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Vulnerability to climate change in Igloolik, Nunavut: what we can learn from the past and present

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ABSTRACT. Significant and rapid climate change is predicted for Arctic regions. These changes are expected to have implications for indigenous communities. This paper argues that the starting point to understand how future climate change may affect communities is analysis of past and present experience of, and response to, climate variability and change. Using a vulnerability approach, the paper provides an historical account of changing vulnerability to climate-related risks among Inuit in Igloolik, Nunavut. The research demonstrates that Inuit in Igloolik have been highly adaptable in the face of climatic stresses. This adaptability has historically been facilitated by traditional Inuit knowledge, resource use flexibility and diversity, group mobility, and strong social networks. However, societal changes, and more recently biophysical changes, have increased the susceptibility of people to climatic risks and have undermined certain aspects of adaptive capacity. The research indicates that the implications of future climate change will be influenced by the interaction between biophysical and societal changes, will vary over time in response to forces internal and external to the community, and will be differentiated among social groups.

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Introduction

The recent Arctic Climate Impact Assessment (2005) has predicted dramatic and rapid changes in climate and related environmental conditions for Arctic regions this century (Kattsov and Kallen 2005). It is widely accepted that these changes will have implications for indigenous communities in the Arctic (McCarthy and Martello 2005; Nuttall 2005). It is predicated there will be an increase in the frequency and magnitude of hazardous conditions, including those associated with permafrost thaw, coastal erosion, ice stability, and increasing exposure to storms along the Arctic coast, and there will be an increase in average temperatures and precipitation (Couture and others 2002; Kerr 2002; Johannessen and others 2004; Kattsov and Kallen 2005). In turn, these changes will have implications for the presence, location, and distribution of animal species (Derocher and others 2004; Humphries and others 2004). For indigenous communities, these changes could be potentially devastating to their livelihoods and could significantly increase the dangers of hunting (Nuttall 2005). However, while there is general agreement that future changes in climate are likely to pose serious challenges to indigenous peoples in the North, the nature of these risks is poorly understood (Duerden 2004; McCarthy and Martello 2005; Ford and others 2006 in press).

It is argued here that in order to understand how future climate change may affect indigenous communities, knowledge is required concerning how communities experience and respond to climate variability and change and the processes that reduce or heighten vulnerability. By looking at the past and present, it is possible to identify, more precisely, the potential implications of future climate change (Wigley and others 1985). The present paper uses the vulnerability approach of Ford and Smit (2004) and Ford and others (2006 in press) to provide an historical account of changing vulnerability to climatic risks in Igloolik, Nunavut. This provides a basis for understanding how future climate change may affect Inuit. The paper largely focuses on vulnerabilities associated with the important social and economic livelihood of hunting.

A vulnerability based approach

Conceptual model of vulnerability

The vulnerability approach referred to above builds on work in climate change impacts and adaptation, natural hazards, food security and environmental change. In the natural hazards field, work has focused on the social construction of vulnerability, emphasizing the economic, political, and social conditions that influence the ability of people to cope with, and respond to, hazardous conditions (Hewitt 1983; Liverman 1994; Comfort 1999). This work demonstrates how livelihoods, access to resources, and power relations influence vulnerability (Blaikie and others 1994; Adger and others 2001). Scholarship on food security also focuses on access to resources as determinants of vulnerability, so that disasters are not due only to exposure to natural events, but also to social, economic and political conditions that make people susceptible

(Sen 1981; Bohle and others 1994; Adger and Kelly 1999). In the environmental and climatic change field, Turner and others (2003), O'Brien and other (2004), in a similar manner to the Intergovernmental Panel on Climate Change (2001) and Arctic Climate Impact Assessment (2005), conceptualize vulnerability or sustainability as a mix of exposure-sensitivity, adaptability, resilience or capacity to adapt. This work directs attention to human and biophysical processes at different spatial and temporal scales which affect human environment interactions in specific regions or communities.

Concepts employed in this work are consistent with and are captured in the model of vulnerability employed here. Vulnerability is conceptualized as a function of exposure-sensitivity of a community to climate change effects and its adaptive capacity to deal with that exposure.

Exposure-sensitivity reflects the susceptibility of people and communities to conditions that represent risks. It is a joint property of both the characteristics of climatic conditions, and the nature of the community in question. The characteristics of climate-related conditions include magnitude, frequency, spatial dispersion, duration, speed of onset, timing, and temporal spacing of conditions. The nature of the community concerns its location and structure relative to the climatic risks. It is also strongly linked to livelihood conditions and strategies and will vary among groups in the community. In Arctic communities, different species will be harvested in different locations at different times of the year, based on individuals' knowledge of the environment, past experience, differential time constraints, and access to technology. This results in differential exposure-sensitivity. In Igloolik, experienced full-time hunters, for instance, hunt walrus from the moving pack-ice. This exposes them to the risks of being stranded on drifting ice if there is a wind from the north. Others in the community, including inexperienced hunters and young Inuit rarely hunt on the moving pack-ice, and will only hunt there if accompanied by experienced hunters. Exposure-sensitivity is clearly dynamic, changing as the community changes its characteristics relative to the climatic conditions, and changing as the stimuli themselves change.

Adaptive capacity refers to a community's potential or ability to address, plan for, or adapt to exposure-sensitivity (Smit and Pilifosova 2003). People have learned to modify their behaviour and their environment to manage and take advantage of their local climatic conditions. Most communities, therefore, are adaptable to normal climatic conditions and a range of deviations around norms (Ford and Smit 2004). This ability to adapt reflects resource use options and risk management strategies to prepare for, avoid or moderate, and recover from, exposure effects (Hewitt and Burton 1971; Smit and Pilifosova 2003). It is influenced by characteristics of the human system including economic wealth, social capital, infrastructure, social institutions, experience with previous risk, the range of technologies available for adaptation, and equality. These characteristics may facilitate or constrain the ability of a community to deal with climate related risks (Adger 2003; Ford and Smit 2004; Ford and others 2006 in press). These determinants are interdependent and are influenced by human and biophysical conditions and processes operating at various scales from the local to global. Adaptive capacity is also dynamic, varying over space and time with the characteristics of the human system.

Exposure-sensitivity and adaptive capacity are not mutually exclusive (McLeman and Smit 2005 in press). Exposure to repeated climate-related conditions, for instance, can develop experience of how to manage the climatic conditions. Certain adaptive strategies can also change the nature of the community (location, structure, organization) such that the community is less exposed-sensitive, or more exposed-sensitive, or exposed-sensitive in a different way. Factors that influence adaptive capacity can also influence exposure. For example, the range of technologies available for adaptation may enable exposure-sensitivity to be managed. The same technology, however, may also affect risk evaluation strategies and result in more risk taking behaviour.

Learning from the past and present

To learn about how future climate change may affect communities, the starting point is an examination of how indigenous peoples have experienced, responded to, and coped with variability, change, and extremes. Inuit have always lived with fluctuations in climate and associated environmental conditions: seasonal and year-to-year changes in weather, snow, ice, and animal populations are part of life in the Arctic (Beaubier and others 1970; Wenzel 1991; Duerden 2004). If anything, change is considered the norm. Krupnik (1993: 156) comments: 'Any .... normal state [of the environment] is in reality at most a short-term transition from 'bad' to 'good' or back again.' Inuit oral histories tell of periods of glacial surges, exceptional cold, scarcity of animals, and population movements (Vibe 1967; Krupnik 1993). In recent years, indigenous peoples in many parts of the Arctic have reported that they are already observing and experiencing climate change (Krupnik and Jolly 2002; Helander and Mustonen 2004; Ford 2005a). In the face of fluctuating and changing climatic conditions, Inuit have historically demonstrated significant adaptability (Balikci 1968; Brody 1987; Sabo 1991; McGhee 1996; Berkes and Jolly 2002).

Examining past and present experience and response to variability, change and extremes provides an empirical foundation and baseline for an assessment of how future climate change may affect communities. It allows for the characterization of how communities manage and experience climatic risks, the identification of those processes and conditions which have determined the efficacy, availability, and success of past and present adaptations, the development of a greater understanding of how social and biophysical processes shape vulnerability, and the establishment of a range of possible societal

responses to future climate change (Glantz 1988; Duerden 2004; Burton and Lim 2005; Naess and others 2005). The experience of, and ability to, respond to climate changes in the future are likely to be facilitated and constrained by similar factors.

Igloolik case study

Igloolik

Igloolik is a coastal Inuit community of around 1400 people (95% Inuit) located on Igloolik Island in northern Foxe Basin, Nunavut, Canada, approximately 320 kilometres north of the Arctic Circle (69°23′N, 81°48′W). Located off the east coast of Melville Peninsula, the island and the mainland have a relatively flat topography. The settlement has expanded dramatically since the 1960s, and the economy has shifted from being based entirely on subsistence activities to a mixed economy where both the informal and formal economic sectors assume an important role (Damas 2002). The harvesting of renewable resources continues to be a valued activity among Iglulingmiut (Inuit from Igloolik), and has social, cultural and economic significance (Rasing 1999; Nunavut Wildlife Management Board 2001). The mainstays of the wildlife harvest include walrus, ringed seal, caribou, char, polar bear, narwhal, beluga, and a variety of migratory birds during spring and summer (Nunavut Wildlife Management Board 2001). Except for a period of open water from mid-July to early October when travel by boat is possible, travel and harvesting are largely performed on sea ice, and, for walrus, on the moving ice beyond the floe edge. Participation in harvesting activities, however, varies throughout the community. Many older generation Inuit continue to hunt full-time, but many younger generations balance hunting with full or part-time jobs. Furthermore, there are signs that many in the community, particularly the younger generations, have a diminished taste for locally harvested produce, preferring instead store bought processed foods, a trend that leads inevitably to a disinclination to hunt (Qamaniq 2002; MacDonald 2004).

Methods

Two field seasons were undertaken. During the first, forty semi-structured interviews were conducted with a cross section of community members to identify those climatic risks that people have had to deal with, and are currently dealing with, to provide insights into how these risks are experienced and managed, to identify those factors that influence exposure-sensitivity to climatic risk and adaptive capacity and, to characterize how these factors have changed over time. Semi-structured interviews are a standard method used in ethnography for gathering information in an open-ended format (Pretty and others 1995; Kvale, 2001) and have been used widely in various northern research contexts (Huntington, 1998; Fienup-Riordan, 1999). A fixed list of questions was avoided in favour of an interview guide identifying the key themes to cover (Table 1). This allowed for flexibility in the interview: participants were guided by the interviewer's questions, but the direction and scope of the discussion followed the associations they identified. This allowed participants to identify and specify conditions and processes they found important, with openness allowing for new and unexpected relationships to be conveyed. A purposive sampling strategy was employed to obtain sufficient representation of all groups in the community. Within identified groups, interviewees were identified by a 'snowball' sampling method under which community assistants identified people willing to take part, who in turn suggested others who might be willing to be involved.

Table 1. Key themes in the interview guide and example of some of the topics covered under each theme.

Key theme	Example of topics covered
Life in the community	• Individual life history • Seasonal cycle of activities • Geographic location of activities
Important conditions for livelihoods	• What conditions (social, economic, biophysical) affect activities and in what way are they sensitive • How do people manage risks • What facilitates ability to mange risks/what impedes this ability
Change	• What changes have been experienced • Sensitivity of livelihoods to change • Problems/benefits of change • Management of change and influencing factors
Future challenges	• What future challenges face people • Sensitivity of livelihoods to change • Ability to cope • What can be done

The data collection was undertaken with two Inuit colleagues. Interviews were conducted in Inuktitut and in English with the majority of interviews taking place in the homes of interviewees. Simultaneous translation was employed for interviews conducted in Inuktitut by local Inuit colleagues. For preliminary verification and validation, after each interview the key points raised were reviewed with the local assistants.

The interviews were complemented with experiential trips on the land with Inuit and informal meetings with key informants. The analysis of all available secondary sources, including interviews in the Igloolik Oral History Project, government reports, newspaper articles, books, university theses, accounts of polar explorers, and journal articles, was used to add an historical context on how communities manage and experience climatic variability and change. During the second field season, the results and interpretation from the first field session were evaluated and reviewed with people interviewed during the first trip.

Changing exposure-sensitivity to environmental conditions

Over the past 50 years, exposure-sensitivity of Igluling-miut has altered significantly as a result of changes in how Inuit interact with the environment and, more recently, because of changing climatic conditions. These trends have resulted in the creation of new exposure-sensitivities, attenuation of old exposure-sensitivities, and exacerbation of others.

Societal change

There have been rapid societal changes in Arctic regions (Nelson 1982; Wenzel 1991; Rigby and others 2000; Damas 2002; Csonka and Schweitzer 2004; Nuttall 2005). With the exception of Christianity, introduced to the Igloolik area in the 1920s, the other major societal changes have largely been experienced in the later half of the twentieth century. These have included: the move of Inuit from scattered hunting camps on the land to a permanent, government-sponsored settlement; the development of waged employment; the participation in, and dependence on, external markets; compulsory schooling for children, some at distant residential schools; population growth; and a decline in participation in harvesting activities (Ross 1960; Bisset 1965; Crowe 1969; Mary-Rousselliere 1984; Rasing 1994, 1999; Damas 2002). These changes have affected harvesting practices, including the technology used and the timing and location of hunting activities, which in turn have affected exposure to climate-related risks.

Technological change, harvesting behaviour, and exposure-sensitivity

There has been profound change in the technology used in harvesting since the 1950s. Settlement of semi-nomadic hunting groups in fixed communities in the 1960s resulted in the increased use of, and dependence on, imported technology such as snowmobiles (beginning in the early 1960s) and motorized boats (beginning in the mid to late 1950s) to enable travel beyond the limited zone of exploitation imposed by fixed settlement (Crowe 1969; Wenzel 1991; Condon and others 1995; Wenzel 1995, 2004). Other technology adopted for harvesting includes VHF radios, and, more recently, CB radios, Global Positioning Systems (GPS), personal location beacons (PLB), and the consultation of satellite images of the sea-ice prior to travel. The adoption of these modern technologies has occurred in the context of the decreasing time availability for hunting due to participation of hunters in the formal economic sector, a reduction in land based skills especially among younger generations, the requirements of hunting with snowmachines and motorized boats, and the perceived safety that many of these devices provide.

The adoption of new technology and equipment has had implications for the ecological relations of harvesting. These developments confer improvements in safety and reduced susceptibility to environmental risks. VHF radios allow the community to be contacted in case of an emergency, personal location beacons have saved lives by enabling rescue teams to locate lost or injured hunters, GPS permits navigation in near zero visibility, larger and faster boats offer more protection than kayaks when hunting in open water, and satellite images allow hunters to identify dangerous areas to avoid. These developments also improve the accessibility of hunting areas and the efficiency of hunting. Snowmobiles, for instance, allow distant and multiple hunting areas to be accessed on short trips if animal numbers are low or if hunters have limited time. VHF radios allow hunters to co-ordinate their hunting efforts while out hunting, and GPS allows hunters to mark the location of their kills for later retrieval.

Technology, however, is in many ways a double-edged sword, creating new exposure-sensitivities and exacerbating old ones. The replacement of dog teams with snowmobiles, beginning in the 1960s, for instance, has increased the dangers of travelling on ice; snowmobiles, unlike dog teams, cannot locate dangerous ice and due to their weight have difficulty travelling over thin ice. Interviewees talked about the dangers of snowmobile use; since their introduction, there have been incidents where hunters have failed to notice ice thickness and have gone through thin ice. Community members also expressed concern regarding the now widespread use of GPS, particularly the perception of safety provided by GPS to its users. GPS allows travel with limited knowledge about navigation and about the environment (Aporta and others 2005). Consequently, young and inexperienced hunters can now travel alone or in absence of more experienced hunters and to locations to which they would not have previously gone. While inexperienced hunters tend to avoid travelling at dangerous times (ice break-up and freeze-up) and to dangerous locations (the floe-edge or moving ice), even travel along well-used routes that are perceived as safe can be problematic if the GPS fails and traditional navigation skills are not known.

> 'GPS enhances your navigation, but if it runs out of batteries it doesn't enhance navigation, it disables you. It can be your blessing and your downfall at the same time.' – Theo Ikkumaq

In addition, not all community members have equal access to technology. For those who cannot afford or borrow the necessary equipment, lack of equipment or equipment breakdown can mean loss of livelihood and inability to procure traditional food. This is reinforced by the reduction in animal numbers close to the community due to the noise from snowmachines and other equipment.

Risk assessment, decision making, and exposure-sensitivity

Inuit risk assessment when making decisions regarding hunting has also changed in other ways, with people more likely to harvest in spite of poor weather conditions. This is partly due to the reduced time available for harvesting. Many hunters now balance full or part-time jobs with hunting activities. Time off from work, which

Table 2. Implications of changing climatic conditions for risks associated with harvesting.

Activity	Activity timing	Important environmental conditions for activity	Implication of changing climatic conditions for harvesting
General Hunting/ Travel on the sea ice	October–December: hunting on new ice, travel to mainland, ice fishing	Ice – thickness, stability, freeze-up timing	• Slower ice freeze-up and snow during freeze-up have resulted in hidden thin ice. This has increased the dangers of travelling on sea ice and lake ice. People have lost and damaged equipment. • Slower freeze-up has forced hunters to wait longer in the community unable to access hunting areas on the mainland and ice
	October–July: Seal hunting, walrus from moving ice, caribou on mainland	Weather – predictability, timing	• More unpredictable weather and sudden weather changes have forced hunters to spend extra unplanned nights on the land. • Unusual weather – rain in winter, extreme cold in spring – is dangerous because hunters are not prepared.
	October–July: Seal hunting, walrus from moving ice, caribou on mainland	Wind – speed, direction, variability, timing	• Change in the predominant wind direction is affecting the shape of snowdrifts (Uqalurait) used for the purposes of navigation • Sudden and rapid changes in the wind have stranded walrus hunters on moving pack-ice, and resulted in the loss of hunting equipment
General Hunting/ Travel by boat	July–September: Open water fishing, caribou on mainland, walrus from coast	Waves/Stormy weather – wind speed, direction, variability	• Sudden changes in wind strength and direction, combined with stronger winds, have forced hunters to spend extra nights out on the land waiting for calm weather to return to the community • More windy days have limited the opportunities for boating reducing accessibility to hunting areas.

is used for hunting trips, has to be booked weeks, if not months, in advance. Weather or safety concerns may, therefore, be superseded by consideration of time availability when harvesting decisions are made (Aporta 2004). More risk-taking behaviour is also associated with technological developments. Interviews indicated that GPS, VHF radios, and the functioning of a community search and rescue group, which provide a safety net if problems are encountered, have resulted in less caution and in overconfidence. Hunters are now travelling and hunting in conditions that would have traditionally been considered dangerous. Beaubier et al. (1970), for example, in their work on hunting behaviour in Igloolik in the late 1960s, concluded that wind and visibility were major factors constraining hunting. While true to a certain extent today, many community members now go out in conditions previously considered unsuitable.

> 'I think some people will now go out when they wouldn't normally go out.' – James Ungalak

Risk-taking behaviour is also linked to deskilling and incomplete transmission of knowledge for safe hunting among younger generations. Aporta and others (2005), for instance, note that many younger people do not have the depth of knowledge to move about safely. Younger generations often do not perceive the risks that more experienced hunters do. Few younger Inuit, for instance, can read the weather and identify precursors to hazardous conditions.

Changing biophysical environments

There is widespread feeling among Inuit in Igloolik that climatic conditions have been changing beyond expected natural fluctuations and variability since the 1990s (Fox 2002, 2004; Ford 2005a, b). As perceived locally, these changes have exacerbated the risks associated with harvesting, have created new risks, and have reduced access to hunting areas and hence supply of country food. Table 2 documents how climatic conditions to which harvesting is sensitive are being affected by climate change. Changing human-environment dynamics in many cases have amplified the risks associated with climate change. The increasing dangers posed by unpredictable weather conditions and wind, for example, are occurring in the context of more risk-taking behaviour among hunters and deskilling among younger generations. Hunters are taking more risks at the same time as their knowledge about the environment is becoming less profound.

Adaptive capacity

Continuity and change in adaptive capacity

The success of Iglulingmiut to adapt to climate variability and change is well documented and indicative of their adaptive capacity. Characteristics of Inuit society that historically facilitated adaptability include: traditional knowledge and land-based skills, resource use diversity and flexibility, group mobility, and strong social networks.

Many of these characteristics remain important in facilitating adaptive capacity. Societal changes, however, have undermined certain aspects of adaptive capacity, made others obsolete, and have resulted in emerging vulnerabilities in certain sections of the community. In other ways, adaptive capacity has increased.

Traditional knowledge and land-based skills

The detailed knowledge of Inuit about the local environment, including knowledge of physical and biological processes, is widely recognized (Boas 1888; Nelson 1969; Duerden and Kuhn 1998; MacDonald 1998; Riedlinger and Berkes 2001; Aporta 2002). Evolving in the context of unpredictable and variable biophysical conditions from personal engagement in the environment and from knowledge and skills handed down the generations, this knowledge (referred to herein as *Inuit Quajimajatuqangit (IQ)*) is utilized by Inuit to facilitate safe and successful hunting, and to deal with climatic fluctuations and extremes. Hunters manage the risks characteristic of everyday hunting by knowing the dangers of hunting, taking precautions, being sensitive to critical signs in the environment and knowing how to respond, knowing how to survive if they are caught in bad weather, knowing what equipment to take along and what preparations to make, and knowing how to navigate using traditional means if caught out in bad weather. Knowledge of animal behaviour underpins the adaptability to changing animal numbers and location.

The importance of *IQ* in facilitating safe hunting is demonstrated in the hunting of walrus on the moving ice. Through generations of observation and experience, Igloolik hunters have developed the knowledge to predict the behaviour of the moving ice (Aporta 2002). The direction and strength of the wind and tidal stage is particularly important; a sudden shift in the wind direction from the south/southeast to the north/northwest on an outgoing tide would carry hunters away on drifting ice. Tide strength is important too. Before going to the moving ice, hunters closely watch the weather and the tides, and look for subtle warning signs that are precursors to hazardous conditions (see Aporta 2002). Decisions will be continuously re-appraised while travelling to, and while hunting on, the moving ice. Waiting for the right conditions of wind and tide is essential. If hunters do get stranded, they draw upon their knowledge to manage the situation.

> '[When stranded] our instructions are in great detail in that we don't stay where we get stranded. We go to where it is more solid and once you get there you find snow for shelter, snow for water, and you stay there until it gets light,' – Theo Ikummaq.

IQ has not always guaranteed safety. Local elder Herve Paniaq recollected stories from his youth about hunters who went to the moving ice and never returned. But it has enabled Inuit to manage the risks inherent in hunting. Changes in climatic and environmental conditions in recent years, however, are challenging Inuit knowledge and understanding of the environment, specifically the ability to evaluate risks. Like other forms of indigenous knowledge, however, Inuit knowledge is continually evolving and being updated and revised in light of observations, trial and error experience, collective discussion, and the incorporation of non-traditional knowledge alongside the traditional (Stevenson 1997; Ignold and Kurttila 2000; Usher 2000; Davidson-Hunt and Berkes 2003). In this way, *IQ* has evolved with changing climatic conditions to frame individual practice and decision-making, taking into account changed conditions, and continuing to facilitate successful adaptations to an increasingly risky environment. Strategies used to manage these changes include risk minimization, risk avoidance, risk sharing, the modification of the timing and location of harvesting activities, and the modification of the equipment used to harvest (Table 3). As Table 3 shows, however, these strategies are not without significant costs. In a similar manner, *IQ* facilitates adaptability to changing animal numbers and accessibility by underpinning the flexibility and diversity of resource use.

There is evidence in Igloolik that the traditional mode of knowledge transfer and learning is not functioning as it was in the past (MacDonald 1998). This has implications for exposure-sensitivity, and for adaptive capacity. Among younger generations in particular, skill sets and knowledge for hunting have been lost, including traditional forms of navigation. Others have been transmitted incompletely, including skills and information on what to do in certain dangerous situations, how to dress appropriately, what to take along on trips, and the ability to identify precursors to hazardous conditions. Consequently, many younger and inexperienced hunters are not as well equipped as formerly to cope with the risks of hunting. There have been numerous cases of young Inuit getting into difficulties on the land, and changing climatic conditions are making it even more dangerous for them.

> '[The younger people] who don't go out as much are more likely to be in danger,' Elizabeth Awa.

This deskilling is linked to a gradual disengagement of younger generations from the land, beginning with the settlement of fixed communities in the 1960s, and accelerating particularly in the last 10–20 years. Disengagement has been linked to numerous factors: the requirements of contemporary schooling, increased dependence on waged employment, desire among youth to follow 'western' social norms, alternative activities such as computer games and TV, the emergence of intergenerational segregation between young and older generations, and a decline in prestige acquired from hunting among younger generations (Brody 1987; Condon and others 1995; Rasing 1999; Kral 2003; Takano 2004). It has been reinforced by changing social relations brought about by new technology (Aporta and others 2005). Bane (1982), for instance, discusses how the individualized nature of snowmobile travel compared to dog teams eliminated the transmission of geographical knowledge to

Table 3. Adaptive strategies employed to manage climate change related risks.

Climate change related risks	Adaptive strategies	Adaptation costs
Unpredictability of the weather, wind, ice	• Hunters are taking extra food, gas, and supplies in anticipation of potential dangers • Hunters are making sure that they travel with others when possible • Some hunters are being risk averse, avoiding travelling on the land or water if they have reason to believe the weather is going to be bad • Use of weather forecast on the TV and radio to complement traditional forecasts • New equipment taken along e.g. personal location beacons, immersion suits, satellite phones	• Costs of purchasing extra supplies prohibitive for many who have limited income • Avoiding travelling at certain times results in shortages of some traditional foods and need to purchase more store food • New equipment is often expensive
Waves/stormy weather for summer boating	• Identification of safe areas prior to travel where shelter can be found • Waiting in the community for adequate conditions	• Waiting results in reduced harvests and need to purchase more store food • Avoiding certain areas can result in higher gas costs and add more time onto hunting trips (a problem for those with full time jobs)
Snow covered thin ice	• Avoidance of snow covered areas • Extra care while travelling	• Avoiding certain areas can result in higher fuel costs and add more time onto hunting trips (a problem for those with full time jobs)
Reduced accessibility to hunting areas	• Waiting in the community until hunting areas are accessible • Switch species and location • Sharing of country food	• Waiting results in reduced harvests and need to purchase more store food • Not all have the hunting skills to switch species

younger generations while travelling (see also MacDonald 1998).

Similar trends have been documented in indigenous communities across the Arctic (Nelson 1969; Condon and others 1995; Ohmagri and Berkes 1997; Ford 2005a). In Igloolik, however, the re-assertion of cultural values has attempted to counter the erosion of traditional knowledge. 'Land Camps,' in which elders take young Inuit on the land for weeks at a time throughout the year and teach hunting skills, have been partially successful in developing essential survival skills and in strengthening inter-generational relationships (Wachowich 2001; Takano 2004). The introduction of seasonal outpost camps also helps to transmit and develop *IQ* (Rasing 1999). Nonetheless, the success of such experience is debatable, and the continued difficulties younger generations encounter while out on the land indicates limited adaptive capacity.

Group mobility and resource use flexibility and diversity

Historical, anthropological, and archaeological work has demonstrated how flexibility and diversity in resource procurement and group mobility has facilitated successful adaptation to, and exploitation of, climate variation and change (Balikci 1968; Guemple 1976; Bane 1982; Sabo 1991; McGhee 1996; Berkes and Jolly 2002). During the Little Ice Age (AD 1550–1850), for instance, changing sea ice conditions resulted in the disappearance of the bowhead whale from many Arctic regions, including the Igloolik area. The bowhead was the main source of food and building materials at the time, upon which large semi-permanent settlements had been based. When the security that came with harvesting the 20–30 tonne bowhead was removed, new forms of social organization and mobility emerged to manage the change (Taylor 1966; McGhee 1972, 1984, 1996). In the Igloolik area the resulting adaptations involved the fragmentation of groups by family unit beginning in mid-December, and coalescence into semi-permanent villages in the autumn to hunt walrus (Mathiassen 1928; Helm and Damas 1963; Crowe 1969; Damas 1972; Mary-Rousselliere 1984; Rasing 1999). This pattern changed in the 1920s with the establishment of more regularly populated semi-permanent camps concomitant with the introduction of the whale boat and development of the fur trapping economy (known as the 'camp system') (Damas 1963; Crowe 1969; Beaubier and others 1970; Brody 1976). Mobility, however, remained high during this period (Phillips 1957; Bisset 1965). In the late 1950s, for instance, Ross (1960)

observed the winter dispersion of hunters to locations close to the floe edge and walrus hunting grounds.

The seasonal mobility cycle, linked to availability and accessibility of animals, was effective in facilitating exploitation of the environment during periods of ecological and environmental stress; people responded to changes in animal populations or their accessibility by altering their locations, movement patterns, and utilizing alternative hunting strategies. In response to greatly reduced caribou herds on Melville Peninsula in 1937, for example, many Iglulingmiut groups migrated to the east coast of Foxe Basin where caribou were plentiful (Phillips 1957; Ross 1960). This enabled Inuit to make best possible use of the environment, allowing location near, and accessibility to, hunting grounds (Ross 1960).

By the late 1960s the majority of Inuit in the region had moved into Igloolik (Phillips 1957; Mary-Rousselliere 1984; Damas 2002). This significantly altered Inuit ecological relationships, making group mobility essentially obsolete as an adaptive strategy. However, some features of camp life have remained, notably the functioning of seasonal 'outpost camps,' which during the 1970s, '80s and '90s became increasingly important for Inuit disillusioned with settlement life. Particularly in the spring and summer months, people will camp, sometimes at great distance form the community, close to hunting areas (see Alexander and Alexander 1996). This resembles the pre-settlement dispersal of families (Rasing 1999) and maintains some of the flexibility characteristics of earlier times. There are also other continuities with the past. Harvesting remains opportunistic; hunters will harvest what is available when it is available and where it is available, making *ad hoc* changes to take advantage of game availability and specific local conditions during hunting where quota limits allow. This opportunism in Inuit resource use, involving the utilization of all available species and the switching of species and harvesting locations, based upon *IQ,* of animal population dynamics and behaviour, is recognized as having traditionally facilitated adaptability among Inuit (Taylor 1966; Balikci 1968; Sabo 1991). This has enabled hunters to take advantage of year to year variability and has been important in facilitating adaptability to late twentieth century climate change. Temporary local scarcities can be met by shifting effort to other resources. This substitution not only allows people to cope with variations in animal numbers but also enables them to manage variations in biophysical conditions. In recent years, for example, with later and longer ice freeze-up delaying access to hunting areas, hunters have harvested seal from the shores of Igloolik island until hunting areas further away are accessible.

The erosion of *IQ* described above has important ramifications for flexibility in resource use. The ability to switch species or exploit new hunting areas is dependent, in part, upon knowledge of the behaviour of other species and of the environment in which they can be harvested. For instance, many of the inexperienced hunters predominantly hunt seal (which can be harvested close to the community and in safe locations on the landfast ice). For them, switching species to walrus is difficult due to their lack of the knowledge required to hunt on the moving ice and to travel to the floe edge, unless they join other, more experienced hunters. In addition, increasingly middle-aged and younger hunters admit openly to a disinclination to hunt walrus because of the amount of work required to properly butcher, prepare, and cache the meat.

Social networks

Several types of food-sharing practice among traditional Inuit groups have been distinguished, characterized by intent (rule, voluntary, demand) and direction of flow of food (transfer, exchange, redistribution) (Boas 1888; Taylor 1966; Balikci 1968; Sabo 1991; Wenzel 1991, 1995; Collings and others 1998; Kishigami 2004). Complex systems of voluntary and rule-based resource redistribution and transfer characterised traditional Iglulingmiut society (Damas 1963, 1972; Mary-Rousselliere 1984). Principal sharing practices included obligatory village-wide sharing of large animals caught, voluntary sharing of food with less fortunate households without an obligation to reciprocate, and communal meals during times of food shortage (Damas 1972). These practices formed a core aspect of Inuit environment relations and were central to Inuit culture and identity. The extended family formed the primary unit of traditional resource production and consumption, with material transactions structured through fundamental rules of kinship and age relations that regulated virtually all aspects of interpersonal contact. Premised partly upon the knowledge that a person may expect to receive reciprocal treatment from others, the various systems of food-sharing enabled the risks associated with the highly unpredictable nature of hunting to be managed (Damas 1972; Guemple 1976; Wenzel 1991). During periods of scarcity or environmental stress, sharing underpinned the food security of the group.

'Westernization' has changed many social relationships and has resulted in rising inequality, individualised behaviour, and withdrawal from the subsistence economy. The introduction of the firearm (in widespread use by the twentieth century), for example, created a more individualistic approach to hunting at the expense of the co-operative activities previously employed (Hughes 1965; Mary-Rousselliere 1984; Rasing 1994). New belief systems and ethical stances brought to the Arctic by missionaries, the Royal Canadian Mounted Police, and government agents conflicted with many Inuit practices. Consequently, rituals that reinforced a sense of belonging and a sharing ethic, including betrothal and spouse exchange were gradually abandoned (Guemple 1976). More profound changes occurred in the second half of the twentieth century with settlement in fixed communities, compulsory schooling for children, the development of a wage-based economy, and the accessibility of store-bought food at all times of the year. One consequence has been a decline in the number of people hunting and

the development of a small group of full-time hunters who supply most of the country food to the community, especially caribou and walrus that require considerable skill and time to hunt. New forms of reciprocity have emerged to balance this trend, including the sharing of equipment and pooling of resources in the extended family between those with a cash income and full time hunters. However, as Chabot (2003) comments concerning Inuit communities in Northern Quebec, these new forms of reciprocity are not always easy to fulfil. Many younger generations with full-time jobs are no longer prepared to share their income within the household unit. The sustainability of reciprocity is threatened in such instances. Nonetheless, social values and practices have been largely resilient to change; the production, redistribution, and transfer of locally harvested resources based on the extended family remains important in Igloolik.

Food sharing networks have maintained food security in the light of changing resource availability and accessibility in the later half of the twentieth century. For example, with limited availability of caribou in recent years due to their migration some distance away from Igloolik, sharing networks have ensured those 'in need' of caribou meat do not go without when it is available. Moreover, with changing climatic conditions making certain areas inaccessible to people who do not have the equipment, knowledge, or time, the availability of shared food underpins their country-food security.

Considerable strain, however, has been put upon the networks through which non-food resources are shared. While equipment is still shared within the extended family and sometimes between friends, economic stratification in the community has resulted in a considerable undercurrent of conflict evident in Wenzel's (1995) description of Clyde River, Nunavut. On the one hand, some younger members of the community and those who went through the school system, have access to cash resources through waged employment and hence can afford harvesting equipment. On the other hand, older members of the community and those who hunt full time have limited cash access to purchase the equipment necessary for harvesting. Conflict arises when those employed refuse to share their equipment. Wenzel (1995: 53) offers an explanation: 'Many of these employed persons are also hunters who are concerned that their equipment be available to them in serviceable conditions when they do have time to go out.' Today, when sharing of equipment does occur, it frequently requires monetary transaction.

> 'The only way we can go out with friends or family is to rent. That's how it is these days. Even if my husband wants to use a skidoo from his brother he has to rent it!' – Leah Ivvalu.

Division and social tension have emerged in other aspects of community life. Animal quotas, introduced first in the 1970s, are a particular source of conflict. With regards the polar bear quota for instance (in 2005 there were 15 tags to hunt polar bears), some want to allocate it to sports hunters and others to traditional Inuit uses.

> 'They fight amongst each other, they divide families because [of] disagreement [about] how they should distribute the quotas.' – James Ungallak.

In addition, interviewees noted the emergence of intergenerational segregation, a decline in practice of traditional cultural values, and substance abuse.

> 'There is no communication link between elders and young people anymore. They're out of touch with each other.' – Nick Arnatsiaq

Thus while the sharing of food within the extended family remains strong and important in ensuring food security, in other areas the relations of trust, reciprocity and exchange that have facilitated sharing and the pooling of risk have been weakened. This has implications for the ability to manage climate change risks. With longer open water season in summer, for example, those without their own boats are dependant upon others to share with them. And with the environment becoming increasingly risky, the sharing of safety equipment and communications technology is important. Institutional support from the federal and territorial government and from Land Claims Institutions, to an extent, has emerged to fill the gap. Transfer payments, including welfare, pension, and family allowances along with various hunter support programs facilitate the purchase of hunting equipment. External institutional support, however, cannot provide a substitute for internal, culture-based support provided by traditional sharing networks.

Discussion

Inuit have always lived with and responded to climate variability and change. In this respect, late twentieth century climate change, as observed by communities and scientists, is nothing new. Analysis of past and present experience with, and response to, climate variability and change develops a greater understanding of what makes a system vulnerable to change. A number of insights can be drawn regarding the potential implications of future climate change.

Firstly, in the face of climate variability and change, Inuit in Igloolik have been, and continue to be, highly adaptable. There remains considerable continuity in those characteristics of Inuit society that traditionally facilitated adaptability, including traditional knowledge and land-based skills, resource use diversity and flexibility, a certain degree of group mobility, and strong social networks. However, societal changes, including the settlement in fixed communities, the development of waged-based economy, and the utilization of new technology, have created new vulnerabilities, attenuated old vulnerabilities, and exacerbated others. Among younger generations in particular, there are emerging vulnerabilities to climatic risks, a consequence of weakening social networks, increasing technological dependence, and risk-taking behaviour which has undermined certain aspects of adaptive capacity and increased exposure-sensitivity. In other ways adaptive capacity has increased. Institutional support and diversification of food sources away from

total reliance on traditional foods, for instance, means that starvation does not occur today as it occasionally did in the past (see Rasmussen 1929; Bisset 1965). The dynamic nature of these Inuit environment interactions in the twentieth century highlights that the implications of future climate change are not calculable from the physical dimensions of the shift alone, but will be conditioned by the interaction between biophysical and societal processes operating within and across local, regional, and global scales.

Secondly, the implications of future climate change will be socially differentiated. Particularly among younger generations, there have been emerging vulnerabilities in the last few decades of the twentieth century. Part-time hunters are more vulnerable to changes in the animal numbers and accessibility, particularly seal. Hunting other species such as walrus in winter is not an option for them due to the knowledge requirements and disinclination to hunt walrus because of the amount of work required. At the same time, declining numbers of young people involved in harvesting and reduced reliance on traditional foods may result in limited exposure, and hence reduced vulnerability, to climate change risks among the young. Full time hunters, through their extensive experience, knowledge, and time availability are better equipped to cope with climate change. However, their reliance on others for equipment places them at risk of changing social circumstances which affect sharing networks, and their dependence on hunting for their livelihoods makes them exposed to changing environmental conditions.

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