Generation and Transmission of Environmental Knowledge and Land Skills in Adaptation to Climate Change in the Arctic

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Abstract

This paper outlines the rationale and objectives of research that documents and describes how environmental knowledge and land skills are generated and transmitted among Inuit in an arctic community, and investigates how this influences adaptation to climate change. Previous research on vulnerability to climate change in the Arctic identified environmental knowledge and land skills as key determinants of adaptive capacity to climate change risks that affect subsistence hunting and the transmission of environmental knowledge and land skills as important in conditioning future adaptive capacity. However, Inuit have expressed concern that as a result of rapid societal changes, the traditional modes of knowledge generation and transmission by which Inuit have developed the skills to hunt safely and successfully no longer function effectively. This is cause for concern among Inuit as climate change is expected to continue into the future with further implications for ecosystems and livelihoods.

Introduction

Research on climate change impacts, vulnerability, and adaptation in the Arctic has documented Inuit sensitivities to climate change risks and how they are already having to adapt (Huntington and Fox, 2005; Pearce et al., 2006; Ford et al., 2008; Pearce et al., in review). In the context of subsistence hunting, changes in seasonal patterns, precipitation, sea ice dynamics, and weather variability have affected the health and availability of some species of wildlife important for subsistence and have exacerbated risks associated with hunting and travel. These climatic changes are expected to continue into the foreseeable future, with further affects on Inuit in the social, economic, and political sectors of arctic communities (Anisimov et al., 2007). Despite this knowledge we are limited in our understanding of the factors and processes that influence adaptation within the broader context of Inuit society. Climate change research has tended to focus on the physical impacts of climate change with limited, if any, attention being given to the interactive effects of climate change with other social, cultural, and economic processes which influence how communities experience climate change and which condition adaptive capacity. This gap in research constrains our ability to fully understand the adaptive capacity of Inuit to future climate and societal changes.

Inuit have a long history of coping with and adapting to the arctic environment. This ability to adapt is associated with a profound knowledge of the arctic ecosphere, which affords Inuit 'dynamic' and 'flexible' use of the environment and its resources. Inuit knowledge of the environment is a collective and dynamic social memory that represents both competence on the land and in skills and technology necessary for safe and successful hunting, and an asset base from which adaptation actions can be made to deal with routine and novel events (Davidson-Hunt and Berkes, 2003; Ford et al., 2006a). Hunters manage the risks associated with hunting by taking precautions, knowing what equipment to take along and what preparations to make, and being sensitive to critical signs in the environment and knowing how to respond. Knowledge of animal behaviour enables hunters to adapt to changing animal numbers and location. Recent changes in climatic conditions, however, are challenging Inuit knowledge and understanding of the environment. In light of observations and exposure to a diversity of experiences and conditions, Inuit knowledge is evolving to take into account new risks and to facilitate adaptation. An important component of adaptation to current and projected future climatic

changes is the transmission of Inuit knowledge among community members, specifically younger generations (Freeman, 1996).

Traditionally, environmental knowledge and land skills were developed and transmitted through on-the-land education or "people's practical engagement with the environment…" (Ingold and Kurttila, 2000 in Berkes and Jolly, 2002), and from listening to and learning from elders and other experienced individuals. However, some Inuit are concerned that the traditional modes of intergenerational knowledge generation and transmission by which Inuit have developed the skills to hunt safely and successfully no longer function effectively (Condon et al., 1995; Takano, 2005). Younger generation Inuit are spending considerably less time involved in subsistence activities beyond organized land-camps and occasional hunting trips but comparatively more time engaged in formal education and wage employment. The rate of climate change coupled with the dramatic social change already proceeding in arctic communities raises questions about the adaptive capacity of Inuit to respond to projected future climatic changes.

A doctoral research project is currently underway to address this research need. The research goals are to document and explain how environmental knowledge and land skills are being generated and transmitted among Inuit in the case study community of Ulukhaktok, Northwest Territories (NWT), Canada and to identify if there is a relationship between environmental knowledge transmission and Inuit adaptive capacity to deal with climate change. The central hypothesis is that the traditional modes of environmental knowledge generation and transmission are not functioning as they were in the past and some skills and knowledge important for safe and successful hunting have been lost among younger generations. This has implications for exposure-sensitivities and for adaptive capacity to deal with projected future climate change. This hypothesis has been formulated based on research that addressed vulnerability to climate change in arctic communities, including preliminary work in Ulukhaktok. This paper outlines the rationale for this research by providing background information on climate change vulnerability and adaptation in the Arctic, adaptive capacity, and knowledge and skills transmission among Inuit. The nature and significance of anticipated results are discussed in the context of adaptation planning for climate change.

Climate Change, Vulnerability, and Adaptation in the Arctic

Research on climate change, vulnerability and adaptation in arctic regions is rapidly expanding in response to the growing evidence that the global climate is changing and the already documented and anticipated future affects on the arctic environment and Inuit livelihoods (see McBean, 2005; Anisimov et al., 2007). The main response to concerns over climate change has been to seek reductions in greenhouse gas emissions to 'mitigate' changes to the climate system. However, it is recognized that even under the most aggressive control measures, current greenhouse gas emissions commit the Earth to some degree of climate change requiring communities, regions, and nations to undergo some level of adaptation (Klein et al., 2005; Hare and Meinshausen, 2006). Adaptation to climate change is recognized as an important policy issue by international institutions, including the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 1992) (see Article 4.1b and 4.1e), the Arctic Council (ACIA, 2005), the Government of Canada (Lemmen et al., 2008), territorial governments (GN, 2003; GNWT, 2008), arctic communities (Nickels et al., 2006), and indigenous organizations (NTI, 2001). Planning to adapt to climate change requires knowledge of the nature of vulnerability in terms of who and what are vulnerable, to what stresses, in what way and the capacity of the system to adapt to new conditions (Wheaton and Maciver, 1999; Smit et al., 2000; Turner et al., 2003). There are several conceptual models of vulnerability, sustainability, resilience, and natural hazard and risk management and many have common elements (Flax et al., 2002; Turner et al., 2003; Ford and Smit, 2004; Schroter et al., 2005). Given the formal recognition of 'vulnerability' in the UNFCCC, Canada's national climate change assessment, and the recent IPCC Scientific Assessment Report the research being discussed employs vulnerability and its constituents, exposure-sensitivities and adaptive capacity, as central concepts.

Past research on climate change impacts and adaptations has often focused on modeling hypothetical adaptations in response to specific future climate change scenarios (e.g. IPCC, 2001). Referred to as the 'impact-based approach,' these studies have been conducted at large scales, and focused on long-term changes in average climate conditions (variables most readily available from climate models) for the purpose of quantifying the net impact of climate change (Brooks, 2003). Adaptive capacity, if addressed at all, was defined by a static list of

determinants, and adaptation focused on implementing hypothetical technical measures (Klein et al., 1999). The impact-based approach has improved our understanding of the potential severity of future climate change impacts, but it does not explicitly address adaptation (Jones, 2001). Recognizing this deficiency in knowledge on adaptation, recent adaptation research has drawn on theory from social vulnerability and work in human ecology of natural hazards and risk management to develop an integrated definition of vulnerability. As Smit and Pilifosova (2001) argue in the context of adaptation to climate change, vulnerability is related to the exposure-sensitivity of a system to hazardous climatic conditions and to the adaptive capacity of the system to deal with those conditions. The 'vulnerability approach,' as described in the Arctic Climate Impact Assessment (ACIA) (McCarthy and Martello, 2005) and IPCC (IPCC, 2007b), has been applied at various scales - countries (Brooks et al., 2005), regions (Leichenko and O'Brien, 2002), and communities (Pearce, 2006; Wall and Marzall, 2006; Ford et al., 2008), and to address different research and policy questions. While some research has applied the vulnerability approach to identify and map 'the most' vulnerable regions or members of society (Downing and Patwardhan, 2003; O'Brien et al., 2004), other research has concentrated on identifying, describing, and assessing vulnerabilities and adaptation processes in particular places, not to rank vulnerability, but to help understand why vulnerability exists, and what adaptations are realistic (Smit et al., 2000; Belliveau et al., 2006). This work has shown how vulnerability is affected by the social structures and processes that influence how a community experiences a climatic risk and the ability of the community to respond.

Research addressing vulnerability to climate change in the Arctic has generated an extensive inventory of physical and biological changes in the Arctic, risks and responses, largely drawing on the observations of local people (Nickels et al., 2006). Linkages between climate change and other social, economic, and cultural factors that influence adaptive capacity have sometimes been discussed, and some common determinants of adaptation have been identified Specifically, research has identified Inuit knowledge of the local environment and land skills as a key determinant of adaptive capacity to respond to climate change (Berkes and Jolly, 2002; Ford et al., 2006a). However, research has documented a loss of environmental knowledge and land skills among Inuit youth (Condon, 1995; Takano, 2005). This raises questions about the adaptive capacity of Inuit to respond to future climate change, and the roles that knowledge and skills generation and transmission play in adaptation.

Adaptive Capacity and Inuit

Existing frameworks for evaluating adaptation have limited scope in explaining the full range of pressures that shape adaptive choices. In the case of communities, adaptive capacity is often said to be determined by certain characteristics that influence the propensity or ability to adapt, known as the determinants of adaptive capacity (Parry et al., 1999; Berkhout et al., 2002). For example, according to Bohle et al. (1994), adaptive capacity is based on diverse system endowments, including technology, knowledge, wealth, and socio-ecological attributes. The IPCC Third Assessment Report (TAR) defines adaptive capacity categorically as a function of certain key attributes or features related to indicators of economic wealth, technology, information and skills, education, infrastructure, access to resources, and stability and management capabilities (IPCC, 2001). Yohe and Tol (2002), based on the IPCC definition and determinants, define the determinants of adaptive capacity as: the range of available technological options for adaptation, availability of resources and their distribution across the population, structure of critical institutions and decision-making, human capital, including education and personal security, social capital, including property rights, the system's access to risk-spreading processes, ability of decision-makers to manage information, and the public's perceived attribution of the source of stress. These attributes will differ among regions, communities, and individuals and will vary over time, translating into different capacities to adapt (Cutter, 1996; Adger and Kelly, 1999; Duerden, 2004).

There are varying perspectives on the relationship between adaptive capacity, its determinants, and the process of adaptation itself. One perspective considers adaptive capacity as the *propensity* or *potential* to adapt, not a certainty, which relies upon its underlying determinants. These determinants are usually defined as fixed and static attributes with the socially constructed and variable nature of each of these attributes largely ignored. Further, it is unclear what determines the degree to which a system can exploit its innate or developed capacity. Another perspective focuses on "the realization of adaptive capacity" (Brooks, 2003) or "manifestation of adaptive capacity" as adaptation (Smit and Wandel, 2006). Adaptive capacity is described as a set of resources that represent an asset base from which adaptations can be made. The question is whether or not adaptive capacity will be drawn upon to bring about adaptation, something that depends on a range of uncertain variables (Vincent, 2007). To assess

adaptive capacity we must understand the adaptation process – how adaptive capacity is constituted and how it is translated into adaptation (Smit et al., 2000).

The Arctic is a highly variable environment and Inuit have long known about and coped with this variability. Anthropologists and other social scientists have identified several groups of cultural practices that are considered to be adaptive responses to the changing arctic environment, including mobility and flexibility in terms of group size, flexibility with regard to seasonal cycles of harvest and resource use supported by oral traditions to provide social memory, detailed local environmental knowledge and land skills, sharing networks to provide mutual support and minimize risk, and intercommunity trading (Balikci, 1968; Krupnik, 1993; Freeman, 1996). However, the changes in the Arctic associated with climate change are recent, and how Inuit have responded up to now may not be a reliable indicator of their ability to adapt in the future. Inuit society has undergone rapid societal changes in the past half century, and the availability of traditional adaptive strategies will be influenced by current social arrangements. Inuit adaptive capacity to changing environmental conditions will likely depend in part on their ability to learn and reorganize and in part on culturally available options (Berkes and Jolly, 2002). Some traditional adaptive strategies are clearly no longer feasible, namely mobility and flexibility in terms of group size since Inuit across the Canadian arctic now live in permanent settlements. Other traditional adaptive strategies such as 'flexibility' in terms of harvesting techniques, locations, timings and species sought continue to be an important source of adaptive capacity in Inuit society (Wenzel, 1995; Damas, 2002).

Flexibility is complemented by skills of improvisation and adaptability which have enabled Inuit to cope with and adapt to the frequently changing arctic environment. Rather than trying to predict or plan for the future, Inuit deal with the present and respond to each situation as and when it presents itself (Bates, 2007). Having adequate knowledge of the present is more important than predicting what might happen next as adaptability is a process of continual learning and readjustments. Innovation and improvisation skills are gained through personal experience in the environment, and are transmitted among generations to generate a wealth of flexibly utilized opportunities at any given point in time. Inuit knowledge is dynamic, continually evolving and being updated and revised in light of observations, new experiences, and the incorporation of non-traditional knowledge alongside the traditional (Stevenson, 1996; Berkes, 1999). There is concern among Inuit, however, that younger generations are not

spending enough time on the land and engaged in subsistence activities needed to learn the knowledge and skills essential for safe and successful hunting under changing conditions. Several factors have been identified as affecting Inuit involvement in subsistence activities including access to income to purchase hunting equipment, expansion of the wage sector of the economy, formal education requirements, and changing value systems (Condon et al., 1995). These and other factors have worked to affect some young people's entry into subsistence activities and the generation and transmission of environmental knowledge and land skills.

Knowledge and Skills Transmission among Inuit

The detailed knowledge of Inuit about the local environment, including knowledge of physical and biological processes, is widely recognized (McDonald et al., 1997; Duerden and Kuhn, 1998; Berkes, 1999; Riedlinger and Berkes, 2001). Honed through personal interaction with the environment and from knowledge and skills handed down through generations by cultural transmission, this collective, dynamic, and cumulative social memory represents both competence on the land and in skills and technology necessary for safe and successful hunting, and an asset base from which adaptation actions can be made to deal with routine and novel events. As a reservoir of accumulated knowledge of changing conditions and experiences of adaptation, environmental knowledge and land skills allow 'response with experience' to current climatic risks (Ford et al., 2006a); this enhances adaptive capacity (Berkes et al., 2003).

The generation of environmental knowledge and land skills entails a thorough experience of, and interaction between, human beings and their natural resources (Berkes, 2000). Knowledge and skills transmission can occur through imprinting, conditioning, imitation, active teaching and learning, or any combination of these (Cavalli-Sforza et al., 1982). It may occur between individuals of different generations but within genealogy (vertical transmission), between individuals of the same generation (horizontal transmission), or between genealogical lines (oblique transmission), from one individual to many (one-to-many), or from many individuals to one (concerted or many-to-one) (Cavalli-Sforza et al., 1982; Boesch and Tomasello, 1998). Traditionally, knowledge and skills among Inuit were developed and transmitted through on-the-land education, and from listening to and learning from elders and other experienced individuals. In traditional Inuit education, learning and living were the same

things, and knowledge, judgment, and skill were not separated (Nunavik Educational Task Force, 1992). However, there is evidence that the traditional modes of knowledge generation and transmission are not functioning as they were in the past, particularly for younger generations (Irwin, 1989; Condon et al., 1995; Takano, 2005).

This 'deskilling' is linked to a gradual disengagement of younger generations from the land and subsistence activities, beginning with the settlement of Inuit in communities in the 1960s and accelerating over generations. Disengagement has been linked to several factors: requirements of formal schooling, increased dependence on wage employment, alternative activities (e.g. sports, television, video games), increasing intergenerational separation between young and older generations, new technologies, a decline in the prestige of being a hunter, and the desire among youth to follow 'western' rather than 'traditional' social norms (Condon, 1995; Ohmagari and Berkes, 1997; Ford et al., 2006b). However, research has found that while some knowledge and skills have been lost, some are being transmitted incompletely, and others are new skills that the older generation did not possess (Berkes and Jolly, 2002; Ford et al., 2006b). Two general findings are, that skills tend to be transmitted later in life and incompletely, and there has been a change in the skill sets and kinds of environmental knowledge held and transmitted. Despite these observations few studies have investigated the process of knowledge and skills transmission, and these claims have not been substantiated. With the exception of Ohmagari and Berkes' (1997) case study on the transmission of indigenous knowledge and bush skills among the Western James Bay Cree Women of Sub-arctic Canada, the transmission of environment knowledge and land skills remains a neglected field, in the Arctic, and in research that addresses vulnerability to climate change.

Nature and Significance of Anticipated Results

The discussed research project is significant in that it addresses the processes by which multiple social and environmental factors interact to influence the adaptive capacity of Inuit to changing conditions. Furthermore, it explicitly addresses the generational dynamics that influence adaptive capacity and it engages younger generation Inuit in adaptation research. Several initiatives to help facilitate the generation and transmission of land skills and related environmental knowledge to Inuit youth are underway across the Canadian Arctic. These include, the

introduction of ‘cultural schools’ in Nunavut, community-run land camps designed to teach youth land skills (e.g. Takano, 2005), the Inuvialuit Harvester’s Assistance Program (IHAP) - a financial assistance program aimed at enabling young people to participate in subsistence activities, and classroom teaching tools developed by researchers and communities to introduce students to environmental knowledge and land skills (Aporta, 2006). This research is expected to make a practical contribution to these and other related efforts by documenting what land skills and related environmental knowledge are and are not being successfully transmitted to younger generations, who the key knowledge holders and teachers are, and the modes of transmission that are effective under current social arrangements. Furthermore, by documenting the factors and problems that impede transmission, opportunities can be identified, within current institutions and decision making structures, to help remedy these barriers to learning. This will indirectly support adaptation planning to deal with projected future climate change impacts to subsistence harvesting.

References

ACIA. 2005. *Arctic Climate Impacts Assessment Scientific Report. C. Symon*. *Cambridge University Press. Cambridge.*

Adger, N. and Kelly, P. 1999. Social Vulnerability to Climate Change and the Architecture of Entitlements. *Mitigation and Adaptation Strategies for Global Change* 4, 253-266.

Anisimov, O., Vaughan, D., Callaghan, T., Furgal, C., Marchant, H., Prowse, T., Vilhjalmsson, H. and Walsh, J. 2007. Chapter 15: Polar regions (Arctic and Antarctic). M. L. Parry, O. Canziani, J. Palutikof, P. van der Linden and C. Hanson. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Pg. 653-685. Cambridge, UK: Cambridge University Press.

Aporta, C. 2006. Anijaarniq: Introducing Inuit landskills and wayfinding. Iqaluit, Nunavut, Nunavut Research Institute.

Balikci, A. 1968. The Netsilik Eskimos: adaptive processes. R. Lee and I. DeVore. *Man the hunter*. Pg. 72-82. Aldine, Chicago, Illinois, USA.

Bates, P. 2007. Inuit and scientific philosophies about planning, prediction, and uncertainty. *Arctic Anthropology* 44(2), 87-100.

Belliveau, S., Smit, B. and Bradshaw, B. 2006. Multiple exposures and dynamic vulnerability: Evidence from the grape industry in the Okanagan Valley, Canada. *Global Environmental Change* 16, 364-378.

Berkes, F. 1999. *Sacred ecology: Traditional ecological knowledge and resource management*. Philadelphia: Taylor & Francis.

Berkes, F. 2000. Indigenous knowledge and resource management systems in the Canadian subarctic. F. Berkes and C. Folke. *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. Pg. 98-128. Cambridge, UK: Cambridge University Press.

Berkes, F., Colding, J. and Folke, C. 2003. *Navigating social-ecological systems: building resilience for complexity and change*. London: Cambridge University Press.

Berkes, F. and Jolly, D. 2002. Adapting to climate change: Social-ecological resilience in a Canadian western arctic community. *Conservation Ecology* 5(2), 1-18.

Berkhout, F., Hertin, J. and Jordan, A. 2002. Socio-economic futures in climate change impact assessment: using scenarios as 'learning machines'. *Global Environmental Change* 12(2), 83-95.

Boesch, C. and Tomasello, M. 1998. Chimpanzee and human cultures. *Current Anthropology* 39(5), 591-614.

Bohle, H., Downing, T. and Watts, M. 1994. Climate change and social vulnerability. Towards a sociology and geography of food security. *Global Environmental Change* 4, 37-48.

Brooks, N. 2003. *Vulnerability, risk and adaptation: A conceptual framework. Tyndall Centre for Climate Change Research. Norwich. 20 p.*

Brooks, N., Adger, N. and Kelly, M. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15(2), 151-163.

Cavalli-Sforza, L. and Feldman, M. 1981. *Cultural transmission and evolution: a quantiative approach*. Princeton, NJ: Princeton University Press.

Cavalli-Sforza, L., Feldman, M., Chen, K. and Dornbusch, S. 1982. Theory and observation in cultural transmission. *Science* 218(4567), 19-27.

Collignon, B. 2006. *Knowing Places: The Inuinnait Landscapes, and the Environment*. Edmonton, Alberta: Canadian Circumpolar Institute (CCI) Press.

Collings, P. 2000. Aging and life course development in an Inuit community. *Arctic Anthropology* 37(2), 111-125.

Collings, P. 2005. Housing policy, aging, and life course construction in a Canadian Inuit community. *Arctic Anthropology* 42(2), 50-65.

Collings, P., Wenzel, G. and Condon, R. 1998. Modern food sharing networks and community integration in the Central Canadian Arctic. *Arctic* 51(4), 301-314.

Condon, R. 1995. the rise of the leisure class: adolescence and recreational acculturation in the Canadian Arctic. *Ethos* 23(1), 47-68.

Condon, R., Collings, P. and Wenzel, G. 1995. The best part of life: Subsistence hunting, ethnicity and economic adaptation among young adult Inuit males. *Arctic* 48(1), 31-46.

Cutter, S. 1996. Vulnerability to environmental hazards. *Progress in Human Geography* 20(4), 529-539.

Damas, D. 2002. *Arctic migrants/arctic villagers*. Montreal: McGill-Queens University Press.

Davidson-Hunt, I. and Berkes, F. 2003. Learning as you journey: Anishinaabe perception of social-ecological environments and adaptive learning. *Conservation Ecology* 8(1), 5-26.

Downing, T. and Patwardhan, A. 2003. *Assessing Vulnerability for climate adaptation. United Nations Development Programme. New York City.*

Duerden, F. 2004. Translating climate change impacts at the community level. *Arctic* 57(2), 204-212.

Duerden, F. and Kuhn, R. 1998. Scale, context, and application of traditional knowledge of the Canadian north. *Polar Record* 34, 31-38.

Flax, L., Jackson, R. and Stein, D. 2002. Community vulnerability assessment tool methodology. *Natural Hazards Review* 3(4), 163-176.

Force, N. E. T. 1992. *Final Report of the Nunavik Educational Task Force. Lachine, Quebec.*

Ford, J., Macdonald, J., Smit, B. and Wandel, J. 2006b. Vulnerability to climate change in Igloolik, Nunavut: What we can learn from the past and present. *Polar Record* 42(2), 1-12.

Ford, J. and Smit, B. 2004. A framework for assessing the Vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic* 57(4), 389.

Ford, J., Smit, B. and Wandel, J. 2006a. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. *Global Environmental Change* 16(2), 145-160.

Ford, J., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusujurat, H. and Qrunnut, K. 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal* 174(1), 45-62.

Frank, O. 1979. Estimation of population totals by use of snowball samples. P. Holland and S. Leinhardt. *Perspectives on social networks*. New York: Academic Press.

Freeman, M. 1996. Identity, health and social order. M. Foller and L. Hansson. *Human ecology and health: adaptation to a changing world*. Pg. 57-71. Gothenburg, Sweden: Gothenburg University.

GN. 2003. *Nunavut climate change strategy. Government of Nunavut. Iqaluit. 26.*

GNWT. 2008. *NWT climate change impacts and adaptation report. Northwest Territories Environment and Natural Resources. Yellowknife. 1- 36.*

Hare, W. and Meinshausen, M. 2006. How much warming are we committed to and how much can be avoided? *Climate Change* 75(1 -2), 111-149.

Haythornwaite, C. 1996. Social network analysis: an approach and technique for the study of information exchange. *Library and Information Science Research* 18, 323-342.

Huntington, H. and Fox, S. 2005. Chapter 3: The Changing Arctic: Indigenous Perspectives. C. Symon. *Arctic Climate Impact Assessment (ACIA) scientific report*. Pg. 62-95. Cambridge, UK: Cambridge University Press.

Ingold, T. and Kurttila, T. 2000. Perceiving the environment in Finnish Lapland. *Body & Society* 6, 183-196.

IPCC. 2001. *Climate change 2001: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. J. McCarthy, O. Canziani, N. Leary, D. Dokken and K. White. Cambridge University Press. Cambridge, UK. 1032.*

IPCC. 2007b. *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. Parry, O. Canziani, J. Palutikof, P. van der Linden and C. Hanson. Cambridge University Press. Cambridge and New York.*

Irwin, C. 1989. Lords of the Arctic: Wards of the State. The Growing Inuit Population, Arctic Resettlement and their Effects on Social and Economic Change - A Summary Report. Ottawa: Canadian Arctic Resource Committee. *Northern Perspectives* 17(1).

Jones, R. 2001. An environmental risk assessment/management framework for climate change impacts assessment. *Natural Hazards* 23, 197-230.

Klein, R., Nicholls, R. and Mimura, N. 1999. Coastal Adaptation to Climate Change: Can the IPCC Technical Guidelines be Applied? *Mitigation and Adaptation Strategies for Global Change* 4, 239-252.

Klein, R., Schipper, E. L. and Dessai, S. 2005. Integrating mitigation and adaptation into climate and development policy: Three research questions. *Environmental Science & Policy* 8(6), 579-588.

Krupnik, I. 1993. *Arctic adaptations: Native whalers and reindeer herders of northern Eurasia*. Hanover, New Hampshire, USA: University Press of New England.

Leichenko, R. and O'Brien, K. 2002. The dynamics of rural vulnerability to global change: the case of southern Africa. *Mitigation and Adaptation Strategies for Global Change* 7, 1-18.

Lemmen, D., Warren, F., Lacroix, J. and Bush, E. 2008. *From Impacts to Adaptation: Canada in a Changing Climate 2007. Government of Canada. Ottawa, ON. 448.*

McBean, G. 2005. Chapter 2: Arctic Climate: Past and Present. C. Symon. *Arctic Climate Impact Assessment (ACIA) Scientific Report*. Pg. 22-60. Cambridge, UK: Cambridge University Press.

McCarthy, J. and Martello, M. 2005. Chapter 17: Climate change in the context of multiple stressors and resilience. C. Symon. *Arctic Climate Impact Assessment (ACIA) scientific report*. Pg. 945-988. Cambridge: Cambridge University Press.

McDonald, M., Arragutainaq, L. and Novalinga, Z. 1997. *Voices from the Bay*. Ottawa, Ontario: Canadian Arctic Resources Committee Environmental Committee of the Municipality of Sanikiluaq.

Miles, M. and Huberman, A. 1994. *Qualitative data analysis*. Thousand Oaks, California: Sage.

Nickels, S., Furgal, C., Buell, M. and Moquin, H. 2006. *Unikkaaqatigiit - Putting the human face on climate change: Perspectives from Inuit in Canada.* Ottawa: Inuit Tapiriit Kanatami; Nasivvik Centre for Inuit Health and Changing Environments at Universite Laval; Ajunnginiq Centre, National Aboriginal Health Organization.

NTI. 2001. *Elder's conference on climate change. Nunavut Tunngavik Incorporated. Cambridge Bay, Nunavut.*

O'Brien, K., Sygna, L. and Haugen, J. 2004. Vulnerable or resilient? A multi-scale assessment of climate impacts and vulnerability in Norway. *Climatic Change* 64(1), 193-225.

Ohmagari, K. and Berkes, F. 1997. Transmission of indigenous knowledge and bush skills among the western James Bay Cree women of subarctic Canada. *Human Ecology* 25(2), 197-222.

Parry, M. L., Rosenzweig, C., Iglesias, A., Fischer, G. and Livermore, M. 1999. Climate change and world food security: a new assessment. *Global Environmental Change* 9, 51-67.

Pearce, T. 2006. *Vulnerability and adaptation to environmental change in Ulukhaktok.* MA thesis, University of Guelph.

Pearce, T., Smit, B., Duerden, F., Kataoyak, F., Inuktalik, R., Goose, A., Ford, J. and Wandel, J. (2008). *Travel Routes, Harvesting and Climate Change in Ulukhaktok, Canada.* In: Heininen, L. and Laine, K. (eds). The Borderless North. Pg. 56-64. Oulu, Finland: The Thule Institute, University of Oulu and Northern Research Forum.

Pearce, T., Ford, J., Laidler, G., Smit, B., Duerden, F., Allarut, M., Andrachuk, M., Baryluk, S., Dialla, A., Elee, P., Goose, A., Ikummaq, T., Joamie, E., Kataoyak, F., Loring, E., Meakin, S., Nickels, S., Shappa, K., Shirley, J. and Wandel, J. in press. Community Collaboration and Climate Change Research in the Canadian Arctic. *Polar Research*.

Pearce, T., Smit, B., Duerden, F., Ford, J., Goose, A., Inuktalik, R. and Kataoyak, F. (in review). Living with Climate Change in Ulukhaktok, Northwest Territories, Canada. *Polar Record*.

Riedlinger, D. and Berkes, F. 2001. Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. *Polar Record* 37(203), 315-328.

Schroter, D., Polsky, C. and Patt, A. 2005. Assessing Vulnerabilities to the Effects of Global Climate Change: An Eight Step Approach. *Mitigation and Adaptation Strategies for Global Change* 10, 573-596.

Scott, J. 1991. *Social network analysis: A handbook*. London: Sage.

Smit, B., Burton, I., Klein, R. and Wandel, J. 2000. An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45, 223-251.

Smit, B. and Pilifosova, O. 2001. *Adaptation to Climate Change in the Context of Sustainabile Development and Equity. Cambridge University Press. Cambridge, UK.*

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16(3), 282-292.

Stevenson, M. G. 1996. Indigenous knowledge in environmental assessment. *Arctic* 49(3), 278-291.

Takano, T. 2005. Connections with the land: land-skills courses in Igloolik, Nunavut. *Enthnography* 6(4), 463-486.

Turner, B., Kasperson, R., Matson, P., McCarthy, J., Corell, R., Christensen, L., Eckley, N., Kasperson, J., Luers, A., Martello, M., Polsky, C., Pulsipher, A. and Schiller, A. 2003. A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences* 100(14), 8074-8079.

UNFCCC. 1992. *United Nations Framework Convention on Climate Change. Climate Change Secretariat. Bonn.*

Vincent, K. 2007. Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change* 17(1), 4-7.

Wall, E. and Marzall, K. 2006. Adaptive Capacity for Climate Change in Canadian Rural Communities. *Local Environment* 11(4), 373-397.

Wasserman, S. and Faust, K. 1994. *Social network analysis*. Cambridge, MA: Cambridge University Press.

Wellman, B. 1988. Structural analysis: From method and metaphor to theory and substance. B. Wellman and S. Berkowtiz. *Social structures: A network approach*. Pg. 19-61. Cambridge: Cambridge University Press.

Wenzel, G. 1995. Ningiqtuq: resource sharing and generalized reciprocity in Clyde River, Nunavut. *Arctic Anthropology* 32, 43-6.

Wheaton, E. and Maciver, D. 1999. A framework and key questions for adapting to climate variability and change. *Mitigation and Adaptation Strategies for Global Change* 4(3), 215-225.

Yohe, G. and Tol, R. 2002. Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change* 12(1), 25-40.