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Climate change policy responses for Canada's Inuit population: The importance of and opportunities for adaptation

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ABSTRACT

We identify and examine how policy intervention can help Canada's Inuit population adapt to climate change. The policy responses are based on an understanding of the determinants of vulnerability identified in research conducted with 15 Inuit communities. A consistent approach was used in each case study where vulnerability is conceptualized as a function of exposure-sensitivity to climatic risks and adaptive capacity to deal with those risks. This conceptualization focuses on the biophysical and human determinants of vulnerability and how they are influenced by processes and conditions operating at multiple spatial-temporal scales. Case studies involved close collaboration with community members and policy makers to identify conditions to which each community is currently vulnerable, characterize the factors that shape vulnerability and how they have changed over time, identify opportunities for adaptation policy, and examine how adaptation can be mainstreamed. Fieldwork, conducted between 2006 and 2009, included 443 semi-structured interviews, 20 focus groups/community workshops, and 65 interviews with policy makers at local, regional, and national levels. Synthesizing findings consistent across the case studies we document significant vulnerabilities, a function of socio-economic stresses and change, continuing and pervasive inequality, and magnitude of climate change. Nevertheless, adaptations are available, feasible, and Inuit have considerable adaptive capacity. Realizing this adaptive capacity and overcoming adaptation barriers requires policy intervention to: (i) support the teaching and transmission of environmental knowledge and land skills, (ii) enhance and review emergency management capability, (iii) ensure the flexibility of resource management regimes, (iv) provide economic support to facilitate adaptation for groups with limited household income, (v) increase research effort to identify short and long term risk factors and adaptive response options, (vi) protect key infrastructure, and (vii) promote awareness of climate change impacts and adaptation among policy makers.

1. Introduction

There is strong evidence that human induced climate change is underway in the Canadian Arctic (IPCC, 2007b). Temperatures have been increasing at twice the global average, recent years have witnessed a dramatic reduction in summer sea ice cover and ice thickness, and extreme weather conditions appear to be increasing in both magnitude and frequency (IPCC, 2007b; Serreze et al., 2007; Barber et al., 2008; Comiso et al., 2008; Graversen et al., 2008; Min et al., 2008; Kaufman et al., 2009). These changes are having implications for Canada's Inuit population, many of whom depend on hunting and fishing for their livelihoods (ACIA, 2005; Furgal and Prowse, 2008). Climate models indicate that climate change will be amplified in Arctic regions (Serreze and Francis, 2006; IPCC, 2007b; Lenton et al., 2008) and communities, governments, and Inuit organizations have expressed their concern. In this context, discussion over what constitutes appropriate policy action on climate change for Inuit is a prominent area for climate policy debate in Canada and internationally (Ford, 2009b). While mitigation is needed if we are to avoid 'runaway' climate change, in an Arctic context adaptation is perhaps the most important policy response and is needed to reduce the negative effects of current climate change and help Inuit adapt to changes in climate that are now inevitable. Despite a proliferation of climate change research on impacts,

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adaptation, and vulnerability in Arctic regions in recent years however, and occasional studies addressing broad principles of adaptive management (Berkes et al., 2005; Chapin, 2006; Chapin et al., 2006; Berkes et al., 2007; Keskitalo, 2008a,b; Keskitalo, 2009), few studies have examined policy initiatives for adaptation. This is limiting the ability of governments, communities, and businesses in identifying opportunities for adaptation and progressing on adaptation planning (Budreau and McBean, 2007; Ford et al., 2007; Ford, 2008a, 2009b; Ford and Furgal, 2009).

In this paper we identify and examine opportunities for adaptation policy to reduce Inuit vulnerability to climate change and increase adaptive capacity. In doing so we build upon completed community-based vulnerability assessments and take the next step, using understanding of how Inuit are experiencing and responding to climate change to identify and examine policy entry points. Specifically, we analyze how multiple levels of government in Canada can establish and strengthen conditions favorable for effective adaptation to help reduce the negative impacts of climate change on resource harvesting, travel, food systems, and community infrastructure. Our recommendations are of direct relevance to article 4 of the United Nations Framework Convention on Climate Change (FCCC), which stresses the importance of identifying measures to facilitate adequate adaptation, and are intended to support climate change policy development in Canada's northern regions. The focus on Inuit reflects the urgency of developing policy initiatives for this highly vulnerable segment of the Canadian and global population. At a broader level, the Inuit experience of climate change, the urgency of adaptation, and recommendations for policy entry points have relevance for Indigenous peoples and northern communities in general, particularly those whose culture and livelihoods are closely linked to land-based aspects of traditional lifestyles.

2. Canada's Inuit population

In the 2006 census, 50 480 Canadians defined themselves as being Inuit, 24 635 of whom live in Canada's newest territory of Nunavut. The other 25 845 live primarily in three Inuit settlement regions: the Inuvialuit Settlement Region (ISR) in the Northwest Territories, Nunavik in the province of Quebec, and Nunatsiavut in the province of Newfoundland & Labrador (Table 1). Together, Inuit administered regions cover 31% of the Canadian landmass. The climate of Arctic Canada is characterized by very cold, long winters and short, cool summers, with the majority of the land surface area of the four Inuit regions continuous permafrost. Sea ice is an integral part of life in the Arctic. Depending on geographic location, the length of time at which the ocean is frozen varies from seven months in Nunatsiavut to nearly year-long coverage in northern Nunavut. The frozen ocean provides services essential to Inuit well-being, including transportation between communities and hunting areas, a hunting platform, and important cultural services (Eicken et al., 2009).

Most Inuit live in small, remote, coastal communities, with economies composed of waged employment and subsistence harvesting. The wage economy is largely based on public administration, resource extraction, and arts and crafts, with tourism also important in some regions. Many Inuit retain a close and intimate relationship with the environment and a strong knowledge base of their regional surroundings, with traditional foods derived from hunting and fishing having social and cultural importance, and continuing to supply principal elements of Inuit diet (Furgal and Prowse, 2008). Social, economic, and demographic characteristics of Inuit communities in Canada often mirror those in developing nations (Table 1). Communities are challenged by limited access to health services, low socio-economic status, high unemployment, crowded and poor-quality housing, concerns

Table 1
Selected characteristics of Inuit regions of Canada.

Inuit region	Province/Territory	Relevant land claim	Inuit population (% of total)[a]	Average community size[b]	Population density	Population 15+[c]	Average individual total income[c]	Unemployment rate[c]	% getting majority (>50%) of meat from traditional sources[d]
Territory of Nunavut	Nunavut	Nunavut land Claim Agreement (1993)	24,635 (84%)	1063	0.0123 ppl/km^2	16,650	$26,924	17.4	41%
Inuvialuit Settlement Region	Northwest Territories	Inuvialuit Final Agreement (1984)	3,115 (55%)	876	0.0344 ppl/km^2	3,655	$29,509	12.3	38%
Nunavik	Quebec	James Bay and Northern Quebec Agreement (1975)	9,565 (90%)	688	0.0145 ppl/km^2	5,830	$23,215	14.5	40%
Nunatsiavut	Newfoundland & Labrador	Nunatsiavut Agreement (2005)	2,169 (89%)	1767	0.0279 ppl/km^2	1,785	$17,945	40.3	33%

[a] Statistics Canada (2006).
[b] Senécal and O'Sullivan (2006).
[c] Statistics Canada, 2001 Census of Population, INAC customized tabulations.
[d] Poppel et al. (2007).

Table 2
A summary of changes affecting Canada's Inuit population since the 1950s. Note that specific dates at which these changes occurred differs by region and community, and the date attached can be considered an approximate generalization (based on Myers et al., 2005).

	Change	Impact
1950s	Resettlement of Inuit into centralized communities	Reduced harvesting, increased participation in wage economy, changing socio-cultural norms, reduced mobility
	Adoption of mechanized transportation replacing dog	Travel further and faster to hunt and fish, dependence on imported technology, need cash income for subsistence activities
	Increasing individualization in hunting	Reduction in group hunting activities
	Increasing commercialization of harvesting	Increasing commercialization of aspects of hunting to support subsistence, participation in international markets, animal rights campaigns target hunting activities, increasing importance of money
	Economic development promoted	Big resource development affect wildlife health and population, increasing integration into global economic markets
	Transportation improvement	Development of regular scheduled flights improves access and importation of food, improved opportunity for economic development
	Wildlife regulations implemented	Affects the flexibility of harvesting by controlling what can harvested, when, and where for certain species, conflict among hunters regarding division of quotas, conflict with regulatory agencies.
	Inuit land claims negotiations begin	Increased political power and decision making capability for Inuit, increasing community involvement in decision making
	Contaminants affecting traditional foods	Anxiety over traditional food consumption
2000s	Climate change impacts begin to be noted by scientists and communities	Alteration to access and availability of traditional foods, increasing danger, international political actors begin to demand decreased hunting activity

regarding basic services such as drinking water quality and sanitation, and low educational achievement (AHDR, 2004; Furgal and Prowse, 2008; Seguin, 2008). These challenges reflect the sweeping socio-cultural changes in the second half of the twentieth century, as former semi-nomadic hunting groups were re-settled into centralized communities and incorporated into a colonial relationship with the Canadian state (Table 2). Not all of these changes have been negative but many have been undesirable, transforming livelihoods and social and cultural interaction within a generation (Table 2). It is within this context that Inuit communities will experience and respond to climate change, with social and economic conditions predisposing communities to be adversely affected by a changing climate (Duerden, 2004; Furgal and Prowse, 2008; Pearce et al., 2009a).

3. Climate change and Canadian Inuit

Inuit communities have been particularly susceptible to changing climatic conditions documented in the last decade due to their dependence on climate sensitive resources for livelihoods (Table 3). Compromised food security, increasing danger of engaging in traditional practices, and the inability to hunt at certain times of the year have been noted across northern Canada (Nickels et al., 2006; Tremblay et al., 2006; IPCC, 2007a; Furgal, 2008; Furgal and Prowse, 2008; Pearce et al., 2009b). Increasing sea levels, coastal erosion, and permafrost thaw are also threatening the viability of some Inuit settlements, damaging important heritage sites, and compromising municipal infrastructure and water supply (Martin et al., 2007; Furgal and Prowse, 2008; Larsen

Table 3
Observed climate change and documented impacts in Canada's Inuit regions.

Documented Changes	Implications
Sea ice dynamics	
Later ice freeze-up	Constrained access to hunting areas and other communities
Earlier sea ice break-up	Increased danger of traveling on the ice
Thinning of ice	Longer open water period in summer for shipping
Slower freeze-up	Need to develop new trails
	Increase in summer storm surges and coastal erosion
Wind	
More unpredictable wind	Increased danger of resource harvesting activities
Change in predominant direction	More difficult to hunt and fish
More frequent storms	Accelerated coastal erosion
Temperature	
Warmer summer, warmer winter	Affecting aging process for traditional foods
Permafrost thaw	Implications for infrastructure including buildings, roads, and airstrips
Animals	
Changing migration behaviour, declining animal health in some regions for some species (e.g. polar bear in Hudson's Bay), declining population numbers in some regions	Imposition of import ban by the US on polar bear skins
	Altered hunting behaviour
	Species switching
Geomorphological processes	
Permafrost thaw	Infrastructural damage (roads, runways, housing)
More active slope processes	Reduction in available space for development
Accelerated coastal erosion	Damage and loss of cultural sites

et al., 2008). In parts of the Canadian Arctic average temperatures have already increased beyond the 2 °C threshold that is widely believed to represent dangerous interference with the climate system, with similar impacts noted in indigenous communities across the North American Arctic (Chapin et al., 2004; Huntington et al., 2007; White et al., 2007a; Alessa et al., 2008a,b). Benefits have also been noted with climate change, including improved hunting opportunities with longer ice-free summers, reduced exposure to the health effects of extreme cold, enhanced opportunities for economic development, and potential for commercial fisheries (ACIA, 2005; Nickels et al., 2006; Barber et al., 2008; Ford, 2008b; Furgal, 2008; Wenzel, 2009). The overall impacts of current and projected climate change will vary by location but are generally are believed be negative (IPCC, 2007a; Furgal and Prowse, 2008). In this context, it has been argued that climate change is challenging the human rights of Inuit (Crump, 2008).

4. Climate change policy in the context of the Canadian North

4.1. Mitigation and adaptation

The United Nations Framework Convention on Climate Change (FCCC, 1992) outlines two key areas for climate policy, mitigation and adaptation, both of which are essential for Canada's Inuit population. *Firstly*, the FCCC and its principal update the Kyoto Protocol legally obligates parties to "stabiliz[e] greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system," (Article 2). In Canada, a 6% reduction in emissions was negotiated at Kyoto, although the federal government has since indicated it will not meet these targets. *Secondly*, adaptation, which seeks to develop measures to reduce or moderate the negative effects of climate change and take advantage of new opportunities, is an important component of the Framework Convention (FCCC, 1992). In Canada, adaptation has been recognized at federal, provincial, and territorial levels (Ford et al., 2007). The federal government has commitments to support adaptation and a national impacts and adaptation assessment was recently published by Natural Resources Canada (Lemmen et al., 2008). In Arctic Canada, policy makers have also begun to discuss adaptation as a response to climate change (e.g. Many Strong Voices, Nunavut climate change adaptation plan, Indian and Northern Affairs Canada's Assist Northerners in Assessing Key Vulnerabilities and Opportunities program, Health Canada's Climate Change Adaptation in Northern First Nations and Inuit Communities program). Despite discussions about adaptation, however, Canada has made limited progress beyond statements of general principles; mitigation still dominates the climate policy agenda (Newton et al., 2005; Ford et al., 2007; Ford, 2008a,b; Ford et al., 2009). The political agenda on adaptation remains nascent, with an 'adaptation deficit' between what policies and research are needed to promote and support adaptation and what is currently available (Budreau and McBean, 2007; Ford, 2009b).

4.2. The increasing importance of adaptation

Mitigation is central to efforts to tackle climate change and lower emission futures will give Inuit and the ecosystems on which they depend more time to adapt. Reducing emissions in Arctic communities could also have significant pollution and health benefits. For instance, as Reimann et al. (2009) highlight, snowmobiles are a major source of local air pollution with a preference for polluting high powered machines observed in some locations (Ford et al., 2009), and all Inuit settlements are powered by polluting diesel generators. Moreover, 'dangerous' climate change may already be occurring in Canada's Arctic regions, or will happen soon, thereby compelling Parties to the FCCC to act immediately through mitigation to avoid "dangerous anthropogenic interference with the climate system," (Article 2) (Ford, 2009b).

We argue, however, that *adaptation* should become a central feature of climate change policy for Canada's Inuit population. As Ford (2009b) argues, adaptation is needed to uphold domestic Inuit rights and to prevent internationally recognised human rights being compromised. Indeed, it is now accepted that some degree of climate change is inevitable, even if atmospheric concentrations of greenhouse gases were dramatically curtailed, and the Arctic's climate is already changing rapidly (IPCC, 2007b; Ramanathan and Feng, 2008; Schellnhuber, 2008). Communities, regions, and economic sectors will therefore have to adapt to some degree of climate change. Adaptation offers a tangible way in which vulnerability to current and future climate change can be moderated and Inuit livelihoods strengthened. We further argue that the current focus of climate policy in and for Canada's Arctic regions *primarily* on mitigation is misplaced on account of low populations, the absence of a sizable industrial base, limited consumption levels in northern Canada, and current vulnerability to climate change. Reducing emissions in Inuit regions will have limited impact on the speed, magnitude, or effects of climate change. This is not to downplay mitigation but to *prioritise* adaptation where human and financial resources are limited and changes in climate that could be classified as dangerous already occurring (Ford, 2009b).

5. Identifying adaptation entry points for Canada's Inuit population: a vulnerability approach

Efforts to identify adaptation needs and inform the development of policies to reduce the negative impacts of climate change, are dependent upon an understanding of vulnerability of a system to climate change, in terms of who and what are vulnerable, to what stresses, in what way, and determinants (Turner et al., 2003; Adger, 2006; Smit and Wandel, 2006; Fussel, 2007; Keskitalo, 2008b). In this paper we draw upon completed community-based vulnerability assessments conducted by the authors with 15 Inuit communities (over 1/4 of all the Inuit settlements in Canada) (Fig. 1), forming a transect from the western Arctic to the eastern subarctic and reflective of the diverse culture, livelihoods, and settlement characteristics of Canada's Inuit population and the different climatic, ecological, and physiographic contexts which they occupy (Table 4). Case studies were conducted independently by each author using a consistent approach to vulnerability assessment, providing a detailed characterization of vulnerability and adaptive capacity. Here we build upon this work and take the *next step*, synthesizing key findings consistent across the case studies to provide the basis for identifying and examining opportunities for policy to address vulnerability determinants and enhance adaptive capacity. Given the diversity of our case studies and similarities in general determinants of vulnerability, our policy recommendations are targeted at Canada's Inuit population in general; community specific adaptation options are addressed elsewhere (Nickels et al., 2006 for communities in all four Inuit regions; Ford et al., 2007 in Nunavut). The examination of policy entry points also draws upon extensive interviews with policy makers at all levels of government (municipal, territorial/regional, federal), and analysis of secondary sources and the peer reviewed literature, to identify existing management and support systems, examine current policies with implications for climate vulnerability, identify the levers of government most appropriate for specific adaptation recommendations, and identify opportunities for adaptation policy and mainstreaming.

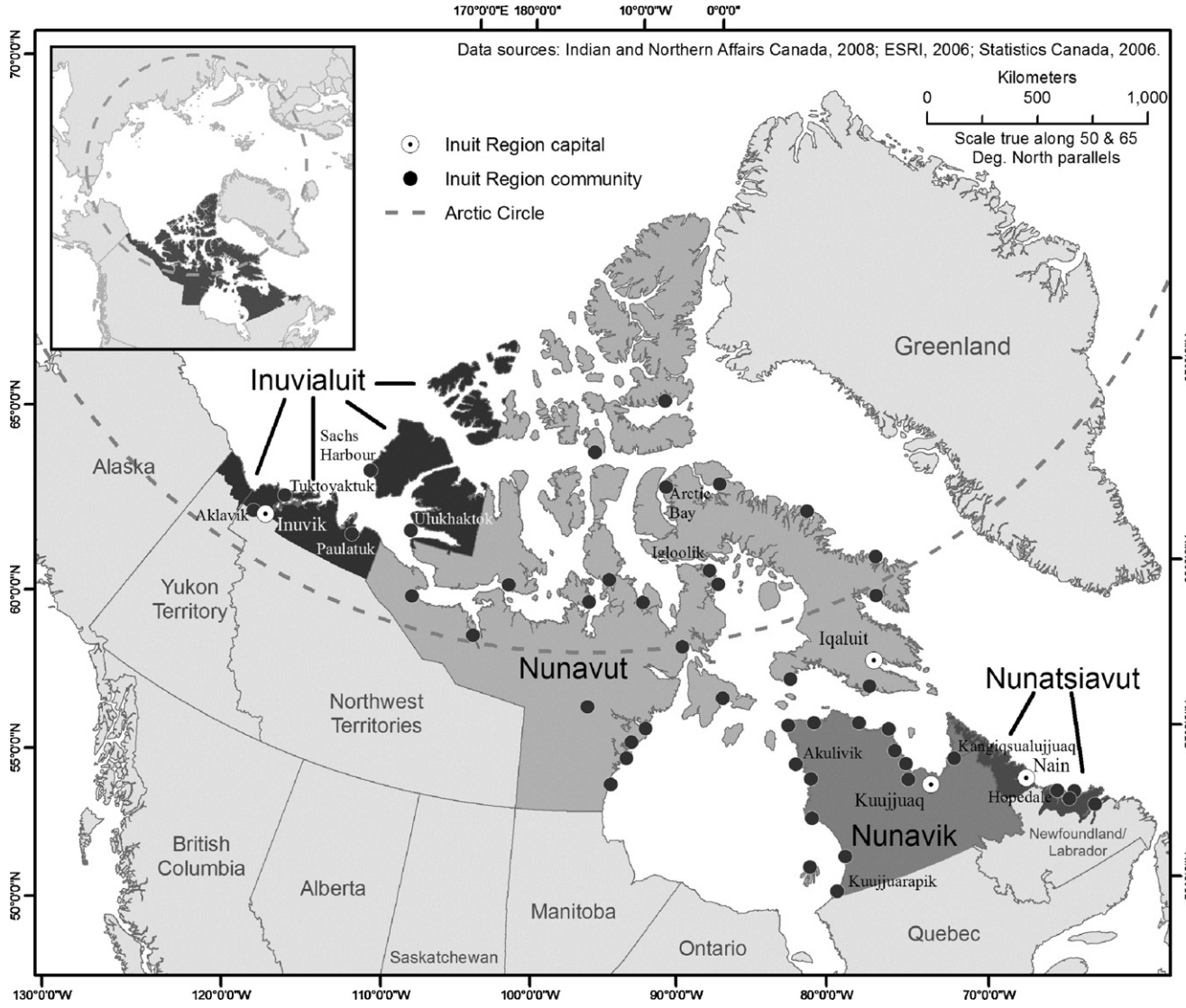

Fig. 1. Canada's Inuit regions – including the Inuvialuit Settlement Region, Nunavut, Nunavik and Nunatsiavut – cover 30% of the Canadian land mass. The area is sparsely populated with an average population density of 0.014 people per km^2, and approximately 51 permanently settled communities. This study builds upon completed case studies conducted with the 15 Inuit communities listed on the map.

The case studies use a consistent approach to vulnerability based upon the vulnerability approach of Ford and Smit (2004), Ford et al. (2006a,b) and Smit and Wandel (2006), where vulnerability is conceptualized as a function of exposure-sensitivity to climatic risks and adaptive capacity to deal with those risks. This conceptualization is broadly consistent with that employed by others, including Turner et al. (2003), Fussel (2007), and Keskitalo (2008a,b). Exposure-sensitivity reflects the susceptibility of people and communities to biophysical conditions that represent risks, and adaptive capacity reflects a community's potential or ability to address, plan for, or adapt to exposure-sensitivities. The recognition of the role of adaptive capacity and sensitivity in vulnerability research emphasizes the importance of non-climatic factors (including economic resources, technology, information and skills, infrastructure, institutions, and equity (Smit and Pilifosova, 2001)) in amplifying or attenuating vulnerability alongside the nature of the climatic stress, and builds upon a long history of social science research in the natural hazards field (Sen, 1981; Hewitt, 1983; Blaikie et al., 1994). Poverty, for example, can increase household sensitivity to climatic stress by forcing people to engage in dangerous activities, while lack of economic resources can constrain the ability of households to prevent, avoid, or recover from climatic hazards. These determinants of vulnerability are influenced by social, economic, cultural, and political conditions and processes operating at multiple scales over time and space, and change in these non-climatic conditions play an important role in determining vulnerability to climate change. Importantly, the emphasis on multiple stresses broadens the scope for adaptation to include initiatives to reduce sensitivity and exposure while increasing adaptive capacity.

Empirical assessment of vulnerability in each case study was also consistent, beginning by examining vulnerability to climate variability, extremes, and change based on actual experience in the immediate and distant past—a common approach in the literature (Burton et al., 2002; Lim et al., 2005; Leary et al., 2008). This allowed us to: (1) identify conditions that represent risks to community members, (2) characterize how communities experience and manage climatic risks, (3) identify the processes and conditions that influence exposure-sensitivity and determine the efficacy, availability, and success of past and present adaptations, (4) identify opportunities for and constraints to adaptation, and (5) identify entry points for adaptation policy. To achieve this, each

Table 4
Summary of findings from community-based research in which the authors are involved and upon which this paper draws to identify and examine opportunities for adaptation.

Study	Communities involved	Methods used	Key determinants of climate change vulnerability	Sources of adaptive capacity
Ford et al. (2006a,b, 2007, 2008a,b), Ford (2009b)	**Nunavut**: Arctic Bay, Igloolik, Iqaluit	Semi-structured interviews ($n=216$) Participant observation Policy maker interviews, all levels ($n=26$) Focus groups ($n=10$)	Erosion of land based skills Reduced resource use flexibility due to quotas Limited financial resources Community location	Social networks Traditional knowledge and culture Flexibility in resource use Technology Territorial policy (e.g. harvester support) Formal search and rescue
Pearce et al. (2009a,b,c) and Ford et al. (2008a,b)	**ISR**: Ulukhaktok	Semi-structured interviews ($n=112$) Policy maker interviews, all levels ($n=12$) Participant observation	Erosion of land based skills Limited financial resources (limited number of wage jobs, lack of qualifications, nepotism) High cost of hunting Time constraints due to employment obligations Substance abuse (health and well-being)	Social networks traditional knowledge and land skills Flexibility in resource use Financial capital Wellness
Duerden and Beasley (2006)	**ISR**: Ulukhaktok, Aklavik, Tuktayuktuk	Synthesis of existing studies/observations Semi-structured institutional interviews ($n=12$)	Erosion of land based skills Institutional capacity already stretched Limited financial resources Community location High costs of hunting Population turn-over	Experience and traditional knowledge Wage income Technology
Furgal and Seguin (2006)	**Nunatsiavut**: Nain **Nunavik**: Kuujjuaq **ISR**: Inuvik, Tuktoyaktuk, Aklavik	Focus groups ($n=6$) Semi-structured interviews ($n=8$) Community workshop/focus groups ($n=3$, participants 15-20/workshop)	Limited financial and technological resources Decrease in generation and sharing of land based knowledge Erosion of land based skills Existing health status Community location Lack of formal institutional support for adaptation	Social networks Communication networks and pathways for sharing/distribution of knowledge Traditional knowledge and land based skills Financial resources (among some individuals) Access to technology
Alain (2008)	**Nunavik**: Kangisualujjuaq	Semi-structured interviews ($n=22$) Focus group ($n=1$) On the land trips and personal observation	Limited financial resources Limited access to technological resources Limited social networks Erosion of land based skills and knowledge Limited pre-existing knowledge of region Approach to adaptation – perception and strategy	Financial resources Social networks Traditional knowledge and land based skills Knowledge of region/area (residence time in community) Access to technology (equipment) Perception of risk/hazard
Tremblay et al. (2006)	**Nunavik**: Kuujjuaq, Kangiqsualujjuaq, Akulivik, Kuujjuarapik	Semi-directed interviews ($n=15$) On the land trips and personal observation	Perception of risk Erosion of land based skills Experience/age	Traditional knowledge and land based skills Access to technology
DeSantis (2008), Fleming (2009)	**Nunatsiavut**: Hopedale	Semi-directed interviews ($n=80$) Policy maker interviews, all levels ($n=15$) Secondary source review Participant observation	Traditional knowledge and skills Community location Changes to wildlife availability and accessibility Limited local employment & investment (natural resource development) Changing Governance systems Compromised sharing networks Increasing costs of living (remote, limited transportation)	Financial capital—personal mobility (connection to financial capital) Traditional knowledge Diversity of wildlife resources available Institutional support Local informal sharing norms, networks, principles of sustainability Wage income opportunities; out-migration for jobs Ability to make trade-offs in resources harvested

study used a combination of methods, including semi-structured interviews with a cross section of local people ($n = 443$), focus groups/community workshops ($n = 20$), and interviews with policy makers at local, regional, and national levels ($n = 65$) (Table 4). It is noteworthy that the interviews were guided by open-ended interview guides that identified key themes to be covered. This allowed interviewees to identify vulnerabilities they considered important and permitted a greater understanding of the complex web of factors that shape vulnerability. Analysis of secondary sources was also used in each case study to add historical context on how communities manage and experience climatic variability and change. Once current vulnerability was characterized, studies then assessed *future vulnerability* by analyzing how climate change might alter the nature of climate-related risks identified as important by community members and whether the community's coping strategies would be capable of dealing with these risks.

All case studies involved close collaboration with community members at all stages of the research, from project design to interpretation to dissemination of results. Involving communities and stakeholders at risk in the research process is central in linking research to policy formulation (Pearce et al., 2009c). Interventions to reduce vulnerability will be more successful if they are identified and developed in co-operation with local actors and policy makers, helping to achieve relevance, credibility, and legitimacy (Newton et al., 2005; Chapin et al., 2006). Indeed, decision makers are often disinclined to make judgments in the absence of a specific context (Ford et al., 2007). Many of the policy opportunities we specify in the next section were identified by and have been reviewed with local people and northern policy makers.

6. Entry points for climate change adaptation policy

In this section we examine opportunities for adaptation policy based on an understanding of determinants of Inuit vulnerability and adaptive capacity. In particular we focus on adaptation to risks associated with resource harvesting, travel, food systems, and community infrastructure. The policy entry points target different levels of decision making, including strengthening and prioritizing existing management and support systems; targeting local, territorial, and federal institutions charged with wildlife management, harvester support, and education; enhancing municipal decision making and planning; targeting current and future climate change risks; and identify priority areas for further research. Table 5 summarizes the entry points.

6.1. Adaptation to the effects of climate change on resource harvesting

6.1.1. Accessibility of hunting and fishing areas

Climate change is reducing access to traditional hunting areas and compromising the ability for resource harvesting at certain times of the year in all case study communities. Inuit are not passive in the face of such change and community members are autonomously adapting by utilizing new equipment to maintain access to hunting areas. More ice-free open water in the summer is considered a benefit in many communities and people are using boats to take advantage of the new hunting opportunities. At other times of the year when the ice is unsafe, All Terrain Vehicles (ATVs) are being used to bypass the frozen ocean. New trail networks which detour unsafe and impassable areas are also being developed to access hunting areas.

Table 5
Synthesis of key opportunities to establish or strengthen conditions favorable for effective adaptation for Canada's Inuit population.

Measure	Level	Form	Benefits: climate and non-climate change related	Barriers: climate and non-climate change related
Harvester support	Regional governments, land claims organizations	*Institutional*: federal/regional governments, Inuit organizations develop/refine support mechanisms *Financial*: Economic support to adapt	Increased viability of resource harvesting sector Ability to purchase necessary equipment Strengthening of existing programs	Rising cost of equipment Territorial budget constraints
Co-management of wildlife resources	Regional governments, land claims organizations, federal government	*Institutional*: federal/regional governments, Inuit organizations to enter co-management bodies *Legal*: legal responsibility to formalize role of Inuit in wildlife management *Regulatory*: co-management procedures developed for species harvested by Inuit	Reduce conflict within communities and between communities and government/scientists More effective and successful wildlife management	Internationally established wildlife regulations International opinion Science—traditional knowledge incompatibility?
Land skills training	Regional governments, land claims organizations, municipalities	*Institutional*: creation and enhancement of educational programs *Behavioural*: modifying behaviour of younger generations to reduce their risks in a changing climate	Preservation of culturally important skills and knowledge Increased interest for harvesting among youth Enhancement of safe harvesting and traveling Key policy goal across Inuit regions	Cost Administration – inc. insurance and liability for taking youth out on the sea ice
Capacity assessment in search and rescue	Regional governments, municipalities, Dept. of National Defence, Coast Guard	*Institutional*: review of current and future operational capacity and effectiveness, worse case contingency planning.	Enhanced search and rescue capacity	High turn-over of personnel: institutional knowledge and capacity assessment challenges
Food system enhancement	Regional governments, land claims organizations, municipalities, federal government	*Institutional*: review current polices targeted at the food system	High baseline food insecurity across Inuit regions	High turn-over of personnel: institutional knowledge and capacity assessment challenges
Infrastructure protection	Regional governments, land claims organizations, municipalities, federal government	*Engineering*: Investment in engineering structures to protect infrastructure *Risk assessment*: Identify cultural sites at risk with climate change *Institutional*: land-use planning to avoid high risk areas in future development	Protection from climatic risks Identification and mapping of cultural sites	Cost: infrastructure protection very expensive in the a northern context Availability of gravel

Adaptation involving changing resource use patterns and technology in response to environmental circumstances has defined the very nature of Inuit survival in the Arctic for millennia, as it has among many indigenous communities globally (Wenzel, 1991; Krupnik, 1993; Damas, 2002). In the contemporary setting, however, Inuit households, especially hunting households or those without wage earning members, often do not have the financial capacity to afford adaptations. ATVs and boats, for example, are often too expensive and the costs of having to travel further and use additional fuel often exceed financial means. As Ford et al. (2008b) and chapters in Riewe and Oakes (2006) note, constrained access to adaptive options is exacerbating existing social inequalities between those with waged employment and those who depend on hunting for a living. In absence of financial support, future climate change could further increase the burden of adaptation on vulnerable groups.

Harvester support programs for those whose livelihoods are dependent on hunting are offered in all Inuit regions of Canada by regional governments and land claim institutions. These programs do not explicitly aim to reduce vulnerability to climatic conditions – they aim to maintain a strong and thriving traditional resource use sector – but they are important in providing a safety net for households, helping hunters recover from climate-related losses and providing financing for climate adaptations. Research has shown that harvester support has a positive impact on harvester viability and food production (Dorais, 1997; Kishigami, 2000; Myers et al., 2004). However, many of these programs are having difficulty meeting demands placed on them due to rising fuel and equipment costs, and the future of some programs is not secure. There is also evidence that climate change is exacerbating shortcomings in funding allocation and future climate change will further increase pressure on harvester support programs. For those without access to other sources of income, harvester support could determine the sustainability of hunting in a changing climate.

Existing harvester support programs can be strengthened in several ways to increase their effectiveness in light of current and projected climate change. Firstly, enhanced financial support for harvester programs, targeted at helping Inuit afford to adapt would help Inuit maintain their ability to practice culturally important activities in a changing climate. Secondly, there is potential to strengthen the effectiveness of existing programs. Complexity and lack of knowledge of existing programs have been identified as constraining uptake among hunters, many of whom lack formal education (Aarluk Consulting, 2005). Better advertising and promotion to educate community members about harvester programs and promote their use could also increase program effectiveness. Thirdly, reviewing how funds are allocated to address concerns of nepotism within communities would help ensure that harvesters are accessing funding and strengthen community confidence in the programs (Ford et al., 2007; Pearce et al., 2009c). Fourthly, current harvester support programs were not developed in the context of a changing climate. Reviewing current programs in light of new demands as a consequence of current and future climate change should be a priority for all Inuit regions.

6.1.2. Availability and health of animal populations and fish

Climate change is having implications for the migration timing, population health, quality of meat and furs, and availability of wildlife species important in subsistence-based hunting in all the case studies. Ringed seal (*Phoca hispida*) is a principal item in Inuit diet and is widely believed to be susceptible to climate change (Burek et al., 2008; Moore and Huntington, 2008). Caribou (*Rangifer tarandus*) and musk-ox (*Ovibos moschatus*) are important food sources and are sensitive to winter freeze–thaw cycles which are expected to become more frequent (Miller and Gunn, 2003; Tews et al., 2007a,b). Polar bear (*Ursus maritimus*) populations, which rely of sea ice for survival, could also be negatively affected by climate change and may even become extinct at the southern margins of their range (McLoughlin et al., 2008; Schliebe et al., 2008). Negative effects on the health and availability of freshwater and saltwater fish species have also been recorded in the case study communities (Vilhjálmsson and Hoel, 2005; Reist et al., 2006). Warmer temperatures are also affecting the preparation of dry fish and the length of time that fish can spend netted in the water before spoiling (Andrachuk, 2008). The act of hunting, consuming, and sharing traditional foods is an important cultural activity, helping to produce and re-produce community social relations and defining what it means to be Inuit, with climate change potentially threatening these relationships.

Wildlife populations and migration patterns have always fluctuated in the Arctic. Flexibility in resource use has traditionally enabled Inuit to manage such variability and has underpinned Inuit adaptability to changes in climate documented in the last decade (Krupnik, 1993; Berkes and Jolly, 2002; Ford et al., 2006a). Regulations, however, were identified as constraining flexibility in harvesting by limiting how many species can be caught and specifying the timing at which hunting can take place. Moreover, there is concern among community members and politicians across the North that climate change will lead to increased pressure from the international community to strengthen existing quota systems and develop quotas for currently unregulated species (Clark et al., 2008; Dowsley and Wenzel, 2008). Consequently, controversies over how to manage climate change impacts on wildlife have emerged in recent years and have destabilized management and conservation of wildlife across northern Canada (Clark et al., 2008). The recent decision to list polar bears as an endangered species in the United States and the associated ban on US sport hunters importing polar bear skins acquired on sport hunts with Inuit guides in Canada maybe an indication of future conflict (George, 2006; Dowsley, 2009). Developing and altering quotas in response to outside pressures which do not take into account local hunting needs and the ecology of harvesting will almost certainly increase Inuit vulnerability to climate change and fail in conservation objectives, limiting the flexibility of hunting that facilitates adaptive capacity, reducing options at the disposal of communities to adapt to future change, limiting the accountability and transparency of wildlife management institutions, and having implications for economic well-being (and hence adaptive capacity) given the importance of traditional foods in Inuit diet.

Innovative co-management of renewable resources that integrates Inuit traditional knowledge, scientific understanding of population vulnerability to climate change, and allows Inuit to exercise their (legally defined) traditional rights is likely to increase adaptive capacity by maintaining some degree of resource use flexibility (Chapin et al., 2004; Berkes et al., 2005; Armitage et al., 2008; Clark et al., 2008; Dowsley, 2009). Research in Arctic and non-Arctic contexts, for instance, demonstrates that flexible, multi-level governance can help management systems deal with change by promoting the sharing of information between actors at different scales, linking scientific and traditional management systems, permitting greater opportunity to address conflicts over competing vision or goals, and providing an arena to solve conflict (Tompkins and Adger, 2004). Importantly, co-management may serve to strengthen trust between different actors in wildlife management. Management regimes in Inuit regions have progressed significantly in recent years, with new co-management bodies emerging in which federal and territorial/regional regulators and Inuit organizations decide annual harvest quotas (Berkes et al., 2005). This transition has been turbulent and while previous

management systems have been improved, conflict still remains entrenched (Nadasdy, 2003; Natcher et al., 2005; Stevenson, 2006). In particular, differential power relations between actors and conflict over the role of science and traditional knowledge have been noted in the case study communities as compromising effective decision making, ultimately resulting in management outcomes unsuitable to all parties.

Clark et al. (2008) identify a number of policy options to reduce conflict over wildlife management in the context of multiple stresses and competing uses, and which are relevant in a climate change context. In the short term they recommend focusing on sharing traditional and scientific knowledge in management decisions, appraisal and use of best practice from other contexts, and the co-production of knowledge on the health and status of wildlife populations. In the long term they advocate emphasis on local and decentralized decision making to increase the adaptive capacity of regional and local scale management institutors. In light of climate change, it is important that research (involving scientists and local hunters) highlights wildlife populations at risk, explores the sustainability of current wildlife harvesting, and develops response options in co-management bodies.

6.2. Adaptation to the health and safety effects of climate change

6.2.1. Hazard epidemiology

Climate change is increasing the potential for injury and loss of life when harvesting and traveling in all case study communities and affecting psychological status through its cultural impacts. Evidence suggests that climate-related accidents are increasing in part due to changing climatic conditions, including thinning and earlier break-up of sea ice and more unpredictable weather.

6.2.1.1. Affording adaptation. The case studies indicate that Inuit are autonomously employing a number of strategies to minimize risks in a changing climate. Some hunters are using safety equipment such as satellite phones, global positioning systems (GPS), emergency beacons, VHF radios and immersion suits when hunting (i.e. risk minimization strategies) and are utilizing available weather and ice forecasts to assess safety of using the land and sea ice at certain times of the year (i.e. risk avoidance strategies). Small equipment funds are offered as part of harvester support programs to help people afford these new tools for anticipating and managing risks. In some of the case study communities, the local municipality, hunter's organization, and/or RCMP detachment will also loan safety equipment for short periods of time. The availability of funds and loan programs, however, is highly variable between communities. These expensive technologies, therefore, often remain inaccessible to Inuit who have limited access to financial means. As with the harvester support programs noted above, there is a need for enhanced financing to cover the purchase of safety equipment, training costs, and need to review current programs offered in light of climate change. Moreover, research has indicated that some technologies, such as GPS, that are being utilized to adapt to climate change may have unintended consequences and may increase sensitivity to climatic risks if used improperly or without understanding of the risks of hunting and traveling in the Arctic environment (Aporta and Higgs, 2005; Bravo, 2008). As observed in other contexts, technology does not reduce vulnerability unless institutions, communities and individuals know how use and adapt technology effectively. The need for enhanced training in such technologies as part of broader skills development is noted below.

6.2.1.2. Training. In the case study communities, and across Inuit regions, research has documented a weakening of traditional environmental knowledge (TEK) and land skills among younger generations (Collings et al., 1998; Aporta, 2004; Myers et al., 2004; Aporta and Higgs, 2005; Bravo, 2008). This trend is increasing the danger of harvesting and travel among younger generations, exacerbating the negative implication of climate change, and is a major concern for community members and leaders. TEK will remain important for identifying and managing climatic risks and adapting to change: while climate change is undermining some aspects of traditional knowledge including the ability to forecast weather conditions, predict animal migrations, and understand environmental conditions based on place names, other skills are even more important in light of new and exacerbated risks (e.g. ability to identify hazard precursors, survival skills and mentality, knowledge of animal behavior. etc.). Moreover, research has illustrated how the experiential nature of TEK has underpinned social learning to mange emerging risks with climate change (Ford, 2009b; Ford et al., 2009).

Policies that promote and facilitate the generation and transmission of TEK are central to reducing risks in a changing climate, and have the potential to increase safe hunting practices among vulnerable groups, targeting three important aspects of reducing climate vulnerability: prevention, preparedness, and response. Cultural programs which provide land skills training are currently offered in an *ad hoc* fashion in communities across the North. The school system in Inuit regions, for example, has cultural programming as part of the curriculum, although locally these programs are often believed to be inadequate in developing necessary land skills. Some communities offer 'land camps' for young people. Since, 1992, for example, Igloolik's Inullariit Society has organized land skills training camps where experienced hunters take younger generations "on the land" for weeks at a time to train them in skills such as navigating, recognizing and preparing for various hazards, identifying snow formations, and predicting weather (Takano, 2004). Training in non-traditional skills, which includes firearm safety and vehicle management, is also important in these programs. Teaching replicates the way in which knowledge and values were traditionally developed: learning by doing, watching, and being on the land (Bravo, 2008). Important safety lessons for hunting and traveling are passed on to younger Inuit in these sessions. Addressing the erosion of traditional skills through the creation of cultural schools/land skills programs should be part of a broader program in northern regions to place emphasis on skills training and development so that Inuit are better prepared to adapt to and take advantage of climate change alongside new economic opportunities (Fast et al., 2005; Schlag and Fast, 2005). This is particularly important given the demographics of Canadian Inuit communities, where young populations will be entering the workforce and beginning to engage in harvesting activities as the effects of climate change become pronounced.

6.2.1.3. Improved hazard forecasting. Inuit hunters in the case studies, particularly the younger generations who do not have the detailed understanding of the environment, reported making regular use of weather forecasts provided on the radio. Some individuals also make use of sea ice maps and forecasts from the internet when making decisions about where and when to hunt. Improving access to climate and weather information is important so people can make the decisions about where to hunt and fish during times of uncertainty. At present, the quality of forecasting in Arctic Canada is limited: only four meteorologists cover Canada's Arctic region (an area larger than western Europe) and are unable to provide regularly updated weather forecasts that hunters need in a changing climate (Picco, 2007). Additionally, these meteorologists are not based in the Arctic, but in southern Canada, and base their predictions upon synoptic satellite charts with limited availability of higher resolution localized data. Participants in the

case studies noted regularly complaining about the unreliability of forecasts and potential safety implications. Enhancing forecast quality is essential in the context of climate change which is challenging the ability of experienced hunters to predict the weather using their traditional knowledge. Moreover, improved understanding of how Inuit use and access forecasts, and developing means of improving delivery is also needed, if we are to develop forecasting products which are important to local needs.

6.2.1.4. Search and rescue. Traveling and harvesting in the Arctic environment is inherently dangerous for even the most knowledgeable individuals. Even in absence of climate change, accidents involving falling through thin ice, getting stranded on drifting ice, or being affected by bad weather, are common (Bravo, 2008). Beginning in the 1980s, formal search and rescue (S&R) procedures were developed across the Canadian Arctic to provide emergency support and rescue. Jurisdiction for S&R is currently divided between the Canadian Coast Guard, the military (including the Canadian Rangers), Royal Canadian Mounted Police (RCMP), regional/territorial government departments, and municipalities. Formal search and rescue compliments the more informal search teams that are mobilized locally when a person is missing or requires help. The current system involving both formal and informal response is widely believed to be effective among both community members and government officials (Breton-Honeyman and Furgal, 2008). Local search teams are rapidly mobilized when required and involve the participation of skilled local hunters and elders; the more formal search and rescue operations are engaged when additional air, ground, and logistical support is required. Moreover, both formal and informal search organizations regularly review recent operations, identifying strengths and weaknesses of current rescues (Minogue, 2005).

Climate change, however, presents a number of challenges to S&R, as the case studies indicate. Firstly, there is potential for new challenges which search and rescue organizations have limited experience. These challenges may stress the ability to respond if there is a lack of clearly delineated responsibilities and authorities among levels of government. For example, increased opportunity for commercial and tourist ships with longer ice-free open water period in the summer will increase the potential for marine emergencies (Stewart et al., 2007). Jurisdiction of responsibility in responding to marine emergencies are not well specified. Secondly, search-and-rescue efforts are becoming more frequent and more dangerous, increasing the chance of injury and even loss of life (Furgal and Prowse, 2008). In 2005, for instance, two local rescuers died while searching for a lost hunter in a Nunavut community. Thirdly, in the context of de-skilling among today's younger generations, there is concern that the ability and effectiveness of local rescue teams could be compromised. Moreover, S&R operations often involve considerable risk to those involved and time commitment; in the context of weakening social networks and emerging conflict between community members noted in some communities, fewer people may be inclined or available to be involved in local operations. In the larger communities a common complaint is a lack of local people willing or available for search and rescue operations. Notwithstanding, new opportunities are also emerging. In recent years with resource development in Inuit regions, mining companies have provided helicopter air time to help with search operations. Additionally, GIS and GPS offer new tools for S&R coordination and have been effectively used in searches across the North.

In the context of these challenges and opportunities it is important that S&R capability and institutional arrangements be continually reviewed as the frequency, scope, and intensity of climate-related risks and impacts change as result of climate change. In particular, joint planning exercises between the different organizations involved in search and rescue including local, territorial and federal decision makers are required to identify weaknesses and strengths in current search and rescue capability. Additionally, drills and exercises, training of local search and rescue personnel, provision of safety equipment to rescuers, and worse case contingency planning are required to increase emergency preparedness. There is evidence that this is already occurring; Nunavut is in the process of setting up the Nunavut Search and Rescue Association which will manage $500,000 per year for equipment and training, and is currently updating its search and rescue procedures. S&R personnel and planners also need to be aware of potential implications of climate change to S&R and review current procedures in light of climate predictions. In this area, formal and informal search and rescue are less prepared (Bird, 2009). Moreover, the potential for new technology including GPS, GIS, satellite phones, and personal locator beacons, to enhance the safety and effectiveness of S&R needs to be examined.

6.2.2. Food security

Climate change is compromising food security in the case study communities by constraining access, availability, and quality of traditional foods—an observation noted in other locations (Chan et al., 2006; Guyot et al., 2006; Seguin, 2008). While offsetting traditional foods with food from the store is an acceptable option for some community members, particularly the young and those involved in the waged economy, for hunting households traditional foods are preferred because they are believed to be tastier and have cultural significance. Moreover, any decline in traditional food consumption is a concern from the point of view of dietary health, particularly if healthy traditional foods are replaced by high fat nutrient poor store foods (Young and Bjerregaard, 2008). Additionally, for many households store foods are expensive and often not affordable to those without jobs. For instance, a family of four would spend approximately $551 to buy foods for a basic nutritious diet in isolated Nunavut communities compared to $238 in southern Canada and average incomes are significantly lower (Ford and Beaumier, 2009). High levels of baseline food insecurity in Inuit regions are likely to exacerbate the food security implications of climate change. In the context of social-economic and climatic constraints, Damman et al. (2008) argue that the federal government has obligations under international human rights law (e.g. International Covenant on Economic, Social and Cultural Rights) to ensure Inuit food security is upheld.

Strengthening the ability of Inuit food systems to meet present dietary and nutritional requirements will increase the adaptability of the food system in a changing climate. Policy entry points suggested in the literature and our case studies include: subsidization of healthy store foods, development of food-banks, extension of the food mail program to include traditional foods, organized community hunts, strategies to improve the distribution of traditional foods between communities, strengthening food sharing relationships in communities, harvester support, the development and reinstatement of community freezers, and initiatives to develop commercial ventures based around traditional foods (Boult, 2004; Myers et al., 2004; Chan et al., 2006; Lambden et al., 2006; White et al., 2007a; Damman et al., 2008). A number of successful initiatives are helping Inuit meet their dietary requirements including harvester support programs, food donations, and community freezers, although communities have made it clear that more extensive programming and government support is needed (Chan et al., 2006). Notwithstanding these

potential policy opportunities, research is only beginning to analyze how food systems might be affected by climate change in the North. Assessing vulnerability of Inuit food systems to climate change and assessing and evaluating adaptation options is a priority for future research (Chan, 2006; Furgal and Prowse, 2008; Seguin, 2008).

6.3. Adaptation to the effects of climate change on community viability

Community viability depends on a sense of place and historical attachment, and the quality of the physical fabric (e.g. houses, roads, community buildings) of a community. Both are exposed and sensitive to climate change with many Inuit cultural sites (graveyards, hunting camps, etc.) and current settlements located on the coast and/or on permafrost. Sea level rise, coastal erosion, permafrost thaw, and more active slope processes, threaten these sites and limit potential for new development.

Physical interventions are being considered in vulnerable communities across the Arctic to protect infrastructure. These include moving buildings, raising buildings, and installing engineering structures to provide protection from wave action and permafrost thaw (Couture et al., 2003; Larsen et al., 2008). Any engineering-based measures, however, will be costly and will involve trade-offs between cultural benefits and economic cost in communities and regions with limited economic means. For example, Hoeve et al. (2003) estimate infrastructure related adaptation costs for the Northwest Territories could range from $200m to as high as $420m. Moreover, access to local gravel deposits are essential for infrastructural developments yet not all communities have access, the availability of this important resource is limited, and at present the resource is un-managed (Duerden and Beasley, 2006). Importing gravel from elsewhere would be costly given the costs and difficulties of Arctic transportation. Recently announced federal funding under the government's Building Canada long term infrastructure fund will help 'climate proof' some key infrastructure, although cultural sites are not covered by this fund. Documenting cultural sites and infrastructure at risk with climate change, identifying adaptation options and needs, and establishing funds to help protect them should all be a priority to support Inuit adaptation.

Relocation of some communities (e.g. Tuktoyaktuk) maybe inevitable for settlements threatened by sea level rise and accelerated coast erosion. The fate of Inupiaq community of Kivalina in Alaska which has decided it will have to relocate if the community is to survive is a portent for potential future threats affecting communities along Canada's Arctic coastline (Barringer, 2008). The costs of relocation will be extremely high although they will likely be less than protecting communities at all cost. For example, the Canadian government conservatively estimated a cost of $50m to relocate the community to Tuktoyaktuk (pop: 900). Political challenges of relocation will be considerable. The current location of the majority of Inuit communities in Arctic Canada reflects church, trading post, and government policy in the 1950s and 60s which sought to sedentarize semi-nomadic Inuit hunting groups through the provision of housing, health care and education. Many of the communities that were developed this way were located significant distances from traditional Inuit hunting areas, with many Inuit reluctant to move (Damas, 2002). Significant acculturative stress was associated with relocation and thoughts of relocation again raise bad memories for many Inuit in the North (Tester and Irniq, 2008). Notwithstanding, relocation could provide opportunity for some communities (e.g. Igloolik, Nunavut) to relocate closer to traditional hunting grounds or to locations more suited to altered wildlife regimes and accessibility in a changed climate.

7. Discussion

Climate change is occurring in the Arctic and dramatic changes can be expected in the future. Inuit are highly adaptable to climatic variability, change, and extremes as our case studies indicate. However, financial, institutional, and knowledge constraints are constraining adaptive capacity and increasing exposure and sensitivity to climate change effects. We identify a number of priority areas for reducing vulnerability and enhancing adaptive capacity, including: supporting the teaching and transmission of traditional skills, enhancing and reviewing emergency management capability, ensuring the flexibility of resource management regimes, economic support to facilitate adaptation for groups with limit household income, increased research effort to identify short and long term risk factors and adaptive response options, and promotion of awareness of climate change impacts and adaptation among the policy making community. These recommendations stem from the findings of completed vulnerability research in which we are involved and interviews with policy makers. We would argue – based on the diversity of communities represented in our case studies, consistency in findings between communities, discussion with policy makers, and other published research – that these entry points have relevance for Inuit communities across the North. What is also interesting is that many of these recommendations, while explored here in the context of adaptation to climate change, also concern ongoing policy initiatives and priorities in areas of economic, social, health, and cultural development, and can bring immediate benefits in the form of reduced vulnerability to current climatic variability, change, and extremes. What is new is that these policy goals are re-emerging in the unique context of climate change. As such, there is agreement among many scholars and policy makers that 'mainstreaming' or 'normalizing' climate change adaptation into policies intended to broadly enhance adaptability to risk is likely to be the most effective means of reducing vulnerability to climate change (Dovers, 2009).

Dealing with the many barriers to effective adaptation and creating an enabling environment for reducing Inuit vulnerability will require a comprehensive and dynamic portfolio of approaches covering a range of scales and issues. However, two main general strategies for climate change adaptation policy can be discerned: (1) enhancing *existing* adaptive strategies; and (2) introduction of *new* strategies.

Firstly, Inuit communities are autonomously adapting to climate change, mostly using behavioural and technological adaptive strategies. Many of these responses have been reactive in nature, although there is emerging evidence of proactive planning, particularly in the subsistence hunting sector (Ford et al., 2009). Accumulated knowledge and experience of managing climatic extremes and variability, for instance, is structuring individual, household and community decision making and resource and risk management, allowing communities to take advantage of changing conditions and reduce the negative effects. This knowledge base will help moderate vulnerability to future climate change. However, while many of these autonomous adaptations have been effective, there are good reasons to believe that autonomous adaptation has limits. Intervention by different levels of government is necessary to enhance existing climate risk management strategies and create an enabling environment for adaptation. Given that climate change will be expressed via changes in climatic variability, adaptation policy targeted at reducing vulnerability to current climatic risks will inherently help reduce vulnerability to future climate change.

Financial resources are an important component of the means to adapt, and are one of the main barriers preventing Inuit from adapting. Many adaptations are costly and exceed the financial ability of Inuit households, communities, regional governments,

and land claims institutions. Establishing funds and procedures accessible to vulnerable groups and regional governments in advance of future climate change is essential to helping Inuit maintain their livelihoods and culture in a changing climate. To this end, the Canadian State has obligations as a signatory to the FCCC and through the Canadian Charter to commit resources to support adaptation (Budreau and McBean, 2007). Notwithstanding, formidable barriers exist to achieving adaptation support. As non-state actors, Inuit do not have recourse to international legal institutions that enforce international treaties and adaptation funds through the FCCC are targeted at the least developed countries (Budreau and McBean, 2007). Theoretically, as a party to the FCCC, Canada is legally obliged to "cooperate in preparing for adaptation to the impacts of climate change..." although Budreau and McBean (2007) note that a state's legal obligation to adaptation in the FCCC remain vague (e.g. what is "adequate adaptation") and are largely limited to publishing policy documents and official statements.

While adaptation assistance will inevitably require financial support, other options involve assessing the effectiveness of current policies and programs in the context of a changing climate, developing institutional capacity, improving the decision making environment, and integrating climate change into long term strategic planning. One of the main challenges here is institutional capacity. All levels of governance in northern Canada experience high staff turn-over and maintaining intuitional memory and strategic long term planning is challenging in this context (Myers et al., 2004; Bird et al., 2008). Moreover, as Schlag and Fast (2005) note in the Inuvialuit Settlement Region, many of today's younger generations are believed to be not ready to assume leadership responsibilities as older generations retire; an observation noted in other regions of Canada's north and a major challenge to overcome (Furgal and Prowse, 2008).

Secondly, future climate change will require forward looking investment and planning responses to address risks to which communities and institutions in the north have limited experience with. This is particularly pertinent for the implications of future warming on geomorphic process and associated infrastructural impacts, where the full impacts of climate change are not yet discernible. It is likely that it is more cost-effective to develop adaptations early on, especially for infrastructure with long economic life and to incorporate climate change into impact assessments and community planning (Stern, 2006; Larsen et al., 2008; Hallegatte, 2009). Moreover, current understanding of the implications of surprise and changes outside the range of current experience, and potential adaptive options remains limited.

Developing and implementing adaptation policy is not an endpoint in itself but an ongoing process that is part of good risk management, where drivers of vulnerability are identified, monitored, and the effectiveness of policy response continually evaluated over time (Ebi and Semenza, 2008). This is particularly important with regard to climate change in the Arctic, where polar amplification and crossing of thresholds may accelerate climate change impacts in ways not currently understood (Lenton et al., 2008), and rapidly socio-economic-demographic conditions alter the context within which climate change occurs and is experienced. Monitoring climate change vulnerability and adaptation over time is also essential, as vulnerability is inherently dynamic, changing as the communities and the climate changes. Community monitoring across the Arctic is needed to identify emerging threats and new opportunities, and should compliment long term scientific projects.

Perhaps most importantly concerning adaptation research and policy development, however, is that communities and policy makers need to be actively involved in identifying, proposing, enabling, assessing, and enforcing adaptation policy (Ford et al., 2007; Pearce et al., 2009c). This is central in linking research to policy. Interventions will be more successful if they are identified and developed in co-operation with local actors and policy makers, who will be more likely to trust them, find them consistent with their goals, norms, and policy objectives (Newton et al., 2005; Chapin et al., 2006). These points are particularly salient in the context of Arctic Canada, which has a long history of policy initiatives that have been inappropriate because they were based on research by non-local researchers, who defined terms of well-being for indigenous peoples in relation to a worldview different from that of local residents (Berman and Kofinas, 2004). In light of this context, recommendations that have not been identified and developed in collaboration with communities or policy makers are unlikely to have the required legitimacy and integration of Inuit knowledge that are essential to decision making in the new North or understanding of how adaptation links into the policy process. Involving communities and policy makers was a key feature of the research on which we base our recommendations.

8. Conclusion

Adaptation is needed to protect Inuit livelihoods in a changing climate. Acting now on adaptation can bring near-term benefits, reduce current climate vulnerability, and target socio-economic policy objectives alongside managing the effects of current and future climate change. Historically, political action and lobbying by Inuit political actors at all levels has been dominated by a focus on illustrating the impacts of climate change and mitigation, although new initiatives initiative have started to focus on adaptation. Similarly, at a national level in Canada and internationally, mitigation has dominated policy discussions on how to respond to climate change. Scientific research meanwhile has largely focused on documenting climate change vulnerabilities but has rarely taken the next step to identify policy options in both the Arctic and general literature. This is insufficient in light of the vulnerability of Inuit populations, current experience of what could be classed dangerous climate change, and future climate projections.

In this paper we have identified opportunities for adaptation policy development. While our recommendations are not exhaustive, we identify policy priorities that can be implemented within existing policy frameworks today and outline boarder principles of adaptation applicable in multiple contexts. Importantly, the paper highlights that Inuit are not powerless in the face of a rapidly changing climate. Adaptation options are available, feasible, and Inuit have considerable adaptive capacity as history and current experience shows. With support from territorial and federal levels and local action to identify risks and plan for adaptation, some of more severe manifestations of climate change can be moderated. Current support and planning for adaptation, however, is fragmented, requiring a more co-ordinated approach across different levels of government (municipal, territorial, federal) to integrate adaptation into existing policy programmes and develop anticipatory plans.

More broadly, the experience of climate change among Canadian Inuit and nature of vulnerability could be comparable to other Inuit populations of the Arctic and indigenous peoples more generally whose culture and livelihoods are closely linked to land-based aspects of traditional lifestyles. Across the circumpolar north, for instance, many indigenous peoples remain intimately connected to the biophysical environment, are susceptible to climate change, and are undergoing rapid socio-economic-cultural changes with widespread implications for human–environment relations and vulnerability. An expanding body of literature on vulnerability, adaptation, and resilience among Inuit and other indigenous communities in Alaska has paralleled similar trends in Canada, and studies from Arctic Russia and Greenland have also

recently been published. (e.g. Gearheard et al., 2006; Huntington et al., 2007; Alessa, 2008; Alessa et al., 2008a,b; Crate, 2008; Keskitalo, 2008a,b, 2009; Forbes and Stammler, 2009; Keskitalo and Kulyasova, 2009; Loring and Gerlach, 2009; Rattenbury et al., 2009; Trainor et al., 2009). Examining similarities and differences in vulnerability and adaptive capacity between different national contexts offers a promising new direction for research, with potential to increase our understanding of vulnerability determinants and identify best practice for adaptation. Herein, the authors' are involved in the International Polar Year CAVIAR project, which is conducting community vulnerability assessments across the Arctic using a vulnerability approach consistent with the work described here (Smit et al., 2008; Sydneysmith et al., In Press). This major international initiative, to be completed in 2010, will contribute towards further development and examination of adaptation entry points.

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