The highway is being threatened by permafrost degradation and slope instability, resulting in frequent landslide events (GNWT, 2014; Pearce et al., 2009). The Dempster Highway Vulnerability Assessment (DHVA) was conducted by

Transport Canada in collaboration with the Government of the Yukon and the Government of the Northwest Territories. The purpose of the DHVA is "to assess the vulnerability of the highway to the impacts of climate change" (Trimble, 2013). Findings to date indicate the stability of the permafrost underneath the Dempster Highway is very susceptible to small changes in air temperatures (Trimble, 2013). Community leaders have reported delays in community supply shipments due to the adverse and unpredictable weather conditions, affecting local businesses (Deton' Cho Stantec, 2013).

The NWT Department of Transportation (DOT) is responsible for highway repairs and allocation of funding, giving the community little control over highway maintenance. Elected community officials (MLAs) have voiced their concern over the condition of the highway and the safety and economic impacts its degradation is having on the community. Measures have been taken to better insulated and ventilate the ground underneath the highway to delay permafrost thaw (Borsy, 2009).

Ice roads around the town are also degrading, forcing community members to use more expensive and less safe travel routes (Community of Inuvik, 2006). In 2010, $2.8 million in funding was secured under the federal government's Infrastructure Stimulus Fund for road improvements in the community (Infrastructure Canada, 2010). The improvements were cited as being "critical to the success of Inuvik's economy", by former community mayor, Denny Rodgers (Infrastructure Canada, 2010). Leading one to question whether climate change alone can stimulate adaptation action.

More extreme winter storms are causing damage to community infrastructure, including water and sewage systems (GNWT, 2014). Thermosyphons have been installed under the Health

Care Center to protect it against permafrost thaw (Borsy, 2009). This method of permafrost protection involves the use of thermosyphons to extract heat from the ground, thus keeping the frozen ground cool and delaying permafrost thaw (Borsy, 2009).

Drier than usual conditions have resulted in more frequent forest fires near the community, threatening buildings and generating community anxiety (Nickels, 2005). Following a major fire in 1968, fire guards were installed around the town and since then emergency and natural resource management practices have been developed and reflect best lessons learned (GNWT, 2014; Wein, 2002).

Health and Well-being

Climate change is being blamed for an increase in the number of 'hot days' observed in the town, resulting in more heat related health issues, mainly dehydration and stress (Nickels et al., 2006). Insect numbers have increased across the Western Arctic, causing anxiety over the transmission of disease and prompting general annoyance over their abundance (Community of Inuvik, 2006; Community of Aklavik et al., 2005). Residents have reacted to this change by installing window-screens in their homes (Community of Aklavik et al., 2005).

The release of contaminants from thawing permafrost ground is creating anxiety over potential health impacts (Community of Inuvik 2006; Pearce et al. 2009). These leached contaminants are harming fish and wildlife species and there is concern that the community drinking water could be contaminated (Pearce et al., 2009; Community of Aklavik et al., 2005). Long-term sustainability plans and training programs were developed by the community to ensure the quality of life for present and future generations (Kavik-AXYS & Stantec Consulting Ltd., 2010; Pearce et al., 2009; Taylor et al., 2004). The objectives of Inuvik's Community

Sustainability Plan includes celebrating traditional knowledge, creating opportunities for community well-being, environmental stewardship, and sustainable innovation (Kavik-AXYS & Stantec Consulting Ltd., 2010). The development of the plan was spurred in part by funding requirements for federal funding through the Gas Tax Agreement. No municipal climate change adaption plan exists, but a Community Climate Change Adaptation Action Plan (CCCAP) is being developed in partnership with the IRC (S. O'Hara, personal communication, September 30, 2015).

The high costs associated with obtaining traditional foods, such as costs of gasoline, equipment, even the price to purchase country food from community freezers has been cited by community members as a barrier preventing access to country foods, such as caribou (Ford et al. 2013).

Economy and Business

The declining state of the Dempster Highway is deterring tourist from travelling to Inuvik and delaying the transport of goods and supplies into and out of the community, impacting local businesses. The ability of community leaders to adapt to this challenge is hindered by the fact the maintenance of the highway is the responsibility of the DOT. A vertical coordination of adaption efforts would be required in order for community leaders to address this source of vulnerability.

The declining health of harvested wildlife species is affecting the livelihoods of harvesters and residents. The quality of harvested furs is a poorer quality, compromising their value and utility; forcing residents to spend more money on higher quality furs when they are available (Pearson et al., 2009; Community of Inuvik, 2006).

Aklavik

Harvesting and Food Security

The timing of fish and wildlife migration patterns have shifted due to changing weather patterns and warmer water temperatures. Fish are spawning earlier in the year and at different locations than in the past (Communities of Aklavik et al., 2005; Kofinas, 2002). Hunters have reported that whales are becoming harder to find and hunting on the water is becoming more challenging due to stronger coastal winds (Communities of Aklavik et al., 2005; Community of Aklavik, 2002). Caribou populations and goose migration patterns have also shifted away from the community, making it harder for hunters to find reliable sources of meat (Community of Aklavik et al., 2005; Kofinas, 2002). Community members have adapted to these challenges by trading with other communities for meat or relying on the community freezer when their supply runs out (Community of Aklavik et al., 2005). Aklavik and each of the other study communities, have developed Community Conservation Plans to promote the protection of wildlife, lands and a traditional lifestyle (Community of Aklavik et al., 2008; Community of Tuktoyaktuk et al., 2008; Community of Inuvik et al., 2008). These community-based planning documents were first developed by the NWT Wildlife Management Advisory Council (WMAC) and the Fisheries Joint Management Committee (FJMC), as required under the Inuvialuit Final Agreement (Community of Aklavik et al., 2008). In 2008, Aklavik's plan was redeveloped in collaboration with a community working group, the WMAC, the FJMC, the Joint Secretariat and the Department of the Environment and Natural Resources (Community of Aklavik et al., 2008). The existence of the plan and the method through which it was developed, indicates the long-term adaptive capacity of the community and its willingness to collaborate with other bodies.

Infrastructure and Transportation

Similar to the other study communities, infrastructure in Aklavik is sensitive to permafrost thaw. However, unlike Inuvik and Tuk, Aklavik has a limited gravel supply which is hindering their capacity to effectively adapt to infrastructure degradation (Borsy, 2009). Gravel foundation pads can limit ground settlement and permafrost thaw, but unfortunately quantities are limited in the Inuvialuit Settlement (Borsy, 2009). A gravel source does exist 20 km outside of the community, but it is inaccessible without an access road. Community infrastructure is also threatened by increased flooding events and riverbank erosion (GNWT, 2014; Pearce et al., 2011). After a serious flood, the community had to bring gravel in from Inuvik by barge at a cost of over $1 million dollars (OpenNWT, 2009). The community has adapted to its location in a floodplain by raising buildings off the ground and developing a community flood plan that is reviewed annually (Hamlet of Aklavik, 2004; Newton, 1995). The town has also organized weather forecasts and flood warnings (Pearce et al., 2009).

Health and Wellbeing

Similar to community concerns in Inuvik, residents in Aklavik are concerned about drinking water quality as a result of permafrost thaw and the potential release of contaminants (Community of Aklavik et al., 2005). The erosion of traditional land skills and knowledge has prompted the development of land skills and teaching programs in the community to get youth out on the land and promote the transgenerational transmission of traditional knowledge (Community of Aklavik et al., 2005).

Aklavik is unique among the study communities in that it has developed a CCCAP. The Plan was completed in collaboration with ArcticNorth and RavenQuest, two consulting

companies based in the NWT. Community members were involved in various aspects of the plan's development, including research planning, data collection, and the compilation of results (Friendship & Community of Aklavik, 2011). Funding for the plan was provided through the Department of Aboriginal Affairs and Northern Development Canada's (AANDC) Climate Change Adaptation Program (CCAP).

Economy and Business

The economy of the community is strongly rooted in traditional practices, meaning it is volatile, unpredictable and dependent on the transmission of traditional knowledge and skills to community youth. A lack of stable employment opportunities and the erosion of traditional land skills has resulted in unstable youth employment in Aklavik, jeopardizing the quality of life of future generations (Kofinas, 2002). As the climate of the North changes and wildlife migration patterns shift, the distance covered during hunting trips has increased. The fuel costs required to go out on hunting trips are now more expensive than they were in the past (Kofinas, 2002), likely deterring those who have limited financial capacity from partaking in hunting expeditions and exacerbating existing food security challenges.

Chapter 6: Community Readiness Findings

A review and analysis of peer-reviewed and gray literature was conducted, and yielded the following results. The community of Aklavik had the highest readiness score (7.2), followed by Tuk (5.8), and Inuvik had the lowest readiness score (4.5) (Table 6). The readiness factor that saw the highest scoring among all three communities was availability of usable science, where each received a score of 8.8. While the availability for adaptation funding factor received a low score (≤3) across each community. The scoring results for each readiness factor is discussed in more detail in the following sections.

Table 6. Readiness factor scores for Aklavik, Inuvik, and Tuk, rounded to the nearest tenth.

	Aklavik	Inuvik	Tuk
Readiness Score	**7.6**	**4.5**	**5.8**
1. Political leadership	**8.8**	**5**	**8.8**
1a) Community figurehead or adaptation champion.	5	0	5
1b) Climate change identified as an important issue.	10	10	10
1c) Figurehead who can acquire resources.	10	0	10
1d) Ability to work collaboratively & build partnerships.	10	10	10
2. Institutional organization	**5**	**3.3**	**5**
2a) A coordination committee or person who promotes and oversee adaptation activities.	0	0	0
2b) Long term planning to address climate change.	10	10	10
2c) Promotes horizontal and vertical coordination of adaptation actions.	5	0	5
3. Adaptive decision making & engagement	**10**	**2.2**	**2.2**
3a) Stakeholder concerns are considered.	10	0	0
3b) Flexible decision making processes, i.e. evidence of adaptive management.	10	6.7	6.7
4. Availability of usable science	**8.8**	**8.8**	**8.8**
4a) Enhances existing knowledge of climate change impacts, community vulnerability, and adaptive capacity.	10	10	10
4b) Incorporates TEK with scientific knowledge.	10	10	10
4c) Assesses risks and costs of climate change adaptation.	5	5	5
4d) Contribute to decision making processes (produces information relevant for policy development).	10	10	10
5. Funding for adaptation	**3**	**1**	**3**
5a) Specific funding for adaptation activities	6	2	6
5b) Individual(s) at the community level responsible for securing adaption funding	0	0	0
6. Public support for adaptation	**10**	**6.7**	**6.7**
6a) Community acceptance of developed adaptation plans or strategies.	10	0	0
6b) Training opportunities to build awareness, adaptive capacity of residents.	10	10	10
6c) Community concern over climate change impacts.	10	10	10

Political Leadership

While there was evidence within each community that community leaders view climate change as an important issue, statements identifying adaptation has a policy or community priority were only evident in Tuk and Aklavik. Neither of the communities received full a score, however, because there was no evidence that statements identifying adaptation as necessary lead to the implementation of adaptation actions. In both Tuk and Aklavik, the absence of action can be linked to a lack of funding. Despite repeated calls for action by Tuk MLA, Jackie Jacobson, for the GNWT to help the community address shoreline erosion, the community continues to lose meters of coastline each year. In 2010, Jackie Jacobson the current MLA representing Tuktoyaktuk, made a statement addressing shoreline erosion in the community to the Legislative Assembly, November 1st 2010: "This government has to help the community deal with the problem which is going to take a lot of work and resources over a period of time...we need a long-term plan for the community of Tuk before it is too late…I want extraordinary funding for the community" (OpenNWT, 2010).

Unfortunately, since the address, the community has continued to lose meters of shoreline each year, with a storm just this past August removing close to seven (7) meters of shoreline (McFadden, 2015). According to Jacobson it will costs between 10 and 15 million dollars to protect the community from coastal erosion (MacFadden, 2015). Despite a visit to the community from Premier McLeod in the summer, no funding to address shoreline erosion as been announced to date (as of October 6, 2015). The GNWT has, however, partnered with the federal government and the community to secure funding from the Building Canada Program for the construction of an all-weather access road to a gravel source adjacent to the community (OpenNWT, 2010). Gravel is a necessary resource for the construction of stable all-weather

roads and when building on permafrost soil, the intended use of this gravel remains in question. Some have indicated that the gravel source will be used for construction of the Inuvik-Tuktoyaktuk highway, despite the need to improve community infrastructure.

In Aklavik, there have been requests made by community leaders for funding to address damage community roads caused by to climate change[1]. In 2013, funding was acquired from the federal government's Infrastructure Fund program fund to resurface and widen degraded roads in the community (Infrastructure Canada, 2014). The community also acquired funding from Health Canada to conduct community-based research on the impacts of climate change on hunters and their ability to travel on the land (IRC, 2014). In 2010, the community partnered with the private consulting company, ArcticNorth, to secure funding from the federal government to develop a community climate change plan (Friendship and Community of Aklavik). Evidence of the community's ability to secure funding for adaptation activities has contributed to the high score (8.8) the community received for this factor.

Inuvik scored the lowest of the three communities, this is attributed a lack of evidence that community leaders see climate change adaptation as a priority, which was supported by an absence of funding request for adaptation initiatives. Inuvik, along with Tuk and Aklavik, did receive full scores for statements identifying climate change as an important issue and community leaders in each community displayed a strong ability to work collaboratively with other stakeholders across various levels of government. As was evident by community leader attendance at regional workshops, the development and implementation of resource management regulations, participation in the development of territorial action plans. In those cases where

[1] In 2009, Frederick Blake Jr. (MLA for Mackenzie Delta), describes the need for funding to address shifting in community roads due to climate change (OpenNWT, 2009).

funding was successful acquired by community leaders (e.g. Inuvik highway project, shoreline protection, training resources), collaboration with territorial and federal departments played a key role in the acquisition.

Institutional organization & administrative structure for adaptation

None of the communities received full scores for this factor because there is no evidence that a coordinating body exist to oversee or encourage climate change adaptation. This criterion is important because, this without meeting it, establishing such a body would strengthen the institutional structure of each community and its ability to effectively prepare for and adapt to climate change.

The second criterion of a strong institutional organization is evidence of long-term planning to support adaptation. All three communities met this criterion, as all have implemented long-term actions in response to climate change impacts. A long-term plan or action is defined in this study as an action that can minimize the negative or capitalize on the positive impacts of climate change for the unforeseeable future.

In Inuvik, a community food program was developed in response to the growing food security in the community and has been operating since 2004 (Ford et al., 2013; Newman, 2015). Thermosyphons have also been installed under the community hospital to slow the rate of permafrost melt (Hayley, 2004). Despite these 'long-term' actions, no long-term plans have been developed to address climate change. A conservation plan was developed in response to concerns about the changing health of fish and wildlife and the loss of TEK (FJMC, 2000; Community of Inuvik et al., 2008). Although it demonstrates the capacity of community to produce long-term plans, it was not developed in response to climate change, and thus does not meet this criterion. In Aklavik, community buildings have been raised off the ground to better

withstand flood events and the community has developed a disaster plan to help the community better prepare for extreme flood events (Ryder, 2013). These initiatives along with the community's participation in the development of their CCCAP resulted in a long-term planning score of 10. In Tuk, various actions have been implemented to limit community sensitivity to coastal erosion. An 'erosion risk area' zoning by-law was established to restrict development in erosion prone areas (Pearce et al., 2009) and shoreline protection efforts have been ongoing in the community since the 70s. The community has also imposed self-regulated harvesting practices to conserve polar bear numbers, which has the potential to support the long-term viability of the an economically important species. However, despite these individual actions, no coordinated long-term plans to address current and future impacts of climate change exist.

Horizontal and vertical coordination of adaptation initiatives requires a strong institutional structure that is conducive to cross sector communication and collaboration. Effective coordination of adaptation initiatives will require both, horizontal and vertical collaboration and communication, thus in order for a community to receive a full score for this criterion, both had to have been evident. Vertical coordination, i.e. among the community and higher levels of government was evident in the acquisition of funding from the Building Canada fund to upgrade community roads in Aklavik that had been damaged by permafrost degradation, this included adding additional culverts to improve drainage to slow future degradation. Similarly to Aklavik, evidence of vertical coordination of adaptation actions were found to be evident in Tuk, where the community, the Inuvialuit Land Administration (ILA), and the federal government are working together to develop more effective shoreline monitoring strategies for example (Fraser & Bridge, 2010). Evidence of horizontal collaboration, however, was lacking

among each of the study communities and as a result none were found to fully meet this criterion.

Adaptation decision making and stakeholder engagement

Adaptive management flexible plans that can be updated over time to better respond to impacts. Given the unpredictable nature of climate change, the development and implementation of flexible plans and actions will improve adaptation readiness. Throughout the literature review, it was evident that all three study communities are capable of adaptive management, however, few existing management initiatives have been developed in response to climate change impacts. In Inuvik, for example, many lessons have been learned over four (4) decades of fire management, which have been incorporated into emergency and natural resource management practices (Wein, 2002). Even though climate change was not the driving factor for the development of the fire management plans, the existence of an adaptive emergency plan is considered in this study as meeting the criteria of an adaptive management plan that can limit the impacts of a climate change impacts. In Tuk, the fight to slow the rate of coastal erosion demonstrates adaptive decision-making as the protection methodology implemented has been adapted over the years depending on the availability of resources, technology developments and funding. Aklavik, however, is the only community that systematically reviews its adaptive management plans. The community's disaster plan is updated annually by a flood emergency committee to ensure lessons learned from past floods are reflected in the plan. A community-led study on Elder observations of climate change and harvesting practices also indicated that the findings would be incorporated into the community's CCCAP, and thus it is considered a living document.

The inclusion of stakeholders in the development and implementation of adaptive plans is essential to ensure that the concerns of those being impacted are included, ultimately improving the chances of implementation success. Aklavik was the only study community to have an adaptation plan that incorporates stakeholder concerns and involved stakeholders in the development process. However, given that Inuvik and Tuk, do not have climate change adaptation plans, or formal adaption strategies it is not surprising that they scored poorly on this criterion.

Availability of usable science

Understanding the various components that can influencing the initiation and success of adaptation actions is essential when developing effective adaptation plans, strategies or policies. The quantity of literature that exists on the various aspects of climate change in the Inuvialuit Settlement is immense, covering multiple disciplines and sectors. Studies investigating climate change impacts, vulnerability and/or adaptive capacity, existed for all three of the study communities, resulting in a full score of three (3) for criterion 4a. While studies incorporating TEK from each of the study communities were also evident and thus fully met the criterion, they represented less than 10% of the published literature retained in the analysis.

Access to accurate assessments of the costs and risks associated with carrying-out adaptation is equally as important as understanding the impacts being addressed. This information can also provide a solid foundation for responsible governance decisions and reduce the potential of maladaptation. In order for each community fully meet this criterion of usable science, 'user friendly' costs and risk assessments must be available. Tuk is the only community where both risk assessments and cost-benefit analyses have been performed. Aklavik and Inuvik

each received partial scores as the costs of climate change have been assessed for both communities. It should also be noted that the existing studies tended to focus exclusively on risks and costs of climate change on the infrastructure and transportation sector.

The fourth criterion of usable science is that it contributes to decision-making process, whether through policy recommendations, suggestions of feasible adaptation options, etc. The ability of community leaders and members to use this information also depends largely on its availability and format. Thus, in order for communities to receive a full score for this criterion, there must be evidence that the findings and recommendations of relevant studies were communicated with the community. Each community received a score of ten (10), however, with the exception of those studies where community members were also authors, only 5% of authors present their findings to community members[2].

Funding for adaptation

Most effective adaptive responses to climate change impacts will require funding that is beyond purse strings of community governments. Federal and territorial funding intiatives aimed at supporting community adaptation initiatives is essential for initiating and maintaining the momentum of adaptation projects. Thus, in order for a community to fully meet this criterion, multi-year funding for adaptation projects must have been acquired. None of the study communities have acquired or reserved multi-year funding for adaptation. In Tuk, community funds have been reserved for shoreline protection, however given the immense costs that would be required to implement long-term protection measures, community funds alone can only hope to fund short-term solutions. In Aklavik, funding to develop a community climate change plan was secured with the support of an outside partner, however, no funding to support multi-year

[2] As was indicated by the author(s) in their paper.

initiatives have been secured. Adaptation actions in Inuvik have largely been implemented through singular actions to improve public safety or enhance economic returns. As was the rational behind a decision to improve the condition of community roads by paving.

All of the communities have secured funding from Health Canada's Brighter Futures program to fund programs aimed at promoting traditional skills (IRC, 2014). The objective of this program is adaptation related, however, by promoting the development of traditional skills among younger members of the community their adaptive capacity can be inadvertently enhanced. So while this initiative alone is not substantial enough to garner a full score, it can contribute to community readiness and so has been incorporated in the scoring scheme. There are various avenues through which communities can receive adaptation targeted funding from the federal and territorial governments (Table 7).

Table 7. Federal funding initiatives to support adaptation in northern communities

Initiative	Objective	Funding
Public Safety Canada: *Disaster Mitigation Fund* (2015-2020)	Fostering disaster risk reduction as a way of life to protect lives and maintain resilient and sustainable communities; reduce the impacts of natural disasters, with a focus is on flood mitigation (Public Safety Canada, 2014).	$200 million over 5 years, application based.
Infrastructure Canada: *New Building Canada Fund: Gas Tax Fund* (2014-2024)	Provide predictable, long-term, stable funding for Canadian municipalities to help them build and revitalize their local public infrastructure while creating jobs and long term prosperity (Infrastructure Canada, 2014).	$32 billion available to municipalities.
Infrastructure Canada: *New Building Canada Fund: Small Communities Fund* (2014-2024)	Fund infrastructure projects of regional and local significance, i.e. improve drinking water infrastructure, waste management, disaster mitigation infrastructure, or highways and major roads (Infrastructure Canada, 2014).	$1 billion available for municipalities with fewer than 100,000 residents.
Health Canada: *Climate Change and Health Adaptation in Northern First Nations and Inuit Communities Program* (2008-2016)	Support projects that help communities identify and adapt to human health impacts of climate change, this includes funding for 'core capacity building activities' (Health Canada, 2015).	Planned spending for 2015-2016 is $2.1 million, application based.
AANDC: *Climate Change Adaptation Program (CCAP)* (2008-2015)	Support northern communities to prepare for challenges created by a changing environment; projects must be community driven and demonstrate clear links to climate change impacts and adaptation (AANDC, 2014).	$2.25 million was available for projects in 2014-2015.
* Standards Council of Canada (SCC) with support from AANDC *Northern Infrastructure Standardization Initiative (NISI)*	Ensure that codes, standards and other related instruments are effective in addressing climate change impacts to northern infrastructure (Standards Council of Canada. (2015).	N/A

However, there is limited evidence from the study communities that these funding initiatives have resulted in improved adaptation readiness of communities. The IRC applied for

and received funding from AANDC to develop CCAPs for Inuvik, Tuktoyaktuk and Sachs Harbour (S. O'Hara, personal communication, September 30, 2015). Again, demonstrating the important role higher levels of government play in adaptation planning.

The town council of Inuvik has dedicated funding in it's budget for fire protection and has received Gas Tax funding from the federal government, but these measures appear to be driven by public safety motives or to enhance economic returns, and are not necessarily indicative of being ready to do adaptation. Aklavik has also received federal funding from the federal Gas Tax Fund to resurface and widen roadways (Infrastructure Canada, 2014). The aim of the project, however, was to "stimulate new development" and no funding was directed towards riverbank erosion or the maintenance of degraded community structures (Infrastructure Canada, 2014). None the less, the widening of the roadways coupled with improvements to road drainage will reduce the severity of permafrost thaw effects and so was be considered an adaptation action.

Many of funding initiatives are application based with predetermined eligibility criteria and application requirements. While there may be many factors that influence a community's capacity to secure adaptation funding, the designation of a member of council with overseeing the application process to ensure deadlines and requirements are met will promote the acquisition of adaptation funding. Such a position was not evident in any of the study communities.

Public Support for adaptation

The community members residing in each of the study community have displayed support for adaptation. This has been indicated through statements of concern or community

member involvement in the implementation of adaptation plans, decisions or strategies. Community participation in the planning or implementation of adaptive strategies was only evident in Aklavik, where community members were included in the development of their CCAP. Community concerns over climate change impacts, however, was evident across each of the study communities. For example, residents in the study communities have voiced a "desire for organization on Inuit climate change issues" (Communities of Aklavik et al., 2005:7). Community concerns also include fears about the health effects for humans and wildlife, the preservation of transportation routes, and the impacts of erosion on community infrastructure (Pearce et al., 2009; Parewick, 2006). Each community full met this criterion.

Participation in community meetings can promote public awareness and support for adaptation initiatives, the more aware residents understand the necessity of the adaptation process the more likely it is that adaptation projects will go forward. Community meetings and workshops to discuss climate change impacts and adaptation strategies were held and attended to by residents from each community, resulting in a full criterion score of ten (10).

Chapter 7: Discussion of Research Findings

Community vulnerabilities were summarized for each the study communities, Inuvik, Aklavik and Tuktoyaktuk (Tuk). Given the heterogeneous nature of climatic shifts and climate change impacts, a one-size fits all approach to adaptation would be ineffective at addressing the local impacts of climate change. Understanding community specific conditions, vulnerabilities and local capacity to adapt was necessary in order to provide a comprehensive assessment of community readiness and develop relevant and proactive recommendations. Community vulnerabilities were summarized by reviewing the peer-reviewed and gray literature. Following

the review, it was clear that climate change is affecting each of the study communities.

Community exposure-sensitivities were subdivided based on their impacts on four sectors: harvesting & food security, infrastructure & transportation, health & well-being, and community economy. Each community displayed high adaptive capacities to cope with the impacts of climate change, however, many of the adaptive strategies being implemented have been largely reactive in nature. At an individual level, residents have had to adapt to changing and more challenging harvesting conditions by trading with other communities when meat stores run-out, altering the timing of hunting expeditions, or changing hunting practices respond to changing environmental conditions.

A framework for assessing adaptation readiness was used to examine how prepared the study communities are 'to do' adaptation. The six readiness factors, political leadership, institutional structure, adaptive decision making & stakeholder engagement, public support, availability of usable science, and funding for adaptation were assessed within each community using relevant criteria and indicators. The results indicate that the communities of the Western ISR are not fully prepared to do adaptation and the level of preparedness varies cross the region.

Aklavik had the highest readiness score (7.6), followed by Tuk (5.8), and Inuvik (4.5). As this is the first study to examine community adaptation readiness in the Inuvialuit Settlement Region, it is challenging to assess the certainty of the results via comparison with similar studies. However, a study by Ford et al. (2011), found that the impacts of extreme climate-related events can act to stimulate the consideration of adaptation. Similar conclusions were drawn in the Fifth Assessment Report of the IPCC, where extreme natural events are accredited with facilitating adaptation to climate change (Nobel, 2014). These findings support those of this study, whereby

those communities that have experienced serious climatic events were found to be better prepared to adapt. Inuvik received the lowest readiness score which could in part be contributed the fact that the community has not had to respond to any extreme climatic events, as of yet. While extreme flooding in Aklavik and shoreline erosion in Tuk have cost the communities millions in damages. These experiences appear to have enhanced community readiness by facilitating political will and strengthening institutional structures, which is reflected in the factor scores for both communities.

A lack of financial resources is restricting adaptation across multiple scales; at an individual level, community members do not have the financial capacity to purchase hunting equipment, such as a skidoo, which can make travel across the land to hunting areas much quicker. Even purchasing traditional food from the community freezers can be quite expensive and as a result many residents in Inuvik have to purchase cheaper, often less nutritious, store foods. The decline of country foods in the diets of community members is not only affecting their health, but their sense of identity as well.

Despite federal funding initiatives, there is no evidence that multi-year funding has been secured for community adaptation planning. Given the limited financial capacity of northern communities and the many challenges they faced, support from higher levels of government is required before long-term actions can be implemented. There is evidence that a disconnect exist between objectives of federal funding initiatives and the actual adaptation action that occurs in communities. This disconnect appears to be a byproduct of poor collaboration and communication between levels of government and community leaders, a reluctance of some to utilize funds for adaptation unless economic gains are apparent, and perhaps a challenging

funding application processes. Such a disconnect deserves attention and should be examined further by future studies.

It is clear that each leaders and residents in each study community are aware of climate change and considered it an issue of importance. While each displays a high adaptive capacity to adapt, this has not translated to a high readiness to adapt. The readiness of the communities to carryout adaptation action is being hindered by a lack of funding, weak institutional structures and a lack of long-term adaptive planning to address climate change impacts. In instances where funding has successfully been acquired to support adaptation initiatives, it required collaboration across local, regional, territorial and federal levels of government. Highlighting the pivotal role collaboration and intergovernmental action plays in promoting adaptation action.

The decision to promote economic growth over investing in adaptation options was apparent throughout the analysis. In Tuk, there is speculation that the new gravel source located outside the community may be used to support the development of the Inuvik-Tuktoyaktuk highway and not to address infrastructure degradation in the community. Whereas in Aklavik, funding to an access a gravel source outside the community has been delayed, costing the community millions to barge gravel in from Inuvik.

Finally, the findings support the importance of CCCAPs in promoting adaptation readiness. While it is clear that communities should not assume that the development of an adaptation plan is all that is necessary to effectively prepare for adaptation, a CCCAP, as was shown in this study, can promote adaptive decision-making, stakeholder engagement, and facilitate long-term planning to address climate change.

Chapter 8: Conclusion & Recommendations

The findings of this study demonstrate the complexities involved in developing and implementing effective adaption options, the interconnectedness of exposure-sensitivities and the factors constraining community adaptation readiness. While these features present challenges there are also opportunities to capitalize on the complexities. Successful adaptation will require cooperation and collaboration among communities and levels of government to develop dual-adaptation options that reduce exposure-sensitivities across multiple sectors. This approach will also limit unintentional maladaptation effects that can occur when adaptation options implemented in one sector enhance exposure-sensitivities influencing other sectors.

The factors responsible for constraining adaptation readiness in each of the study communities was a lack of funding, particularly for multi-year adaptation projects. Specific to Inuvik, a lack of leadership and adaptive planning further contributed to its poor preparedness score. Fortunately, the community has the opportunity to address these shortcomings and be proactive before an extreme weather event occurs. In Tuk, the lack of a coordinated long-term adaptive plan is hindering the community's readiness to adapt. This is concerning given past history of maladaptation, future projections of sea-level rise and the rates of erosion that are already occurring.

The application of the readiness framework developed by Ford and King (2015), can be utilized to examine readiness at a local level when appropriate criteria and indicators are developed. The timing of this study, as new CCCAPs are being developed, the devolution process is advancing, and the increasing rate of climate change, makes the findings relevant to governments and community decision-makers. The scoring scheme developed for this study should be interpreted as a living methodology that can be adjusted and likely improved upon as

the adaptation readiness literature continues to grow.

Given that the six readiness factors are interconnected, and in some cases interdependent, the following practical recommendations were developed to enhance multiple factors through the streamlining of existing actions or approaches.

1. ***Establish a climate change body or committee at the community level.*** A climate change body or committee established at the community level would enhance horizontal coordination across the ISR, promote the inclusion of adaptation options in community decisions, and strengthen institutional organization. Such a body would likely fall under the auspice of a community council, similar to the already existing community committees. The structure of a community climate change committee should be inclusive, flexible and support the needs of the community (Appendix 4.). If readiness is to be improved, communities need to move beyond individual actions towards collective actions, internally and across the ISR.

2. ***Secure long-term, multi-year funding.*** Following the implementation of the 'New Deal for NWT Community Governments' in 2007, community leaders are now in control of infrastructure priorities at the community level. Infrastructure degradation, however, is a major exposure-sensitivity that will cost millions to effectively address. The Directorate and Community Operations division of MACA has reserved $33 million dollars to address climate change impacts on infrastructure (Department of Transportation, 2013). Once a community's application is approved, the funding is then available to the community until the end of the funding period, 2024. This opens a window of opportunity for communities to access multi-year funding for infrastructure adaptation,

and thus community leaders must show initiative and act on this opportunity to address long-term impacts.

3. ***Improve adaptive decision-making that addresses climate change.*** Steps are being taken to enhance the capacity of local decisions makers by the GNWT. The School of Community Government, in partnership with the Department of Human Resources, the Northwest Territories Association of Communities, and the Local Government Administrators of the NWT, is providing a Public Service Capacity Initiative. This program includes a series of initiatives designed to enhance local capacity of community leaders and administrators (MACA, 2015). This study recommends that an initiative aimed at improving the local capacity of community leaders to develop and implement adaptive options in the face of climate change, is incorporated into this program. This will not only improve the ability of leaders to develop and carryout adaptive plans but will also promote this method of decision making when tackling climate change issues.

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Appendix 1.

CODEBOOK
Evaluating community adaptation readiness in the Inuvialuit Settlement Region, Northwest Territories

(Adapted from Lesnikowski et al. 2015 with suggestions from J. Labbe)

Research Objectives

The objective of this analysis is to examine the current state of community adaptation readiness in the Inuvialuit Settlement Region, Northwest Territories. This will be accomplished by conducting a systematic literature review analysis to identify trends in adaptive readiness by cataloging existing readiness factors present in each study community using Ford and King's readiness framework. The results of the study will provide recommendations to local and territorial governments concerning the status of community adaptation readiness in the ISR.
Sub-objectives:

1. To identify and catalogue current human vulnerabilities to climate change in three Inuit communities in the Inuvialuit Settlement Region, Northwest Territories.

Key questions:

i) Can Ford and King's adaptation readiness framework be applied at the community level in the ISR?
ii) Do discrepancies or trends exist between community readiness and degree of vulnerability?
iii) What factors are important for initiating adaptation action and enhancing readinesss?

Data Sources

Peer-reviewed literature search: Google Scholar, Novanet, and ISI Web of Knowledge.
Grey literature: Google, government and community websites, media reports and local newsletters.

Data Organization

Data collected will be contained in a Microsoft Excel spreadsheet. In the spreadsheet rows will organize data by individual articles and columns will denote the different readiness indicators. The detail of information provided on each readiness factor will vary according to the source and nature of the nature of the document and indicator components. The readiness factors being used are those identified by Ford and King (2015) et al. (2015): political leadership, institutional organization, adaptation decision making and stakeholder engagement, availability of usable science, funding for adaptation, and public support for adaptation.
Information to be obtained:
The following details will be recorded for each identified feature: i) author and title, ii) publication year, iii) iv) URL if applicable, v) readiness factor addressed, vi) actors

(implementing bodies if applicable), vii) funding source (if applicable), and viii) sector addressed (if applicable).

CRITERIA TO GUIDE SEARCH (INCLUSION/EXCLUSION)

Inclusion criteria	**Exclusion criteria**
1. Relevancy: must be concerned with the *current* community *adaptation* response to climate change.	Articles that do not meet the relevancy criteria, i.e. documents relating to climate change mitigation or future climate change projections.
2. Overarching focus is on the human dimension of climate change.	Focus is on response of biophysical systems to climate change.
3. Minimum level of information: information must related to the six readiness factors and provide sufficient information for assessment.	Conceptual adaptation documents, i.e. those that do not include actual adaptation initiatives.
4. Involvement: Adaptation response must be conducted either exclusively by the study community, or in conjunction with the ISR or territorial government.	Adaptation actions conducted exclusively by territorial or federal governments, without local involvement.
5. Literature will only be included in the review if the content is specifically about climate change adaptation and/or vulnerabilities in the ISR.	Literature unrelated to the study region.
6. Government documents and webpages, peer-reviewed articles, adaptation plans and assessments, community/municipal/territorial reports.	Conference papers or abstracts or documents (unless authored by a community member/ organization).
7. Timeframe: 2000-2015	Documents dated prior to 2000.
8. Is in English.	Is not in English.
Both positive and negative impacts of climate change will be included in the dataset	

***Note on titling entries**

Entries should be consistently titled in order to ensure that the name of the readiness factor is obvious.

CODEBOOK: Indicators

Indicators 1 to 8 provide basic identifying information.

1. Community
2. Jurisdiction
3. Reporting year
4. Entry title
5. Author
6. Location in document (i.e. page #)
7. Scale of Study

i. Municipal/Community

ii. Regional

iii. Territorial

8. Sector focus (if appicable)
    1. Infrastructure and transportation
    2. Economy and business
    3. Health and well-being
    4. Subsistence hunter and trapping
    5. Culture and education
    6. Institutional/Resource management

9. Political leadership for adaptation	Criteria	Indicators
	1.1 Adaptation actions initiated by a community figurehead or adaptation champion	Statements identifying adaptation as a policy or community priority
	1.2 Climate change is identified as an important issue	Statements describing climate change impacts or calls for action
	1.3 Figurehead who can acquire resources	Implementation of community adaptation strategies or plans
	1.4 Ability to work collaboratively with multiple stakeholders/others to promote adaptive action & build partnerships	Engagement in climate change workshops or planning events; evidence of partnership building

10. Institutional organization	Criteria	Indicators
	2.1 A coordination committee or person who promotes and oversee adaptation activities 2.2 Capable of long term planning 2.3 Horizontal and vertical coordination of adaptation actions	A coordinating body or committee responsible for climate change adaptation Long-term plans or actions to address future climatic risks Collaboration with stakeholders and across sectors
11. Adaptation decision making and stakeholder engagement	Criteria	Indicators
	3.1 Stakeholder concerns are acknowledged 3.2 Flexible decision making process, i.e. evidence of adaptive management	Adaptation plans or strategies that incorporate stakeholder concerns Resident participation in climate change events or workshops Existence of adaptive management plans
12. Availability of usable science	Criteria	Indicators
	4.1 Provides knowledge on climate change impacts, community vulnerability, or adaptive capacity 4.2 Incorporates TEK with scientific knowledge 4.3 Assesses risks of climate change and costs 4.4 Contributes to decision making processes (produces information relevant for policy development)	Existence of community impact, vulnerability, adaptation assessments Existence of studies that incorporate TEK Community focused risk or cost assessments Policy recommendations are provided

13. Funding for adaptation	Criteria	Indicators
	5.1 Specific funding for adaptation activities	Assigned funding for community adaptation plans
	5.2 Multi-year funding	
	5.3 Individual(s) at the community level responsible for securing adaption funding.	Employed funding coordinator.
14. Public support for adaptation	Criteria	Indicators
	6.1 Community acceptance of developed adaptation plans or strategies	Community member involvement in the planning or implementation of adaptive strategies.
	6.2 Opportunities to build awareness, adaptive capacity of the public	Participation in training or workshops.
	6.3 Community concern over climate change impacts	Statements of concern from residents.

Adapted from Ford et al. 2011 and Ford et al. 2012 and Ford et al. 2015.

Appendix 2.

Peer-reviewed articles retained for analysis.

1. Abele, F., & Institute for Research on Public Policy. (2009). *Northern exposure: Peoples, powers and prospects in Canada's north*. Montréal: Institute for Research on Public Policy.
2. Abelsohn, A., Canadian Electronic Library, & Ontario College of Family Physicians. (2008). *Addressing the health effects of climate change family physicians are key*. Toronto: Ont.: Ontario College of Family Physicians.
3. Aboriginal Affairs and Northern Development Canada. NWT Region. Contaminants and Remediation Directorate. (2008). What's happening in the ISR? *Government of Canada*.
4. Andrachuk, M. (2008). An assessment of the vulnerability of Tuktoyaktuk to environmental and socio-economic changes.
5. Andrachuk, M., & Pearce, T. (2010). Vulnerability and adaptation in two communities in the Inuvialuit Settlement Region. *Community Adaptation and Vulnerability in Arctic Regions,* , 63-81.
6. Andrachuk, M., & Smit, B. (2012). Community-based vulnerability assessment of Tuktoyaktuk, NWT, canada to environmental and socio-economic changes. *Regional Environmental Change, 12*(4), 867-885.
7. Angus, W. D., Mitchell, G., & Canada. Parliament. Senate. Standing Committee on Energy,the Environment and Natural Resources. (2009). *With respect, Canada's north sixth report*. Ottawa: Ont. : Canada Senate.
8. Archibald, B. J. (2005). Weather parameters leading to 2003 Inuvik wildfire event. Paper presented at the *19th Interior West Fire Council Meeting,*
9. Arctic Monitoring and Assessment Programme (2009). *AMAP assessment 2009 human health in the arctic*. Oslo: Norway : Arctic Monitoring and Assessment Programme.
10. Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., & Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's arctic. *Global Environmental Change-Human and Policy Dimensions, 21*(3), 995-1004. doi:10.1016/j.gloenvcha.2011.04.006
11. Arsenault, M., Cape Breton University. Shannon School of Business, & Inuvialuit Community Economic Development Organization. (2010). *Institutionalism and place-based businesses in the Inuvialuit settlement region*. 201:
12. Barber, D. G., Lukovich, J. V., Keogak, J., Baryluk, S., Fortier, L., & Henry, G. H. R. (2008). The changing climate of the arctic. *Arctic, 61*, 7-26.
13. Bell, R. K., & Harwood, L. A. (2012). Harvest-based monitoring in the Inuvialuit Settlement Region: Steps for success. *Arctic,* , 421-432.
14. Berkes, F., & Arctic Institute of North America (Eds.). (2005). *Breaking ice : Renewable resource and ocean management in the Canadian north*. Calgary: University of Calgary Press.
15. Betts, M. W. (2005). Seven focal economies for six focal places: The development of economic diversity in the western Canadian arctic. *Arctic Anthropology, 42*(1), 47-87.
16. Beveridge, L. (2013). A method for assessing coastal vulnerabilities to climate change within an arctic community: The example of Tuktoyaktuk, Northwest Territories.
17. Coastal Zone Canada Association. (2008). Tuktoyaktuk declaration: Coastal zone Canada 2006 conference statement, 18 August 2006. *Arctic, 61*(5), 122-123.
18. Cournoyea, N. J. (2009). Navigating and managing economic, environmental and social change in the Inuvialuit Settlement Region. *Northern Exposure: Peoples, Powers and Prospects in Canada's North,*
19. Couture, R., Robinson, S., Burgess, M., & Solomon, S. (2002). Climate change, permafrost, and community infrastructure: A compilation of background material from a pilot study of Tuktoyaktuk, Northwest Territories. *Geological Survey of Canada, Open File, 3867*.

20. Fast, H., Mathias, J., & Banias, O. (2001). Directions toward marine conservation in Canada's western arctic. *Ocean & Coastal Management, 44*(3-4), 183-205. doi:10.1016/S0964-5691(00)00074-0.
21. Ford, J. D., Lardeau, M., Blackett, H., Chatwood, S., & Kurszewski, D. (2013). Community food program use in Inuvik, Northwest Territories. *BMC Public Health, 13*(1), 970.
22. Ford, J. D., & Smit, B. (2004). A framework for assessing the vulnerability of communities in the Canadian arctic to risks associated with climate change. *Arctic, 57*(4), 389-400.
23. Ford, J. D., & Pearce, T. (2010). What we know, do not know, and need to know about climate change vulnerability in the western Canadian arctic: A systematic literature review. *Environmental Research Letters, 5*(1), 014008. doi:10.1088/1748-9326/5/1/014008
24. Fox, S. (2000). Arctic climate change: Observations from the Inuvialuit Settlement Region. *Arctic Climatology Project—Environmental Working Group Arctic Meteorology and Climate Atlas.Boulder, Colorado: National Snow and Ice Data Center.CD-ROM,*
25. Harwood, L. A., & Smith, T. G. (2002). Whales of the inuvialuit settlement region in canada's western arctic: An overview and outlook. *Arctic, 55*, 77-93.
26. Harwood, L. A., Kingsley, M. C. S., & Smith, T. G. (2014). An emerging pattern of declining growth rates in belugas of the Beaufort Sea: 1989-2008. *Arctic, 67*(4), 483-492.
27. Hoogensen Gjørv, G., & Ebooks Corporation (Eds.). (2013). *Environmental and human security in the arctic*.
28. Hovelsrud-Broda, G., Smit, B., & CAVIAR. (2010). *Community adaptation and vulnerability in arctic regions*. Dordrecht ; New York: Springer.
29. Joint Review Panel, Canadian Environmental Assessment Agency, & Mackenzie Gas Project. (2010). *Foundation for a sustainable northern future : Report of the joint review panel for the Mackenzie gas project*. Inuvik, N.W.T.: Canadian Environmental Assessment Agency.
30. Kofinas, G., Nicolson, C., Berman, M., & McNeil, P. (2002). Caribou harvesting strategies and sustainability workshop proceedings, held in Inuvik, Northwest Territories, April 15–16, 2002. *NSF Sustainability of Arctic Communities Project (Phase II)*.
31. Kofinas, G., Aklavik Village, Old Crow, and F. McPherson. (2002). Community contributions to ecological monitoring: knowledge co-production in the U.S. - Canada arctic borderlands. In I. Krupnik and D. Jolly (Eds.), *The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change* (pp.54-91). ARCUS, Fairbanks.
32. Labour, S., Fedirchuk, G. J., Nicholls, N., Environmental Studies Research Funds, Kavik-AXYS Inc, & FMA Heritage Resources Consultants Inc. (2008). *Traditional knowledge guide for the Inuvialuit Settlement Region, Northwest Territories*. Ottawa: Environmental Studies Research Funds.
33. Manson, G., & Solomon, S. (2007). Past and future forcing of Beaufort Sea coastal change. *Atmosphere-Ocean, 45*(2), 107-122. doi: 10.3137/ao.450204.
34. Manson, G., Solomon, S., Forbes, D., Whalen, D., Taylor, B., Frobel, D., & Parlee, K. (2006). Hazards to coastal infrastructure in Canada and the implications of climate change: With special reference to the Mackenzie delta and Tuktoyaktuk. Paper presented at the *Presentation at Coastal Zone Canada 2006 Conference. Tuktoyaktuk, Northwest Territories, Canada,* 14-18.
35. Manson, G.K., Solomon, S.M., Forbes, D.L., Atkinson, D.E., Craymer, M. (2005). Spatial variability of factors influencing coastal change in the Western Canadian Arctic. *Geo-Marine Letters, 25*, 138-145. doi: 10.1007/s00367-004-0195-9
36. Mathias, J., Ayles, B., Blakney, S., Charles, T., Fast, H., & Irniq, P. (2008). Arctic change and coastal communities: Overview of the coastal zone Canada conference, Tuktoyaktuk, August 2006. *Arctic, 61*(5), iii-xi.
37. Minich, K., Saudny, H., Lennie, C., Wood, M., Williamson-Bathory, L., Cao, Z., & Egeland, G. M. (2011). Inuit housing and homelessness: Results from the international polar year Inuit health survey 2007-2008. *International Journal of Circumpolar Health, 70*(5), 520-531.

38. Nagy, J., Auriat, D., Wright, W., Slack, T., Ellsworth, I., & Kienzler, M. (2004). Ecology of boreal woodland caribou in the lower Mackenzie Valley, NT: Work completed in the Inuvik region, April 2003 to November 2004. *GNWT Department of the Environment and Natural Resources*.
39. Norton, P., Harwood, L. A., Canada. Department of Fisheries and Oceans. Central and Arctic Region, & Workshop on Beaufort Sea Beluga. (2001). *Report of the second workshop on Beaufort Sea beluga, April 22-24, 1996, Inuvik, NT, Canada*. Winnipeg: Fisheries and Oceans Canada.
40. Pearce, T., & Smit, B. (2013). Vulnerability and adaptation to climate change in the Canadian arctic. In Roger A. Pielke (Ed.), *Climate Vulnerability: Understanding and Addressing Threats to Essential Resources, 4* (293-303).
41. Pearce, T., Ford, J. D., Duerden, F., Smit, B., Andrachuk, M., Berrang-Ford, L., & Smith, T. (2011). Advancing adaptation planning for climate change in the Inuvialuit Settlement Region (ISR): A review and critique. *Regional Environmental Change, 11*(1), 1-17. doi:10.1007/s10113-010-0126-4
42. Pearce, T., Ford, J., Duerden, F., & Smith, T. (2009). Climate change vulnerability and adaptation in the Inuvialuit Settlement Region (ISR): A systematic literature review and gap analysis. *Report Prepared for: Department of Indian and Northern Affairs Canada (INAC) Climate Change Impacts and Adaptations Program. Guelph, Ontario, Canada:* 144pp.
43. Prowse, T. D., Furgal, C., Wrona, F. J., & Reist, J. D. (2009). Implications of climate change for northern Canada: Freshwater, marine, and terrestrial ecosystems. *Ambio, 38*(5), 282-289. (Excluded 1, 5)
44. Rawluk, A., Illasiak, V., & Parlee, B. (2010). Intergenerational resilience in Aklavik, NWT. *Conference: Capturing the Complexity of the Commons, North American Regional Meeting of the International Association for the Study of the Commons, Sept. 3-Oct. 2, 2010*.
45. Rawluk, A. (2012). Intergenerational resilience in Aklavik, NT: Exploring conceptualizations, variables, and change across generations. (Doctoral dissertation, University of Alberta).
46. Ritchot, P. P. R. (2011). Tuktoyaktuk: Responsive strategies for a new arctic urbanism. (Doctoral dissertation, Massachusetts Institute of Technology).
47. Rosol, R., Huet, C., Wood, M., Lennie, C., Osborne, G., & Egeland, G. M. (2011). Prevalence of affirmative responses to questions of food insecurity: International polar year Inuit health survey, 2007-2008. *International Journal of Circumpolar Health, 70*(5), 488-497.
48. Slavik, D. (2010). Inuvialuit knowledge of nanuq: Community and traditional knowledge of polar bears in the Inuvialuit Settlement Region. *Wildlife Management Advisory Council (NWT), Wildlife Management Advisory Council (North Slope), and Inuvialuit Game Council, Inuvik, Northwest Territories, Canada*.
49. Smit, B., Wandel, J., & Hovelsrud, G. (2008). *CAVIAR (Community Adaptation and Vulnerability in Arctic Regions) framework document for an international polar year consortium*. Guelph, Ont.: University of Guelph: Dept. of Geography, Occasional Paper No. 28.
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52. Solomon, S. (2001). Tuktoyaktuk erosion risk assessment, 2001. Report prepared for the government of the Northwest Territories and EBA engineering. *Geological Survey of Canada, Natural Resources Canada, Dartmouth*.
53. Solomon, S. (2002). Tuktoyaktuk erosion risk assessment report. *Geological Survey of Canada, Natural Resources Canada*.
54. Steiner, N., Azetsu-Scott, K., Galbraith, P., Hamilton, J., Hedges, K., Hu, X., . . . van der Baaren, A. (2013). Climate change assessment in the arctic basin part 1: Trends and projections - A contribution to the aquatic climate change adaptation services program. *Canadian Technical Report of Fisheries and Aquatic Sciences, 3042*, 1-163,XII,XIII.

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57. Tofflemire, K. (2000). Inuvik regional human contaminants monitoring program: Regional report. *IRHSSB, Inuvik*.
58. Wein, R. W. (2002). Forest fires and northern communities: Lessons from the 1968 Inuvik fire.
59. Wesche, S. D., & Chan, H. M. (2010). Adapting to the impacts of climate change on food security among Inuit in the western Canadian arctic. *Ecohealth, 7*(3), 361-373. doi:10.1007/s10393-010-0344-8
60. ArcticNet. (2010). *Impacts of environmental change in the Canadian coastal arctic a compendium of research conducted during ArcticNet phase I (2004-2008)*. W.F. Vincent, M. Lemay, & C. Barnard (Eds.). Quebec: Que.
61. Waugh, L., Rausch, B., Engram, T., & Aziz, F. (2012). Inuvik super school VR documentation: Mid-project status. *Cold Regions Engineering 2012: Sustainable Infrastructure Development in a Changing Cold Environment,* 221-230.
62. Parewick, K. (2012). Things change, we change: Planning for resilience in the Canadian arctic. Doctor of Philosophy dissertation. Department of Geography, Memorial University of Newfoundland.
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65. Dumas, J., Carmack, E., Melling, H. (2005). Climate change impacts on the Beaufort shelf landfast ice. *Cold Regions Science and Technology, 42*, 41-51. doi: 10.1016/j.coldregions.2004.12.001
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Excluded articles: (refer to Codebook for numerical meaning of exclusion factors 1-8).

69. Abate, R., & Kronk, E. A. (Eds.). (2013). *Climate change and indigenous peoples: The search for legal remedies*. Cheltenham, UK ; Northampton, MA: Edward Elgar. (Excluded 1).
70. Abel, A. (2001). FEATURES-SEEKING MECCA IN INUVIK-which way do you face for sundown prayers in the land of the midnight sun? *Canadian Geographic, 121*(1), 56-57. (Excluded 1).
71. Aboriginal Affairs and Northern Development Canada. (2011). *Report on federal science conducted in support of northern energy development, 2002-2010*. Ottawa: Ont.: Government of Canada. (Excluded 5).

72. Åkesson, S., Morin, J., Muheim, R., & Ottosson, U. (2000). Migratory orientation of savannah and white-crowned sparrows in autumn: Cage experiments in Inuvik, North-Western Canada. (Excluded 2)
73. Alunik, I., Kolausok, E. D., & Morrison, D. A. (2003). *Across time and tundra : The Inuvialuit of the western arctic*. Vancouver : Raincoast Books ; Seattle : University of Washington Press ; Gatineau, Quebec: Canadian Museum of Civilization. (Excluded 1).
74. Angell, A.C. and Parkins, J.R. (2011). Resource development and aboriginal culture in the Canadian north. *Polar Record, 47*(240), 67-79. (Excluded 1, 5).
75. Aplin, L., Fagan-Garcia, K., Geary, J., & Goodman, K. (2011). Household factors associated with h pylori infection in Aklavik, Northwest Territories. *American Journal of Epidemiology, 173*, S230-S230. (Excluded 1).
76. Arctic Council, Munk School of Global Affairs, Walter and Duncan Gordon Foundation, Munk-Gordon Arctic Security Program, Canadian Electronic Library, & Arctic Council. (2012). *Canada as an arctic power preparing for the Canadian chairmanship of the arctic council (2013-2015)*. Toronto, Ont. : Munk School of Global Affairs, University of Toronto: and Walter and Duncan Gordon Foundation. (Excluded 5).
77. Arsenault, D. (2013). The aesthetic power of ancient dorset images at qajartalik, a unique petroglyph site in the Canadian arctic. *Boletin Del Museo Chileno De Arte Precolombino, 18*(2), 19-32. (Excluded 1, 5).
78. Barnett, C. R., & Pemberton, S. G. (2002). Integrated lithofacies and ichnofacies of the Aklavik formation, Mackenzie delta and northern richardson mountains, NWT, Canada: An outcrop study from a frontier basin. Paper presented at the *AAPG Annual Meeting 2002*. (Excluded 1, 2).
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80. Barr, S. (2000). Resolute to Tuktoyaktuk. (Excluded 1).
81. Bateman, M. D., & Murton, J. B. (2006). The chronostratigraphy of late pleistocene glacial and periglacial aeolian activity in the Tuktoyaktuk coastlands, NWT, Canada. *Quaternary Science Reviews, 25*(19), 2552-2568. (Excluded 2).
82. Bej, A. K., Aislabie, J., & Atlas, R. M. (Eds.). (2010). *Polar microbiology : The ecology, biodiversity, and bioremediation potential of microorganisms in extremely cold environments*. Boca Raton: Taylor & Francis. (Excluded 2).
83. Berkes, F., & Jolly, D. (2002). Adapting to climate change: Social-ecological resilience in a Canadian western arctic community. *Conservation Ecology, 5*(2), 18. (Excluded 5)??
84. Berman, M., Nicolson, C., Kofinas, G., Tetlichi, J., & Martin, S. (2004). Adaptation and sustainability in a small arctic community: Results of an agent-based simulation model. *Arctic, 57*(4), 401-414. (Excluded 5)
85. Bilodeau, F., Gauthier, G., & Berteaux, D. (2013). Effect of snow cover on the vulnerability of lemmings to mammalian predators in the canadian arctic. *Journal of Mammalogy, 94*(4), 813-819. (Excluded 1, 2, 5)
86. Bobik, P., Storini, M., & Kudela, K. (2000). The influence of magnetospheric disturbances on the charged particle access to Inuvik location. Paper presented at the *Conference Proceedings-Italian Physical Society, , 68* 39-44. (Excluded 2, 6).
87. Bobik, P., Storini, M., & Kudela, K. (2001). The charged particle access to Inuvik neutron monitor. Paper presented at the *International Cosmic Ray Conference, , 10* 4098. (Excluded 2, 6).
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89. Brooks, G. R., Lane, L. S., & Parks Canada. (2011). *A guide to the landscape of the firth river valley, Ivvavik national park*. Inuvik, NT: Parks Canada. (Excluded 1).
90. Burn, C., Mackay, J., & Kokelj, S. (2009). The thermal regime of permafrost and its susceptibility to degradation in upland terrain near Inuvik, NWT. *Permafrost and Periglacial Processes, 20*(2), 221-227. (Excluded 2)

91. Cameron, E. S. (2012). Securing indigenous politics: A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the canadian arctic. *Global Environmental Change-Human and Policy Dimensions, 22*(1), 103-114. doi:10.1016/j.gloenvcha.2011.11.004 (Excluded 3).
92. Canada Mortgage and Housing Corporation, issuing body. (2014). *Design and construction of the northern sustainable house - Inuvik, Northwest Territories* (Excluded 1).
93. Environment Canada. (2014). *Canada's sixth national report on climate change, 2014 : Actions to meet commitments under the united nations framework convention on climate change*. Government of Canada. (Excluded 5).
94. Natural Resources Canada, Environmental Studies Research Funds, & AMEC Earth and Environmental. (2010). *Assessment of drilling waste disposal options in the Inuvialuit settlement region*. Ottawa: Govt. of Canada. (Excluded 1).
95. Assembly of First Nations, & Centre for Indigenous Environmental Resources. (2006). *Climate change and first nations recommendations for action*. Winnipeg: Manitoba: Centre for Indigenous Environmental Resources. (Excluded 5).
96. Canadian Science Advisory Secretariat, issuing body, & Canada. Department of Fisheries and Oceans. Central and Arctic Region,issuing body. (2014). *Evaluation of a fisheries risk assessment tool (FRAT) for the Mackenzie gas pipeline* (Excluded 1).
97. Carraher, S., Chang, H., Munday, R., Goodman, K. J., & CANHelp Working Group. (2013). Problems with the epidemiologic transition model: Structural inequality, H. pylori bacteria and stomach diseases in Aklavik, NWT. *International Journal of Circumpolar Health, 72*, 742-743. (Excluded 2).
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101. Christensen, J. (2012). "They want a different life": Rural northern settlement dynamics and pathways to homelessness in yellowknife and inuvik, northwest territories. *The Canadian Geographer/Le Géographe Canadien, 56*(4), 419-438. (Excluded 1)
102. Christensen, J. (2013). Pathways to homelessness: Rural-urban migration and housing insecurity in Yellowknife and Inuvik, Northwest Territories. *Northern Public Affairs, 1*(2), 51-54. (Excluded 1).
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Appendix 3.

Summary tables of community vulnerabilities (adapted from Pearce et al. 2009).

Community attribute (INUVIK)	Current exposure-sensitivity	Adaptive capacity
Harvesting & Food Security	• Caribou spending more time closer to the coast, meat is infected with parasites (Nickels 2005:20)	
	• Warm water is affecting the quality of fish meat, spoiling quicker in fisher's nets (Nickels et al. 2005:19) • Better growing conditions for berries (Nickels et al. 2005:10)	• Fishers no longer leave their nets in overnight and limit the time their nets stay in the water during the day (Nickels et al. 2005:19)
	• Goose migration pattern shifting to the east, decline in abundance (Nickels et al. 2005: 17)	• Community greenhouse & food program (Ford et al., 2013)
Infrastructure & Transportation	• Forest fires are more frequent (Nickels et al., 2005:19) • Ice roads degrading (Nickels et al., 2005:20) • Rising sea levels increase risk of flooding (Manson & Solomon, 2005; Cohen, 1997)	• Fire guards built around town (GNWT, 2014) • Government prepared flood evacuation plans (Newton, 1995:158)
	• Lower river water and higher sediment levels make boating difficult (Community of Inuvik et al., 2006) • More extreme winter storms can cause damage to buildings, water and sewage systems or loss of power (MACA, 2014) • Increased frequency of landslides threatening Dempster Highway (GNWT, 2014)	• More expensive and less safe travel routes being used (Nickels et al., 2005:20)
	• Thinning sea ice makes travel difficult (Community of Inuvik et al., 2006) • Permafrost degradation and thermokarst development threatening transportation routes (Bone et al., 1997; Borsy, 2006:137) • Stronger summer storm winds, makes planning safe traveling and hunting trips more challenging (Nickels et al., 2005:8) •	• Thermosyphons used as the foundation of the Inuvik Health Care Center to protect against permafrost thaw (Hayley, 2004; Borsy, 2006)
Health & Wellbeing	• An increase in the number of 'hot days' linked to heat-related stress (i.e. dehydration) (Nickels et al., 2006:87; Frugal & Prowse, 2008:100)	• Biomedical engineering training programs implemented to build sustainability in the health sector (Taylor et al., 2004)

	• Number of insects increasing and staying longer in the fall (e.g. mosquitoes and sand flies), causing anxiety over transmission of infections (Nickels et al., 2005:20) • More extreme winter storms create hazardous driving and working conditions (MACA, 2014) • Appearance of new species causing anxiety (Nickels et al., 2005) • Permafrost thaw is increasing the risk of contaminant leaching (Community of Inuvik et al., 2006) • Leached contaminants are harming fish and wildlife species (Pearce et al., 2009) • Concern over the quality of drinking water, possibility that melting permafrost may contribute to the release of contaminants (Nickels et al., 2005: 16)	• Residents installing window-screens (Nickels et al., 2005:20) • Community sustainability plan developed to ensure the quality of life of present and future generations (Kavik-AXYS and Stantec Consulting Ltd., 2010)
Economy	• Poor condition of Dempster Highway due to permafrost thaw is deterring tourists and limiting the transport of goods into and out of town (Zimmerman, 1997:32; Borsy, 2006:24) • People are spending more money on purchasing furs because of decline in quality of furs hunted (Community of Inuvik et al., 2006)	• Ground bed on which the Dempster Highway sits is better insulated and ventilated to avoid/prevent permafrost damage (Borsy, 2006)

Community attribute (AKLAVIK)	Current exposure-sensitivity	Adaptive capacity
Harvesting & Food Security	• Fish are spawning earlier (Nickels et al., 2005:20) • Location of salmon run altered due to warmer ocean temperatures (Kofinas, 2002:82) • Number of whales has decreased (Nickels et al., 2005:20) • Fishing and beluga hunting more challenging due to stronger coastal winds affecting boat travel (Community of Aklavik et al., 2002:71) • Unpredictable ice conditions due to changes in spring freeze-thaw conditions (Kofinas, 2002:71) • Caribou populations changing as a result of altered foliage growth due to warmer temperatures (Kofinas, 2002:74) • Goose migration pattern shifting to the east, decline in abundance (Nickels et al., 2005:17)	• Community members have had to trade with other communities for meat (Nickels et al., 2005:20) • Individuals rely on the community freezer when their supply runs out (Nickels et al., 2005:20) • Fish health monitoring program implemented by community members (Kofinas, 2002: 81) • Conservation plans developed to promote sustainable land use (FJMC, 2000) • Shipping timing and route rules developed by the community to conserve wildlife migration routes (Nickels et al., 2005).

Infrastructure & Transportation	• Riverbank erosion (Pearce et al., 2011)
	• Stronger summer storm winds, makes planning safe traveling and hunting trips more challenging (Pearce et al., 2011; Nickels et al., 2005:8)
	• Increased frequency of flooding (MACA, 2014; Pearce et al., 2011)
	• Lower water levels in the Delta make traveling and accessing hunting grounds a challenge (Kofinas, 2002:69)
	• Permafrost degradation (Borsy, 2006:28)
	• Increased snowfall and a change in snow quality is making it difficult to pull sleds with skidoo and more challenging to travel on flooded trails (Community of Aklavik et al., 2005:71).
	• Barrier: limited access to granular resources for building foundation pads and roads (Borsy, 2006)
		• Lighter and shallower drift boats are used due to changes in water levels (Nickels et al, 2005:91)
		• Enhanced flood coping strategies
		  ○ Raising buildings off of the ground (Newton, 1995:162)
		  ○ Development of community flood plan (Hamlet of Aklavik, 2004)
		  ○ Community organized weather forecasts & flood warnings (Pearce et al., 2009:61)

Health & Wellbeing	• Weather has become more violent (i.e. tornados), generating community safety concerns (Nickels et al., 2005:20) • Lower water levels; landscape drier than in the past (Nickels et al., 2005:20) • Erosion of traditional skills and knowledge • Temperature changes are inhibiting berry growth (Community of Aklavik et al., 2005:72-3), berry picking is considered a culturally important activity (Nickels et al., 2005:10)	• Land skill camps and teaching programs (Community of Aklavik et al., 2005)

	• Greater variance in abundance of traditional food species (i.e. caribou) due to changing environmental factors is threatening the cultural identity of the community (Wesche & Chan, 2010; Kruse et al., 2004) • Concern over the quality of drinking water, possibility that melting permafrost may contribute to the release of contaminants (Nickels et al., 2005: 16)	
Economy	• A volatile traditional economy has resulted in unstable youth employment (Kofinas, 2002:83) • As traveling distances increase so too do gasoline costs (Duerden et al., 2010)	•

Community attribute (TUK)	Current exposure-sensitivity	Adaptive capacity
Harvesting & Food Security	• Unpredictable weather makes it difficult to know when conditions are suitable for travel to hunting grounds (Andrachuk & Pearce, 2010: 69) • Caribou populations declining (Andrachuk & Pearce, 2010: 69) • Fish spoiling faster in nets due to warmer water temperatures (Andrachuk & Pearce, 2010: 68) • Fewer migratory fish and softer flesh that is more prone to spoiling (Andrachuk & Pearce, 2010: 68) • Herring are thinner, their numbers have decreased (Nickels et al., 2005) • Gamebird numbers have declined, capturing enough to make a meal is difficult and more energy must be spent finding them (Nickels et al., 2005) • Stronger winds deter whales from traditional hunting grounds (Andrachuk, 2008: 55) • Thicker shrubbery makes hunting for game difficult (Community of Tuktoyaktuk, 2005) • Flavor of game meat is changing as a result of increased environmental stresses (Community of Tuktoyaktuk, 2005) • Caribou are getting stuck in areas where the permafrost has melted quickly (Community of Tuktoyaktuk, 2005) • Goose migration pattern shifting to the east, decline in abundance (Nickels et al., 2005: 17)	• Hunting regulations have been put in place to protect declining caribou herds (Andrachuck & Pearce, 2010: 68) • Supplementing the decline of one species with another that is more accessible (e.g. harvesting more fish and musk-ox when caribou numbers are down) (Andrachuk & Pearce, 2010: 70; Andrachuk & Smit, 2012: 876) • Fish earlier in the year (Nickels et al., 2005) • Alter food preparation practices (i.e. more care during hot days, use of freezers to store meats) (Andrachuk & Smit, 2012: 874) • Consumption of more store foods (Andrachuk & Pearce, 2010: 70) • Avoiding travel during adverse weather conditions or altering travel routes (Andrachuk & Pearce, 2010: 70) • Shift location and/or timing of harvesting certain species (Andrachuk & Smit, 2012: 874) • Invest in new technologies to make harvesting more efficient (Andrachuk & Smit, 2012: 874) • Management plans developed to protect important species (Andrachuk & Smit, 2012: 874)
Infrastructure & Transportation	• Permafrost degradation threatening building foundations (Andrachuk & Pearce, 2010: 71; Andrachuk & Smit, 2012: 871; Nickels 2005), also resulting in more frequent and intense landslides (Dyke et al., 1997; French, 2008) • Coastal erosion (Andrachuk & Pearce, 2010: 71; Andrachuk & Smit, 2012: 871) • Increased storm events resulting in damage to buildings and roads (Andrachuk & Pearce, 2010: 63) • Strong storm events cause flooding and inundate sewage lagoons (Andrachuk & Pearce, 2010: 68) • Shorter ice-road season limits the hauling season for supplies (Borsy, 2006: 128; Hinzman et al., 2005) • Travel across land more difficult due to:	• Installation of sandbags, concrete slabs and boulders (Johnson et al., 2003; Andrachuk & Pearce, 2010: 71) Stockpile aggregate during winter months (Andrachuk & Smit, 2012: 874) • Relocation or removal of coastal buildings at risk (Andrachuk & Pearce, 2010: 73; Andrachuk & Smit, 2012: 874) • Construction of all weather road to inland gravel source (Andrachuk & Pearce, 2010: 72; Andrachuk & Smit, 2012: 873)

	○ More extreme winter temperatures and snowfall (Nickels et al., 2005) ○ Altered precipitation patterns, low water levels (Nickels et al., 2005: 21) ○ Stronger summer storm winds, makes planning safe traveling and hunting trips more challenging (Nickels et al., 2005: 8)	
Health & Wellbeing	• Youth spending less time on land (Andrachuk & Smit, 2012: 876) • Loss of TEK (Pearce et al., 2009) • Lack of nutritional value in store foods vs. country foods (Andrachuk & Smit, 2012: 872) • Warmer summer temperatures making outdoor activities uncomfortable (Pearce et al., 2009) • Appearance of new species causing anxiety (Nickels et al., 2005) • Increased number of insects are creating discomfort and stress (Nickels et al., 2005: 13) • Hunting regulations and declining species populations are constraining traditional hunting practices; erosion of cultural identity (Andrachuck, 2008) • Loss of cultural sites to storm induced erosion (Anisimov et al., 2007) • More accessible offshore hydrocarbons stores resulting in a shift from subsistence economy; value of TEK being lost (Carmack, 2008) • Growing abuse of alcohol as a result of less time spent on the land because of rising costs, a changing economy base, and unpredictable weather (Andrachuk, 2008) • Concern over the quality of drinking water, possibility that melting permafrost may contribute to the release of contaminants (Nickels et al., 2005: 16)	• Those unable to hunt purchase traditional foods from full-time harvesters (Andrachuk & Pearce, 2010: 70) • Taking advantage of early ice break-up by spending more time out on the land (i.e. picnicking) (Community of Tuktoyaktuk, 2005)

Economy	• Viability of sport hunting (i.e. polar bears) threatened by rough ice and weather conditions (Andrachuk, 2008) • Wage-dependent tour operators vulnerable to greater seasonal variation (Pearce et al., 2009: 68) • Large proportion of community resources are spent on shoreline protection measures (Pearce et al., 2009)	• Community members seeking employment outside the community instead (Andrachuk & Smit, 2012: 874) • Sport hunting for polar bears is being carried out by dog sled rather than skidoo (Andrachuk, 2008: 61) • Small entrepreneurial enterprises (i.e. tour operators, artisanal crafts) (Andrachuk & Smit, 2012: 874)

Appendix 4.

Suggested governance structure to support the inclusion of a 'Climate Change Committee' in each community.