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Co-management institutions, knowledge, and learning: Adapting to change in the Arctic
Institutions de co-gestion, connaissance et apprentissage. L'adaptation au changement dans l'Arctique

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Résumé de l'article

Jusqu'à quel point les peuples autochtones de l'Arctique sont-ils vulnérables au changement climatique? Comment s'y adaptent-ils et quelles sont leurs aptitudes potentielles à affronter les changements encore à venir? Le Intergovernmental Panel on Climate Change ne mentionne qu'à peine les peuples autochtones, et seulement sous l'aspect de victimes impuissantes de changements qui échappent à leur contrôle. Cette conception des peuples autochtones comme passifs et désarmés doit être sérieusement revue. Les peuples autochtones, y compris les Inuit du Canada, sont des observateurs avisés du changement environnemental et peuvent donner des leçons sur les possibilités de s'y adapter, idée qui s'accorde par ailleurs à l'image de créativité et d'adaptabilité que les Inuit ont d'eux-mêmes. Il existe trois fondements à ces adaptations aux impacts du changement climatique: 1) les adaptations culturelles autochtones à la variabilité de l'environnement arctique, dont nous discutons ici dans le cadre des communautés de Sachs Harbour et d'Arctic Bay; 2) des ajustements à court terme (stratégies au cas par cas) qui ont fait leur apparition au cours des dernières années en réponse au changement climatique; et 3) de nouvelles réponses adaptatives apparues dans la foulée de nouveaux processus institutionnels tels que la co-gestion. Certaines institutions en lien avec le développement de la connaissance et l'apprentissage social peuvent contribuer à accroître le potentiel d'adaptation et à réduire la vulnérabilité. Deux institutions de co-gestion qui ont le potentiel d'accroître la capacité adaptative des Inuit sont le Comité mixte de gestion des pêches (établit par le *Inuvialuit Final Agreement*) et le Conseil de gestion des ressources fauniques du Nunavut.

Co-management institutions, knowledge, and learning: Adapting to change in the Arctic

Fikret Berkes* **and Derek Armitage****

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Jusqu'à quel point les peuples autochtones de l'Arctique sont-ils vulnérables au changement climatique? Comment s'y adaptent-ils et quelles sont leurs aptitudes potentielles à affronter les changements encore à venir? Le Intergovernmental Panel on Climate Change ne mentionne qu'à peine les peuples autochtones, et seulement sous l'aspect de victimes impuissantes de changements qui échappent à leur contrôle. Cette conception des peuples autochtones comme passifs et désarmés doit être sérieusement revue. Les peuples autochtones, y compris les Inuit du Canada, sont des observateurs avisés du changement environnemental et peuvent donner des leçons sur les possibilités de s'y adapter, idée qui s'accorde par ailleurs à l'image de créativité et d'adaptabilité que les Inuit ont d'eux-mêmes. Il existe trois fondements à ces adaptations aux impacts du changement climatique: 1) les adaptations culturelles autochtones à la variabilité de l'environnement arctique, dont nous discutons ici dans le cadre des communautés de Sachs Harbour et d'Arctic Bay; 2) des ajustements à court terme (stratégies au cas par cas) qui ont fait leur apparition au cours des dernières années en réponse au changement climatique; et 3) de nouvelles réponses adaptatives apparues dans la foulée de nouveaux processus institutionnels tels que la co-gestion. Certaines institutions en lien avec le développement de la connaissance et l'apprentissage social peuvent contribuer à accroître le potentiel d'adaptation et à réduire la vulnérabilité. Deux institutions de co-gestion qui ont le potentiel d'accroître la capacité adaptative des Inuit sont le Comité mixte de gestion des pêches (établit par le *Inuvialuit Final Agreement*) et le Conseil de gestion des ressources fauniques du Nunavut.

Abstract: Co-management institutions, knowledge, and learning: Adapting to change in the Arctic

How vulnerable are Arctic Indigenous peoples to climate change? What are their relevant adaptations, and what are the prospects for increasing their ability to deal with further change? The Intergovernmental Panel on Climate Change makes little mention of Indigenous peoples, and then only as victims of changes beyond their control. This view of Indigenous peoples as passive and helpless needs to be challenged. Indigenous peoples, including the Canadian Inuit, are keen observers of environmental change and have lessons to offer about how to adapt, a view

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consistent with the Inuit self-image of being creative and adaptable. There are three sources of adaptations to impacts of climate change: 1) Indigenous cultural adaptations to the variability of the Arctic environment, discussed here in the context of the communities of Sachs Harbour and Arctic Bay; 2) short-term adjustments (coping strategies) that are beginning to appear in recent years in response to climate change; and 3) new adaptive responses that may become available through new institutional processes such as co-management. Institutions are related to knowledge development and social learning that can help increase adaptive capacity and reduce vulnerability. Two co-management institutions that have the potential to build Inuit adaptive capacity are the Fisheries Joint Management Committee (established under the *Inuvialuit Final Agreement*), and the Nunavut Wildlife Management Board.

Introduction

Impacts of global climate change are not distributed evenly. The largest temperature increases are projected to occur over the Polar region, the land of the Inuit and other Indigenous peoples (ACIA 2005; IPCC 2007). Given that these Indigenous groups have also experienced extensive social, cultural, political, economic, and demographic changes in recent decades, it can be said that they have been subjected to the "double exposure" of globalisation and global environmental change. Secondary effects are yet to come, as a seasonally ice-free Arctic encourages additional resource development and further social and economic impacts (Leichenko and O'Brien 2008).

There has been an explosion of research since about 2000 on the impacts of climate change on Arctic peoples (Huntington et al. 2005; Krupnik and Jolly 2002). A number of studies have taken a vulnerability perspective (Ford and Smit 2004; Smit et al. 2008). This perspective requires an assessment of adaptations and adaptive capacity. Here we define *adaptive capacity* as the ability of an individual or group (i.e., community) to cope with, prepare for, and/or adapt to disturbance and uncertain social-ecological conditions (Armitage 2005; Ford et al. 2006). Adaptations are manifestations of adaptive capacity and represent ways to reduce vulnerability. Adaptive capacity further implies learning through change and ability to experiment. Societies throughout the world have a long historical record of adapting to impacts of weather and climate, although the on-going climate change poses some novel risks outside the range of historic experience. Adaptation research was underrepresented on the early climate change agenda but has since become a major focus, and there is a need to understand the capacity of individuals, communities, and regions to adapt (Adger et al. 2007).

How vulnerable are Arctic Indigenous peoples to climate change? What are their relevant adaptations, and what are the prospects for increasing their ability to deal with

further change? As Salick and Ross (2009) noted, the Intergovernmental Panel on Climate Change (IPCC 2007) makes scarce mention of Indigenous peoples—and then only as victims of changes beyond their control. This view of Indigenous peoples as passive and helpless needs to be challenged (*ibid*.; Wenzel 2009). The alternate view is that Indigenous peoples, including the Canadian Inuit, are keen observers of environmental change and have lessons to offer about how to adapt. Such a view is consistent with the Inuit self-image of being creative and adaptable (Irniq 2008) and with historical realities. Arctic human history has been described as a series of adaptations, or a process of sequentially accumulating cultural mechanisms, to deal with the characteristics of the environment. "Dynamic and flexible use of the environment constitutes the chief adaptive strategy of Arctic communities" (Krupnik 1993: 210).

Alongside long-term cultural adaptations, recent climate-related changes in the Arctic have been triggering short-term (or coping) responses (Berkes and Jolly 2001; Smit et al. 2008). In addition to these adaptations and coping responses, there may be other ways to make Arctic communities better able to adapt to further change. Institutions are important in this regard because they are pathways for knowledge development and social learning that can help reduce vulnerability, build resilience, and increase adaptive capacity (Armitage et al. 2009). Co-management institutions developing since the 1980s have the potential to connect the different levels of organisation, or scales from local to national and international, and foster knowledge exchange and speed up learning (Berkes and Jolly 2001). There is a great deal of interest not only in international institutions for global environmental change (Young et al. 2008), but also in decision-making networks and multilevel governance for community adaptation to climate change (Keskitalo and Kulyasova 2009).

In this article, we are interested in the role of institutions in building adaptive capacity and facilitating *social learning*, defined here as the iterative action, reflection, and deliberation of individuals and groups engaged in sharing experiences and ideas to resolve complex challenges collaboratively (Diduck et al. 2005; Keen et al. 2005). We focus on co-management institutions in the Canadian Arctic, grounding our discussion primarily in two communities, Sachs Harbour (Northwest Territories) and Arctic Bay (Nunavut), with reference to other communities in the Canadian Arctic as appropriate. These institutions owe their existence to Indigenous land claims agreements in both jurisdictions (Berkes et al. 2005). They oversee joint management of fish, wildlife, and marine mammals, and include representatives from communities, regional Inuit organisations, and territorial and federal governments to provide institutional linkages among these agencies and groups. Linkages are both *horizontal* (across the same level of organisation or across geographical space) and *vertical* (across levels of organisation), following the terminology of Young et al. (2008).

A co-management agency is a *bridging organisation* that can: make it easier for institutions to interact at multiple organisational levels; bring together different kinds of knowledge and ways of knowing (Indigenous and scientific); access information and resources; and build networks and partnerships for social learning (Berkes 2009). By

collecting, processing, and transferring knowledge, and by providing a forum for practical problem solving, Canadian Arctic co-management institutions have had some success in meeting local needs (Ayles et al. 2007; Eamer 2006). Their overall record is nonetheless mixed. As a creation of non-Indigenous political processes, co-management often follows southern ways of proceeding and may actually contribute to the bureaucratisation of northern Indigenous societies (Stevenson 2006). In some cases, Indigenous participation has been manipulated (Nadasdy 2003), and the actual outcomes should be examined critically (White 2006).

This paper aims to explore the role of co-management institutions in the Canadian Arctic in building adaptive capacity, and how they may relate to long-term adaptations and short-term coping responses. First, we discuss how vulnerability studies are carried out and applied to the Canadian North. Next we discuss three ways to moderate the impacts of climate change. The first way concerns Indigenous cultural adaptations to the variability of the Arctic environment, with reference to our study communities of Sachs Harbour and Arctic Bay. The second pertains to short-term adjustments, or coping strategies, that have begun to appear in recent years in response to climate change. The third relates to new adaptive responses that may be available through new institutions and institutional processes, such as co-management.

Studying vulnerability

Having been identified and explicitly mentioned in the United Nations Framework Convention on Climate Change, vulnerability has become a central concept in climate change and adaptation (Smit and Wandel 2006). This concept, however, has long been used in natural hazards and disaster research where it is recognised as an outcome of physical events and the socio-economic, cultural, and institutional conditions that shape the ability of individuals and societies to cope (Hewitt 1983). In this paper, vulnerability is the extent to which communities are susceptible to conditions (social, economic, biophysical) that may directly or indirectly affect their well-being (see Adger and Kelly 1999). The vulnerability of Inuit communities is thus a function of current and future exposure-sensitivities, current adaptation strategies, and future adaptive capacity. Figure 1 shows how these factors interrelate in a vulnerability assessment (Ford and Smit 2004; Smit et al. 2008). Such assessments have been carried out in an expanding number of places and contexts in Canada's North (Ford et al. 2006; Ford et al. 2007; Laidler et al. 2009). They have involved varying degrees of collaboration with communities, given the methodological assumption that vulnerability must be understood and documented by asking community members to identify relevant information on exposure-sensitivities and adaptive capacity (Pearce et al. 2009).

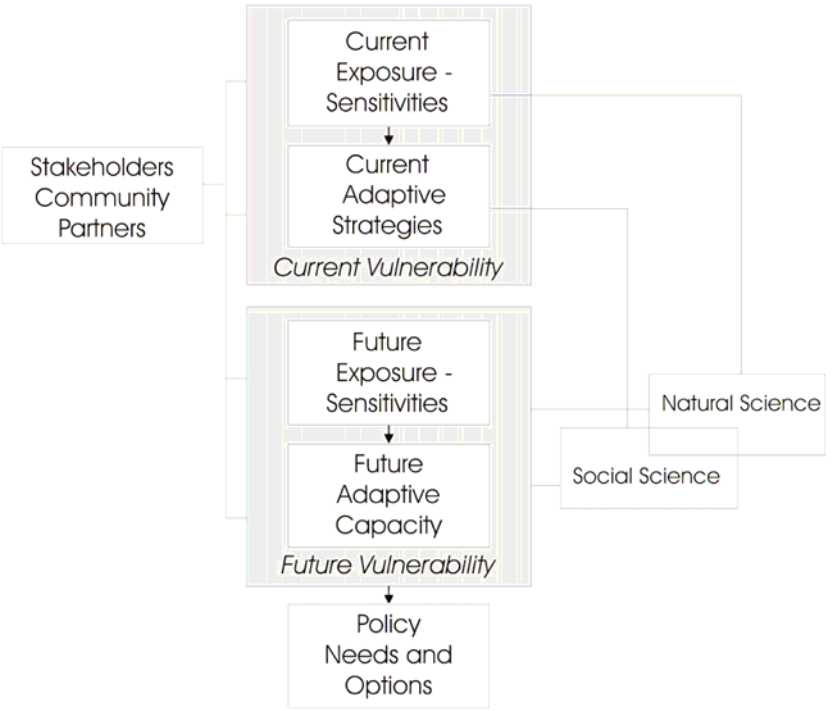

Figure 1: Vulnerability assessment (source: Smit et al. 2008).

People cope with environmental variability within a certain range. Such variability (e.g., seasonal temperatures, break-up and freeze-up dates) has increased in recent years because of climate change (Krupnik and Jolly 2002). As it increases, the coping range may be exceeded from time to time, or the cumulative effects of increasingly frequent extreme events may exceed a threshold beyond which people cannot cope. The result may be loss of livelihood, food insecurity due to inability to hunt (Ford and Berrang-Ford 2009), and even relocation of an entire community. By enhancing the adaptive capacity of individuals, households, and communities (e.g., by building on Inuit practices and institutions), we may expand the coping range and reduce vulnerability. Figure 2 schematically expresses these ideas; it is not meant to be a formal model or a predictive tool. As adaptive capacity is multi-scale in nature, the unit of analysis in Figure 2 may be the individual, household, community, or region. To illustrate these points, we draw on experiences from two Arctic communities where interrelated issues of vulnerability, coping and adaptation, and adaptive capacity have been under study: Sachs Harbour (Northwest Territories) and Arctic Bay (Nunavut). A brief overview of each is provided below.

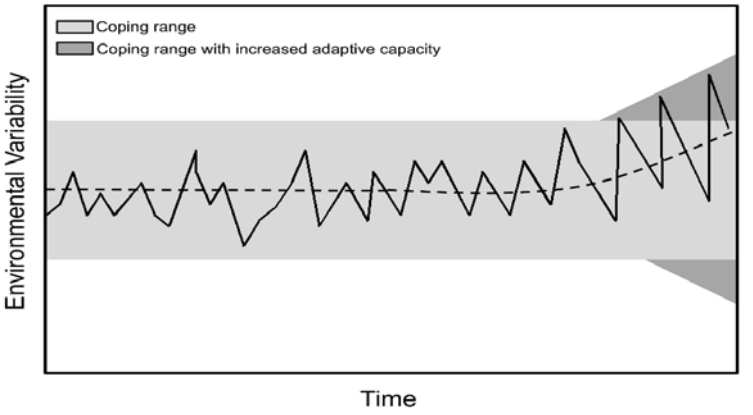

Figure 2. Building adaptive capacity to increase the coping range (adapted from Smit and Ford 2006).

Sachs Harbour and Arctic Bay

Sachs Harbour is on Banks Island, which borders the Beaufort Sea in the western Canadian Arctic. With some 30 households of 136 people (Statistics Canada 2009), it is the smallest of the six Inuvialuit (western Arctic Inuit) communities in the region covered by the Inuvialuit Final Agreement of 1984. Sachs Harbour has been recognised as a permanent settlement only since 1956, having originated as an outgrowth of white fox trapping activities that began in 1928. The residents are descendants of the Mackenzie Delta people to the south, the Inupiat (Alaska Inuit) to the west, and the Inuinnait (Copper Inuit) of Victoria Island to the east (Nagy 1999; Usher 1970). The Inuvialuktun dialects spoken at Sachs Harbour reflect this mixed heritage. Many people lost their native language while attending residential schools that allowed only English, which has become the dominant language among those under 50 (Nagy 2006: 87-88). The subsistence economy is based on musk-ox,[1] some caribou,[2] polar bears, ringed seals, ptarmigan, Arctic hare, snow goose, and various species of fish.

Arctic Bay is south of Lancaster Sound and east of Admiralty Inlet in the northern part of Baffin Island, Nunavut. The area comes under the Nunavut Land Claims Agreement of 1993. The community was first settled in the 1950s and 1960s, and grew with the opening of the nearby Nansivik zinc mine. The mine provided most of the employment opportunities and related income until it was closed in 2002. The

1 The peak of the musk-ox hunt is in November and has been on and off a commercial activity since 1981 due to their enormous population on the island (Nagy 2004: 106-107).

2 Due to their low numbers on the island.

community has a young and growing population of approximately 690, with nearly 35% under 18. Approximately 93% of Arctic Bay residents identify as Inuit, with Inuktitut being the first and dominant language (Dale 2009). Like other small northern communities, hunting and land-based activities are socially and culturally significant. There has been and remains a strong subsistence economy involving the harvest of narwhal, ringed seal, Arctic char, and caribou, among others.

Long-term response to change: Adaptive strategies

To cope with perturbations due to climate change, the Inuit will in part depend on culturally available responses (Irniq 2008). Here we address traditional cultural adaptations to environmental variability and uncertainty, and whether these strategies are still viable. Anthropologists and other social scientists have identified several clusters of these adaptive responses to the Arctic environment: 1) mobility on the land and group size flexibility; 2) flexibility of seasonal cycles of animal harvest; 3) Indigenous environmental knowledge and related skill sets; 4) sharing mechanisms using social networks; and 5) inter-community trade (Balikci 1968; Freeman 1996; Krupnik 1993). We discuss each in turn.

1) Arctic ecosystems are characterised by low biological productivity, patchy resources, and unpredictable resource availability. These conditions profoundly influence social organisation by discouraging large social groups and permanent settlements. Thus, traditional Inuit society was generally organised to facilitate constant grouping and regrouping of economically self-supporting mobile households (Freeman 1996).

2) There was a great deal of flexibility in seasonal hunting cycles. Mobile groups did not always use the same sequence of hunting locations or species. They dealt with unpredictability by harvesting what was available when it was available, and by switching species opportunistically. Seasonal cycles included plans with target areas and species, but also backup plans in case the intended hunts were not viable. The most successful leaders were those with backup plans and alternatives that produced food (Balikci 1968). Oral traditions and group memory of past situations were used to respond to unexpected fluctuations and extreme events (Minc 1986).

3) Inuit had detailed local environmental knowledge and related skill sets to allow such flexibility. This included mastering a diversity of land-based skills, and accumulating a detailed knowledge of various species, the land, and the sea ice. Diversification is a well-known strategy for spreading risk (Turner et al. 2003), and the Inuit tend to be hunting generalists, rather than specialists. Inuit society normally had a division of labour by gender, but men could sew skins and women could hunt, as needed. Survival skills were valued highly, allowing individuals to exercise a high degree of personal autonomy (Freeman 1996).

4) Co-resident social groups among Canadian Inuit were small until the 1960s and 1970s, and kills, for example a seal or small whale, were shared among perhaps a dozen households (Freeman 1996). A high value was attached to sharing. The most prestigious families were those who always had food to share. Social networks for sharing provided mutual support and minimised risk. Food sharing often went beyond the immediate group, as the Inuit tended to have complex social relationships, and exchanges followed these networks.

5) Inter-community trade was important throughout the Arctic and helped address regional differences in resource availability. Some of these trading relations were highly formalised in terms of social relationships and served as mechanisms to provide mutual support during travel to neighbouring areas. Freeman (1996) considers trading to be as much a symbolic act, to establish social relationships between groups and to recruit partners, as an economic transaction.

Since the 1960s and 1970s, Canadian Inuit society has undergone major change with the establishment of permanent villages; thus, traditional adaptations of mobility and group size flexibility are no longer operative. However, the other four clusters of adaptations seem to be viable in many parts of the Canadian Arctic, including Sachs Harbour and Arctic Bay. Hunters still show a "dynamic and flexible use of the environment" (Krupnik 1993: 210), and the flexibility of seasonal cycles of harvesting is the major coping response. In Arctic Bay, fewer young people participate actively in harvesting activities, and less knowledge about the land is being passed down. Because travel and harvesting largely take place on ice (except during the open water period from July to October), it is necessary to know the environment and understand changes in physical conditions (Ford et al. 2006). At a time of demographic shifts in the community, the implications of change to coping responses and adaptation are increasingly uncertain. Yet the loss of *Inuit Qaujimajatuqangit* (Inuit knowledge) is only partial, and the detailed environmental knowledge of the Inuit has made it possible to study climate change in the North (ACIA 2005; Laidler 2006; Riedlinger and Berkes 2001). Some knowledge and skills have been lost, and others are transmitted incompletely. But there are other, newer skills, such as the use of GPS devices and the ability to read remote sensing images available on the Internet. These are becoming a part of new coping strategies.

Inuit values are still in evidence. For example, food exchanges use traditional norms of generosity (giving without asking) and generalised reciprocity, rather than Euro-Canadian modes of economic exchange (Freeman 1996). Food is still shared in Sachs Harbour and Arctic Bay, but mostly within extended families. Since both communities are small and families interrelated, just about everyone gets to share some of the food coming in. However, a relatively small number of hunters account for most of the harvest, and fewer and fewer people seem to be providing for more and more non-hunters. This is one outcome of the general decline in the number of younger Inuit taking part in harvesting activities. Inter-community sharing and trade is one adaptation that does not seem to have declined but rather increased. Sachs Harbour has an abundance of snow geese and musk-ox but a dearth of caribou and beluga whales.

People export snow geese and musk-ox to Tuktoyaktuk and Inuvik, and in turn receive beluga products (*muktuk*) and caribou. In the case of Arctic Bay, inter-community sharing (mostly *muktuk*) is important but generally limited to nearby communities (e.g., Pond Inlet, Igloolik) accessible by snowmobile. These sharing networks may become more important, as access to resources becomes more uncertain with changes in sea ice and other conditions (James Ford, pers. comm. 2009).

To summarise, Inuit still have largely intact adaptive strategies: flexibility of resource use; local environmental knowledge and skills; sharing through social networks; and inter-community trade. However, loss of mobility may hinder adaptation (Wenzel 2009). These strategies together have provided considerable buffering capacity to deal with perturbations, and provide the cultural basis of many emerging short-term responses to climate change.

Short-term responses to change

We have some understanding of how people respond to large-scale environmental change, and the ways in which land-based livelihood systems are vulnerable. Increased variability and greater frequency of extreme events create adaptation problems because they make resource availability less predictable and interfere with the ability of people to access resources (Krupnik and Jolly 2002). Earlier studies in Sachs Harbour have supported the projections of global models, and the western Arctic rim of North America may become the "miner's canary" by providing early warning signs of global climate change (ACIA 2005). Indigenous communities started reporting climate-change-related impacts in the early 1990s, initially in the western Canadian Arctic, and somewhat later elsewhere (Huntington et al. 2005; Krupnik and Jolly 2002).

In analysing the adaptive capacity of Arctic people and communities to deal with climate change, one of the essential steps is to find out their actual response to the stress of climate change, and their coping strategies (Turner et al. 2003). One caveat here is that climate change is not the only stress faced by communities, and sorting out the relationship between specific exposure-sensitivities (e.g., mining development versus climate) is not easy. Arctic Indigenous people are grappling daily with social and economic crises, and climate change was not even at the top of their environmental agenda until the 2000s; Arctic ecosystem contamination was (Anonymous 2000; Berkes et al. 2001).

Coping responses are inevitably context-specific. Resource conditions (e.g., sea ice, species distribution) and social-economic conditions will vary significantly from community to community. In Sachs Harbour and Arctic Bay, it is nonetheless possible to identify a number of coping strategies that are consistent with findings elsewhere (Andrachuk 2008; Laidler et al. 2009). For the most part, coping strategies are adjustments to subsistence activities—changing when, where, or how hunting and fishing take place. The responses may be summarised under five headings: 1) modifying when harvesting is done; 2) modifying where harvesting is done; 3)

adjusting how harvesting is done; 4) adjusting the mix of species harvested; and 5) minimising risk and uncertainty. We highlight a few examples.

1) **Modifying when harvesting is done**. One of the observed impacts of climate change is increased seasonal variability, which forces hunters to adjust their seasonal calendar continuously. For example, in response to shorter and warmer springs and increased rates of snow and ice melt, the duration of spring camps becomes shorter. In Sachs Harbour, people return to the community after the goose hunt, rather than proceeding to lakes for ice fishing. Waiting has become a major coping strategy—people wait for the geese to arrive, for the rain to end, for the land to dry out, and for the weather to improve.

2) **Modifying where harvesting is done.** Unreliable snow conditions on the land force hunters to travel on coastal sea ice rather than inland routes, and this rerouting in turn creates another problem. Difficulties in "reading" the sea ice compel hunters to stay close to the community because of safety concerns, while the animals they seek remain farther out. Permafrost thaw in many places has forced hunters to find new routes to avoid slumps and mudslides, or to change hunting sites. In Arctic Bay, for example, conditions along the floe edge have become a particular concern, with some harvesters choosing to avoid hunting narwhal in these areas because of increased danger (Dale 2009; Ford et al. 2006).

3) **Adjusting how harvesting is done.** Various adjustments have been made in both Arctic Bay and Sachs Harbour. For example, people use all-terrain vehicles instead of snowmobiles to travel to spring camps when there is not enough snow on the land. They hunt seals from boats in the open water, rather than from the ice edge. This adjustment is due to the disappearance of ice floes, where the seals would normally be found in the summer months. In addition, when hunters go onto the land, they are increasingly taking all the supplies they may need (at added cost and difficulty in transporting) because of uncertainty about accessing resources. Meanwhile, technologies are being adopted to improve safety while on the land (e.g., GPS units to determine if ice is moving) (Ford et al. 2006).

4) **Adjusting the mix of species harvested**. Some hunts are becoming very unpredictable and failing in some years (e.g., the goose hunt and egg collection near Sachs Harbour). On the other hand, the appearance of new species has been a bonus in some cases. For example, hunters are reporting pintail (*Anas acuta*) and mallard (*A. platyrhynchos*), which were considered mainland ducks and historically rare on Banks Island. Also, the community is harvesting more *qaaqtaq* (least cisco). In Arctic Bay, reduced access to hunting areas has meant hunters may need to switch target species and hunt locations. Ford et al. (2007) note how fallback species like seal will be harvested if the August/September caribou hunt fails.

5) **Minimising risk and uncertainty.** Sachs Harbour hunters have highlighted the importance of experience when travelling on the sea-ice now, in response to

> increased variability and unpredictability of conditions. People in both communities monitor the environment more closely, such as ice break-up, to avoid being caught in dangerous conditions. There is evidence, in both Sachs Harbour and Arctic Bay, that many individuals forego hunting opportunities because it is getting too dangerous to go out. A number of technological solutions are used to offset this higher risk. In Igloolik (Nunavut) the solutions include: greater use of GPS units; consulting satellite images before leaving the village; more widespread use of VHF radio, even on shorter trips; and use of immersion suits (for warmth and floatation) when crossing particularly dangerous sea ice (Laidler et al. 2009).

As illustrated above, most of these coping responses are due to increasingly uncertain ice conditions (timing of freeze/thaw, ice thickness and quality/strength) because of the changing climate. In Arctic Bay and Sachs Harbour, as across the Arctic, climate change is recognised as amplifying the inherent risk of travel, with uncertain wind and weather patterns making ice conditions and travel safety particularly hard to predict (Laidler 2006; Laidler et al. 2009). There is also a social impact since trails on the sea ice belong to the individual and social memory of a community, such as Igloolik. This memory provides people with reliable hunting and travelling routes. Aporta (2004: 13) characterises travel not as a transitional activity "but a way of being." Under conditions of rapid change, hunters must increasingly rely on formal weather forecasts and new technologies to assess conditions and make choices.

GPS units, VHF radio, and survival suits have been part of the "modern Arctic" for some time. But the use of satellite images developed only in the 2000s. Sea-ice system services (SISS) post periodic snapshots on the Internet at a scale that Inuit hunters can put to practical use (Eicken et al. 2009). The images provide synoptic pictures of ice cover location and conditions, enabling hunters to use them in combination with their knowledge of sea ice. This new technology is used to varying degrees across the Canadian Arctic. Such images are routinely used in Igloolik, which is an island surrounded by often dangerous sea ice (Laidler et al. 2009; Gita Laidler, pers. comm. 2009). By contrast, hunters in Tuktoyaktuk (Erik Kocho-Schellenberg, pers. comm. 2009) and Aklavik (Eva Patton, pers. comm. 2009) say they do not normally need or use this technology, except perhaps for some polar bear hunters. Hunters from Sachs Harbour seem to be somewhere in-between. According to Dan Slavik (pers. comm. 2009), many hunters younger than about 50 rely on satellite images for two purposes: to locate the open leads where polar bears often hunt seals and to find a path around hard-to-cross pressure ridges to the open leads.

Many of the above-mentioned coping strategies require accumulated environmental knowledge and experience, and people are quick to point out they have always adjusted to change, as seen in their ability to adopt modern technology like satellite images. When asked about the impact of climate change on hunting, many in Sachs Harbour have identified how they still always find some way of accessing wildlife. People point out that it is easier to cope now than in the past, since the community does not rely exclusively on country foods and has a range of food options. On the other hand, it is becoming increasingly difficult and risky to hunt. As a result,

fewer people are going hunting or are staying on the land for shorter lengths of time. One consequence is an emerging food security problem (Ford and Berrang-Ford 2009). All of these findings indicate the importance of developing new strategies for coping and adapting, and ways of building adaptive capacity.

Looking forward: Co-management institutions and adaptive capacity

In our current project, we are examining institutions and institutional processes that facilitate or constrain learning and adaptation. The relevant institutions, for our purposes, are the co-management institutions of two Arctic land claims agreements. The *Inuvialuit Final Agreement* of 1984 covers the area that includes Sachs Harbour. This Agreement provided for the creation of several agencies that oversee the environment and resources. The main co-management body is the Fisheries Joint Management Committee (FJMC). The *Nunavut Land Claims Agreement* of 1993 covers the area that includes Arctic Bay and the Baffin region. The main co-management body here is the Nunavut Wildlife Management Board (NWMB), which is technically an institution of public government. As well, other institutions play a role in co-management, including those at the community, regional, national, and international levels (see Figure 3).

The FJMC and the NWMB are similar to other co-management agencies in Canada established under Indigenous land claims agreements in that they are legally constituted bodies, have formal mandates, consist of representatives of various organisations from the community to the federal government level, meet periodically, and have a centrally located secretariat that follows up on decisions and on the regular functions of the agency. While final authority often rests with territorial governments and the relevant federal minister, claims-based co-management institutions like the NWMB have significant scope to regulate resource access, to approve plans and designations, and to set policy. They can also commission background studies and set up working groups as needed. Some of the working experience of the FJMC and the NWMB has been documented (Ayles et al. 2007; Armitage 2005; Berkes et al. 2005). Table 1 summarises various co-management functions that we see as relevant to building adaptive capacity. The table reflects experience with Canadian land claims-based co-management bodies, in particular, the FJMC and the NWMB, and is consistent with the functions of bridging organisations (Berkes 2009). Table 1 is not based on a systematic study but on the evolving experience of the authors with these two bodies, their knowledge of several other co-management agencies, and insights from others who have studied co-management in the North.

The discussion forum function is highly important. Information and concerns can be shared at two levels: the meetings of the co-management agency itself, where Indigenous participants from communities and regions typically make up half the membership, and public meetings sponsored by the co-management institution. An example of the latter was the Beaufort Sea 2000 conference that took place in Inuvik, a predominantly Indigenous regional centre, and involved government and local leaders,

scientists, and Indigenous knowledge holders (Anonymous 2000). It was open to all. The original idea was to hold it as a public education session, but it evolved into an open, far-ranging meeting that discussed locally relevant issues and future options. Given the tendency of government scientists in co-management to "educate" the locals, the FJMC deserves commendation for turning it into a meeting with two-way exchange.

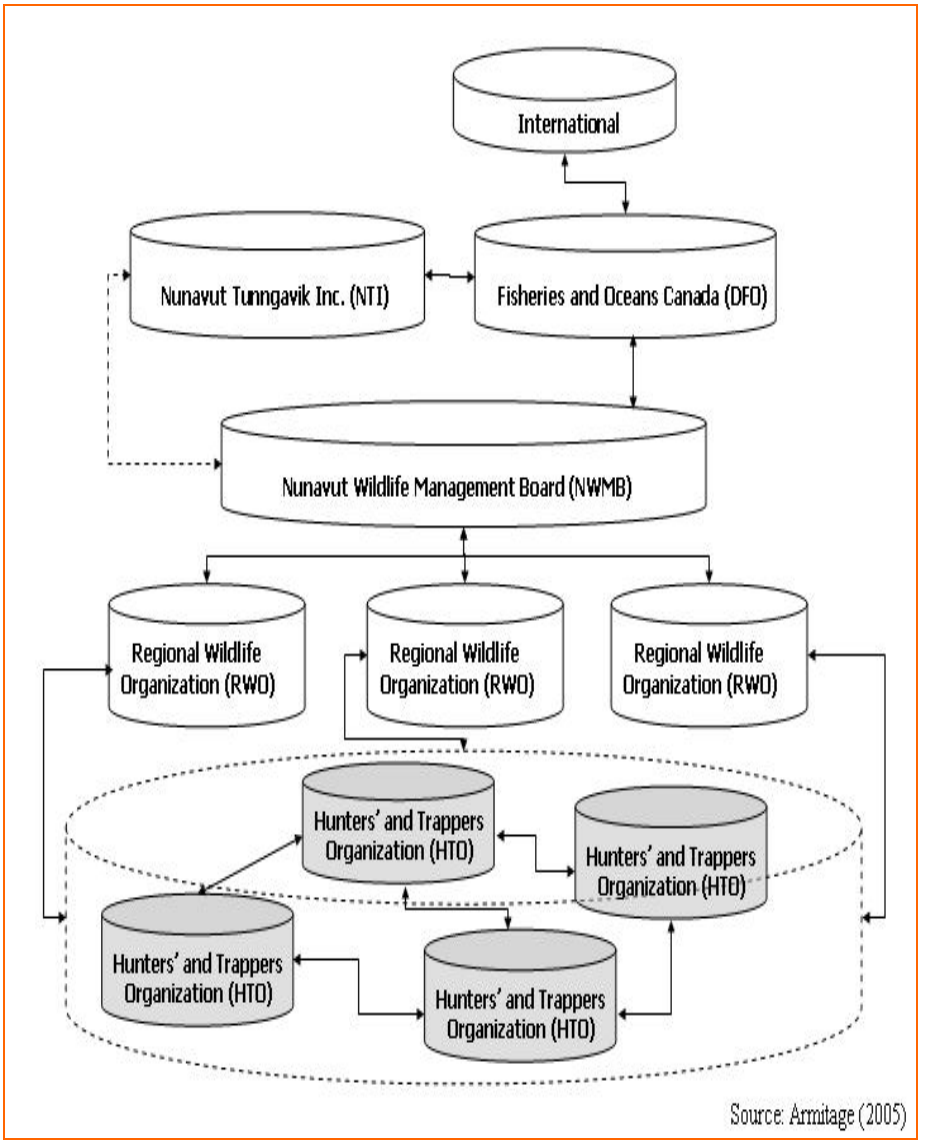

Figure 3. Institutional arrangement for multi-level co-management (source: Armitage 2005).

Table 1. Some of the roles of co-management institutions, under the *Inuvialuit Final Agreement* and the *Nunavut Land Claims Agreement*, that relate to building adaptive capacity.

Discussion forum	Co-management agencies can provide a forum to share information and concerns, to discuss locally relevant issues, and to start building a common vision for the future.
Knowledge mobilisation	The collaborative process of co-management in turn helps integrate and disseminate information and a range of knowledge types among stakeholders in an effort to respond to specific resource management or environmental challenges
Bridging knowledge	Indigenous knowledge and science have both similarities and differences. Potential synergies can be captured by combining complementary knowledge, skills, and capabilities at the two levels.
Co-production of knowledge	Different groups hold different kinds of knowledge. Science and Indigenous knowledge can together result in co-production of knowledge that neither party can produce alone.
Participatory research	Research that includes local and regional Indigenous groups as equal partners helps address locally important issues, builds social capital, and enhances local capacity for problem solving.
Collaborative monitoring	Indigenous monitoring has its own logic. Local groups and agencies can help decide what is to be monitored and how, thus extending the range of inquiry of government systems.
Linkages and partnerships	Multi-level linkages, ranging from local to international levels, establish a flow of information, communicate concerns, and build trust, problem-solving networks, and a sound foundation for governance.
Social learning	Learning at the level of social groups is key to addressing uncertainty. Collective learning processes and knowledge co-production linked to flexible co-management arrangements can transform how actors across levels deal with surprise.

Much of the work of co-management agencies involves knowledge mobilisation and co-production, defined as the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and to build an integrated or systems-oriented understanding. Thus, the mobilised knowledge includes not only science but also Indigenous knowledge. Recognition of Indigenous knowledge has been important for Indigenous leadership and has driven much of the participatory environmental research and management in the Canadian North since the early days of co-management (Berkes et al. 2001). Indeed, northern Canada has probably contributed to much of what we know about Indigenous knowledge and co-management (Armitage et al. 2007; Berkes 2009). Such knowledge has nonetheless been badly misused in

some cases of co-management (Nadasdy 2003). In the area of climate change, bridging science and Indigenous knowledge produces temporal and spatial complementarities and helps people understand impacts, adaptations and, monitoring of needs (Riedlinger and Berkes 2001). Co-management creates a forum in which the two parties can learn from each other to make sense of issues that either party understands only partially. Joint work in the Arctic since about 2000 has led to co-production of climate change knowledge that neither scientists nor Indigenous experts could have produced alone (Berkes 2008, Chapter 8; Laidler 2006).

Participatory research is a powerful tool to build trust, social capital, and adaptive capacity. In the 1990s, participatory research was carried out with several groups on Arctic contaminants and their effects on human health (Berkes et al. 2001). This work helped build networks and enhanced local capacity to cope with climate change (Berkes et al. 2005). Other examples include cooperative management of walrus and polar bear with two US Federal agencies and Alaska Native organisations, including participatory research on the disappearing sea ice (Meek et al. 2008). Participatory research on reindeer management with the Saami of Norway has helped integrate Saami knowledge and views on environmental change with sustainability science (Tyler et al. 2007).

Monitoring is a major area of collaborative work. The federal government largely monitors climate change in the Canadian Arctic, and there seems to be no formal role for co-management institutions or Indigenous groups. However, Indigenous ways of knowing can be used to produce detailed and insightful monitoring of climate change, while broadening the range of inquiry. As compared to scientific monitoring, which tracks a small number of variables quantitatively, Indigenous monitoring seems to take the opposite approach by tracking a large number of variables qualitatively, similar to fuzzy logic applications (Berkes et al. 2007). Some of the best examples do not come from formal co-management but from the long-standing Arctic Borderlands Ecological Knowledge Co-op on the Alaska-Yukon border, where local observations are often followed up by government monitoring (Eamer 2006; Kofinas 2002). These examples highlight the potential of collaborative models and co-management institutions to contribute processes, knowledge, and networks to support adaptive capacity and learning.

Drawing on experiences in several Arctic communities, Arctic Bay among them, Diduck et al. (2005) highlighted the connections between institutions and learning: the role of comprehensive land claims as a catalyst for greater collaboration and participation of Arctic communities in decision making; the need for co-management actors to experiment and be open to some degree of risk; and the willingness to integrate different knowledge sources as a basis for testing assumptions and modifying worldviews. Yet many questions remain and are the focus of on-going work, such as determining the specific attributes and practices of Arctic co-management institutions that enhance learning opportunities and build adaptive capacity.

Conclusion

Inuit are careful observers of environmental change, and have developed diverse adaptations and strategies in response to change and uncertainty. Selected adaptive responses to the Arctic environment include mobility, detailed environmental knowledge and skills on the land, sharing mechanisms, and flexibility with regard to harvesting and group size. Coping responses to climate change include adjustments in subsistence activities, such as changing when, where, or how hunting and fishing take place. Some responses are under stress or increasingly unavailable because the environment is becoming harder to "read" as it becomes more variable and undergoes an increasing pace of change. Hence, there is a need for additional approaches to make Arctic communities better able to adapt to further climate change.

Co-management institutions have developed since the 1980s and may be particularly important in this regard. Our current work examines whether the FJMC and the NWMB can function in a way that allows strategies to be developed and assessed collaboratively. The ability of these institutions to build adaptive capacity is not a given but a hypothesis. There is a temporal element here; it takes time to rework unequal and unjust institutionalised relationships. Hence, our analysis is policy-oriented and forward-looking, rather than dwelling on past injustices. Adaptive strategies, coping mechanisms, and evolving co-management arrangements can work together; they are not discrete items. Coping mechanisms can evolve into adaptive responses, if assisted by linkages that encourage collaboration and learning. Successful adaptation by the Inuit to the new environmental dynamic will include knowledge acquired or co-produced through co-management institutions. Inuit knowledge is not static. The Inuit themselves will find the best ways of adding to and applying such knowledge, thus giving new shape to *Inuit Qaujimajatuqangit*.

Based on a growing body of experience in the Arctic, institutional conditions for adapting, coping, and learning through change are emerging. These conditions include 1) need for institutional flexibility and options (i.e., different management tools, education strategies) to respond to diverse conditions; 2) provisions for training and capacity building across all levels (local, regional, national), given that no one group alone will have all the resources or skills to deal with increasing variability; 3) key leaders or champions (individuals and/or organisations) that ensure lessons and experience in one setting are transmitted across levels (horizontal and vertical); 4) openness of actors to share and draw upon a plurality of knowledge systems and sources; and 5) enabling policy (e.g., land claims agreements) that explicitly supports collaboration and commitment to experimentation and learning through change. These and other conditions, as they unfold in specific places, can make Arctic communities better able to cope with variability and build adaptive strategies for change (Armitage et al. 2009).

The role of Inuit-centred institutions and institutional processes in creating the conditions for learning and building adaptive capacity is not yet fully articulated, and more detailed studies are needed to examine how these linkages through co-

management actually work. As well, it is unclear how the attributes and experiences that build capacity in one area (e.g., wildlife management) can be transferred to another (e.g., climate change). Given that the largest temperature increases are projected to occur over the Polar region, building the capacity of Arctic peoples to cope and adapt is an issue of cultural, economic, and political importance. This challenge must be met through appropriate use of co-management, knowledge, and learning.

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