Chapter 7
Vulnerability and Adaptive Capacity in Arctic Communities

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7.1 Introduction

Arctic communities face challenges related to changing environmental conditions, including climate change, and their interconnections with dynamic global economic, political, and social systems. Fishermen in Finnmark County, Norway have a viable cod industry because of available stocks and their ability to export their products to markets in the south; yet they are susceptible to changing ocean conditions affecting fish stocks and to shifts in markets and institutional arrangements. Subsistence harvesting by Inuit of seals, whales, and other species is highly influenced by changing habitat conditions and by government regulations and international agreements. Efforts to address climate and other changes in the Arctic involve individuals, communities, and governance institutions that, as the examples above allude, are influenced by local, regional, and global forces. Climate change is exacerbating many existing challenges that Arctic communities face related to health and a variety of social issues, wildlife harvesting and animal husbandry, community and transportation infrastructure, and to resource extraction and other competing land uses. Understanding the ways that climate change affects communities and identifying adaptation options requires a broad assessment of the interrelated stresses that communities are facing.

Interest in the ways that people in the Arctic are affected by climate change and how they can adapt has been echoed by researchers, policy makers, and local and indigenous communities (NRI 2002; Government of Nunavut 2003; AHDR 2004;

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Denmark Ministry of Environment 2004; Kofinas et al. 2005; IPY 2005; Watt-Cloutier et al. 2005). Considerable information is now available on climate change and its physical impacts in the Arctic (McCarthy and Martello 2005; ACIA 2005; IPCC 2007; Furgal and Prowse 2008) including evidence from local observations (Berkes and Jolly 2001; Krupnik and Jolly 2002; Ford et al. 2006; Nickels et al. 2006; Tyler et al. 2007; West and Hovelsrud 2008; West and Hovelsrud 2009, forthcoming). Documentation of how Arctic *communities* are affected and how they might adapt is an emerging but still underdeveloped area of research. The project, Community Adaptation and Vulnerability in Arctic Regions (CAVIAR), comprises a consortium of researchers from across the Arctic under the auspices of the International Polar Year 2007–2008 (IPY 2007–2008) designed to address these research and policy needs.

The chapter begins by outlining the CAVIAR project including the key concepts and terms that define the common analytical framework of the project. This framework provides the context and structure for comparing insights into the nature of vulnerability, including the social–ecological processes that shape adaptation and adaptive capacity. In the following sections, empirical material from CAVIAR cases is used to demonstrate commonalities among the types of challenges faced by Arctic communities and the ways that people have been adapting to these challenges. Despite the differences in location and livelihoods, there are key, recurring vulnerabilities that are being experienced by Arctic communities, including the changing conditions to which people are exposed and sensitive, and the types of adaptive responses undertaken. The final section provides some insights into the nature of adaptive capacity in Arctic communities and factors that may constrain or facilitate adaptation to future changes.

7.1.1 The Community Adaptation and Vulnerability in Arctic Regions Project

The CAVIAR project was founded on a conviction that understanding the ways that communities in the Arctic interact with climatic *and* nonclimatic conditions is essential for identifying areas of existing and potential future vulnerabilities. The project seeks to document how communities experience changing conditions, are affected by them, and adapt to them, as a basis for assessing approaches and prospects for adapting to future changes. CAVIAR aims to generate results that are policy relevant at multiple scales of Arctic governance, such that it may contribute to policy and planning for adaptations to existing and future challenges and risks. The international research endeavor includes 26 case studies being carried out in all eight Arctic countries (see Fig. 7.1). Communities range from inland forestry-dependent communities to Sámi reindeer herders, from remote Inuit communities, to larger "gateway" cities. The process by which case study communities were selected is detailed in Smit et al. (2008). The cases stand alone, but by

Fig. 7.1 CAVIAR case study communities

following a common framework also provide the opportunity for comparison and integration of insights across the Arctic. There are three elements of CAVIAR research: (1) a common framework for all case studies that conceptualize vulnerability and adaptive capacity, (2) an orientation towards community engagement and participatory approaches that actively involve local people in the research process, and (3) comparison of case study findings based on the common framework.

The main components of the CAVIAR framework are summarized in Fig. 7.2. CAVIAR research into the vulnerability of Arctic communities, particularly in light of climate change, involves the assessment of existing exposure-sensitivities, existing adaptive strategies, future exposure-sensitivity, and future adaptive capacity (Ford and Smit 2004; Smit and Wandel 2006; Smit et al. 2008). Vulnerability is understood here as the manner and degree to which a community is susceptible to conditions that directly or indirectly affect its well-being or sustainability. Exposure-sensitivities relate to the susceptibility of people or livelihoods to a stimulus or stress

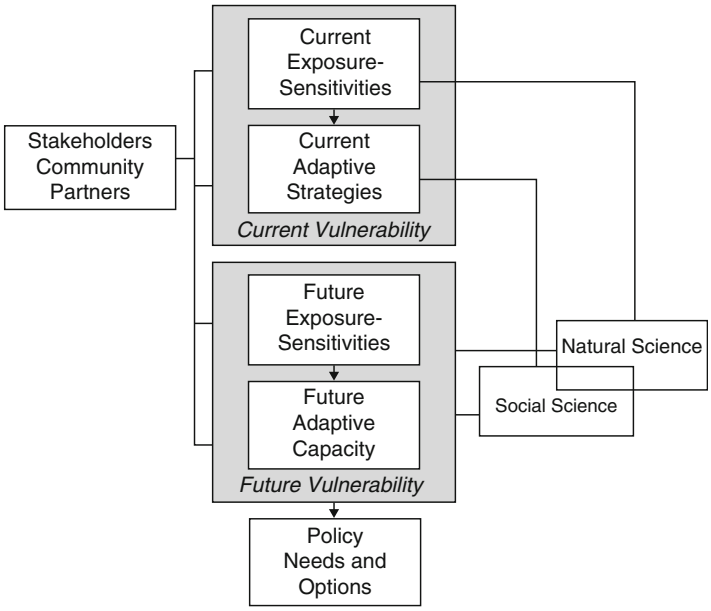

Fig. 7.2 The CAVIAR framework (from Smit et al. 2008)

and are rooted in the community's physical location, social and economic situation, governance, and political systems (Smit and Wandel 2006). There is an explicit understanding within the CAVIAR framework of exposure-sensitivities as dynamic across both temporal and spatial scales. Adaptive strategies are actions, plans, or policies taken by individuals, groups, or governance institutions in response to or anticipation of risks or opportunities (Kasperson and Kasperson 2001; Yohe and Tol 2002; Smit and Pilifosova 2003). Adaptive capacity is a reflection of an individual, group, or community's ability to develop and follow through with adaptive strategies. This conceptualization of adaptive capacity is similar to resilience, in that it attempts to capture a community's ability to adjust to or recover from harm or stress arising from cumulative changes or catastrophic events (Folke et al. 2002; Walker et al. 2002). Both the exposure-sensitivity and adaptive capacity elements of the framework implicitly recognize the central role of institutions, especially governance institutions. Institutional processes influence exposure-sensitivities insofar as they affect the ways in which people live and depend on resources and how people perceive and understand environmental change. Governance institutions are critical to adaptation and adaptive capacity as they provide the necessary frameworks for decision making and action that facilitate or constrain adaptive responses and provide pathways for adaptive capacity to be realized (Agrawal 2008).

Identifying and documenting information under each element of the CAVIAR framework require local input and involvement, as well as information from other sources (Smit et al. 2008; Keskitalo 2004; Pearce et al. 2009a). Community

engagement in the case studies ensures that the research is locally relevant and focused on finding solutions to complex problems of governance and adaptation to environmental change (Duerden and Kuhn 1998; Usher 2000; Berkes et al. 2005; Turner et al. 2003a, b). Information about exposure-sensitivities and adaptive strategies is gained from the experiences and insights of people who are living in Arctic communities. It is expected that meaningful engagement of local people in CAVIAR research will also contribute to adaptive capacity via a community's enhanced understanding of environmental change and increased involvement in governance (Pearce et al. 2009a).

The common analytical framework that guides the CAVIAR research process is detailed in Smit et al. (2008). A principal aim of this coordinated approach is to permit comparison of multiple case studies to identify patterns or common features in the dimensions of vulnerability and adaptive capacity. This chapter draws on results emerging from a selection of CAVIAR case studies to explore common features or contexts of community vulnerability and adaptive capacity.

7.2 Vulnerability Contexts

A host of social, economic, and political changes are taking place in the Arctic, many of which are linked to or compounded by climatic and related environmental change. These interacting conditions threaten and/or present opportunities to communities in complex ways. Adaptations are mostly undertaken in response to past or current threats being experienced at the community level and not in anticipation of future threats. Particular adaptive strategies reflect the application of existing resources and capabilities to solve or manage specific problems that threaten individual or community wellbeing. The following sections are framed around four broad "vulnerability contexts" (Table 7.1), which reflect patterns or similarities in types of exposure-sensitivities and which lead to a variety of associated adaptive strategies in communities across the Arctic. Although the four vulnerability contexts are treated separately below, they are seldom exclusive of one another since each community experiences a mix of exposure-sensitivities and employs a suite of adaptive responses. Adaptive strategies are often in response to more than one "type" of exposure-sensitivity (O'Brien et al. 2004), while multiple exposure-sensitivities may be addressed, in whole or in part, by one adaptive strategy.

7.2.1 Local Culture and Society

Many Arctic communities are experiencing significant cultural and social changes, particularly in light of the influences of "southern" culture and resultant social changes which create stresses and prompt adaptations. Indigenous cultures in the Arctic are well known for their ability to absorb stresses and adapt to change

Table 7.1 Vulnerability contexts and their attributes

Vulnerability contexts	Attributes
Local culture and society	Cultural and social changes are ongoing, driven by "southern" influences and historical legacies, which influence the nature of exposure-sensitivities and the form of adaptive responses. Media, government, technology, tourists, activists, researchers and others play a role in cultural and social changes.
Subsistence-related livelihoods	In communities where harvesting of resources for local consumption is an important part of households and livelihoods. Sensitivity to changes in resource availability because of both physical conditions and institutional arrangements. Implications for income, food security, and culture. Remoteness and cost of living influence nature of exposure-sensitivities and adaptive capacity.
Market-related enterprises	In communities where natural resources are exploited for external markets. Sensitivity to demand and prices in markets, as well as changes in environmental conditions and institutional arrangements. Remoteness and transport costs influence imports and exports.
Community infrastructure	Buildings and roads in some communities at risk due to local biophysical conditions. Sensitivity to biophysical processes and institutional arrangements that influence access to resources for managing risks.

(Csonka and Schweitzer 2004). Over the last century, the pace and scope of change has been unprecedented, creating conditions which often are difficult to manage as familiar, time-tested livelihood practices are altered or replaced. The influence of central governments and governance, new technologies, tourists, media, activists, and researchers all play a role in driving changes in local culture and society. These changes in turn lead to new types of exposure-sensitivities as people and communities adjust to new types of livelihoods and new social settings often accompanied by new or changing governance regimes (Young et al. 2008; Keskitalo 2008).

For Inuit, as well as other indigenous groups in Arctic North America, changes undergone in the past century mark a profound transformation from the semi-nomadic and largely subsistence ways of life which prevailed not more than a few generations ago to settlement in permanent communities and the absorption of many technical, economic, and social elements of western society. The legacy of external influences, including the roles of governments in changing patterns of occupancy, subsistence, and education, continues with "southern" culture, economic expectations, and social norms available through television and other media and widely adopted, particularly by youth. In many respects, Inuit today straddle two worlds: on the one hand seeking to take advantage of a variety of new social and economic conditions thrust upon them and, on the other hand, attempting to maintain traditions and practices essential to both physical and cultural survival. For example, traditional livelihoods have benefited from the adoption of "new" technology such as firearms and motorized transport. But people and communities are also vulnerable to the potential loss or erosion of indigenous language and traditional ecological knowledge which is still critical to survival. The availability

of imported food and supplies from the south reduces the threat of hunger but increases exposure to the negative health effects of substituting traditional country foods for processed southern food (Ford 2010; Furgal and Prowse 2008).

The erosion of traditional livelihood activities, cultural practices, and institutional relationships results not only in spontaneous cultural adaptations to new ways, but also in deliberate adaptive strategies to manage rapid social change. Throughout the Arctic, indigenous groups and communities identify the maintenance of indigenous language and the passing on of traditional ecological knowledge and practices to younger generations as important strategies for countering the distractions and sometimes negative influence of the infiltration of global society. In Russia and Finland there are sharply contrasting perspectives among reindeer herders on the nature of the interaction of indigenous and nonindigenous traditional ecological knowledge. In Russia, a common perspective is that cultural mixing between indigenous pastoralists and ethnic Russians is diluting traditional ecological knowledge about managing and maintaining healthy reindeer herds and as a result may be limiting the range of adaptation options considered by herders. In Finland, on the other hand, Sámi and non-Sámi herders share concerns about the challenges of reindeer husbandry and have found ways to fuse traditional and new knowledge to better respond to challenging environmental and economic conditions. Elders in Fort Resolution, Northwest Territories, and the hamlet of Kugluktuk, Nunavut in Canada report declining youth participation and interest in land-based activities and increased participation in the wage economy outside of the area (e.g., mining employment). From a household economy point of view, particularly among those more accepting of southern values, paid employment is an attractive option to some of the relative hardships of subsistence activities. However, unemployment remains high and has been linked to an increase in a variety of social problems. (Prno et al. 2009, forthcoming). Adaptive strategies include programs to encourage youth to stay in school to enhance their capacity to cope with rapidly changing social and economic conditions. Simultaneously, community and territorial leaders seek to maintain traditional knowledge, skills, and language. Against this backdrop of social and cultural changes, farther reaching institutional changes are emerging through on-going self-government negotiations and outcomes of land claim processes.

It is not only indigenous communities that are vulnerable to the transformation of local culture and society. The Norwegian community of Kjøllefjord is struggling to maintain its identity as a traditional fishing village built around the centuries old Norwegian cod fishery. The local fishing fleet in Kjøllefjord has been declining for several decades, although it has recently stabilized and currently employs around 30% of the municipal workforce (West and Hovelsrud 2008). Environmental and economic conditions are affecting the profitability of the cod fishery but the community is also exposed and sensitive to other changing conditions. For example, the fishing workforce is challenged as older fishers approach retirement and younger members of the community choose to pursue education and other opportunities in urban centers to the south rather than take up a career in commercial fishing. Such demographic and labor-force shifts, which are in themselves

connected to changing social and cultural values, are challenging the social and economic viability of the community. At the same time, these changes open the door for new or modified livelihood opportunities and strategies to adjust and cope with change, such as efforts to connect tourism with fisheries (see Sect. 3.2).

7.2.2 Subsistence-Related Livelihoods

Renewable resources are of critical importance to most Arctic communities, either as part of subsistence or as commodities produced for external markets and in some cases for both. Many communities which depend on the use of resources as part of household livelihoods and food systems are sensitive to changes in resource availability. Resource availability is vulnerable to changes in biophysical and environmental conditions as well as to new or changing institutional arrangements, and social conditions. Subsistence activities are also sensitive to the high cost of living and related aspects of remoteness in Arctic communities which affects both the cost of supplies and access to markets (e.g., furs). The vulnerability of subsistence related livelihoods to these and other interacting conditions has implications for household livelihoods in terms of both income and food security. There are also broader implications for cultural importance of hunting and fishing and other subsistence oriented livelihood activities (Table 7.1).

For example, in most Inuit communities, the harvest of wildlife – fish, whales, caribou, waterfowl – is a key component of household food supply important for healthy diets, community well being, and culture. The practice and role of wildlife harvests are being affected by changing environmental conditions, institutional arrangements, and social and cultural expectations and norms. These different exposure-sensitivities give rise to specific but interdependent adaptive strategies. Changing climatic conditions for example, have triggered changes in the location, timing, and abundance of some species and have affected access to wildlife through changes in ice, snow, and permafrost conditions. People in indigenous communities in North America are adapting to changes in migratory patterns and abundance by shifting the timing and location of hunts and/or substituting one species for another (e.g., Hovelsrud et al. 2008). Where environmental conditions make hunting grounds difficult or dangerous to access, routes may be altered or abandoned entirely. In Igloolik, for example outboard powered boats are replacing snowmobiles as the primary mode of transport to key harvesting areas as ice conditions become more dangerous and less predictable (Ford et al. 2006).

Institutional arrangements that govern or otherwise restrict and control the harvest of wildlife in the Canadian Arctic are on-going and in a state of flux presenting another set of changing conditions to which subsistence livelihoods must adapt. Local management systems (e.g., hunters and trappers associations) are increasingly linked into larger, multi-stakeholder comanagement arrangements with higher levels of government and (in some cases) international interests. Devolution of federal powers to territorial governments, land claims settlements,

and aboriginal self-governance processes also exemplify institutional and governance changes that directly or indirectly affect subsistence livelihoods. Increasingly, indigenous groups have roles in decisions related to the quantity of wildlife that can be harvested, who has access to harvesting grounds, when particular species can be harvested, as well as monitoring of wildlife and programs for supporting harvesters. In the Inuvialuit Settlement Region, for example, community-based Hunter and Trapper Committees (HTCs) work with territorial and federal government agencies to develop recommendations for annual harvesting quotas. The government agencies hold decision-making authority on quotas, but HTC's dispense harvesting tags to individuals in their communities. Comanagement regimes influence exposure-sensitivities insofar as they work across larger temporal and spatial scales than decisions made by individual harvesters. Consequently, they may facilitate and/or constrain options for communities and household subsistence but provide a regionally based governance strategy for controlling and managing stocks (e.g., limits or controls on harvests, protection of calving grounds) which helps to ensure long term viability of subsistence resources.

Societal and cultural changes in Arctic North America have created a variety of conditions which increase the exposure-sensitivities for subsistence related livelihood activities. For the most part, these are not recent changes but the ongoing legacy of European contact and the continued infiltration of "southern" or outside cultural, social, economic, and technological influences. In general the modernization of Inuit life has increased the financial cost of hunting through increased dependence on imported supplies and equipment which in turn depends on employment income. These conditions are of course not new and interact with other elements of Inuit life in complex ways. For example, some communities report declining wildlife resources in close proximity to permanent settlements requiring increased travel to hunting grounds, which increases fuel costs at the same time that it increases exposure to environmental risks some of which are increasing because of climate change (Prno et al. 2009, forthcoming). Alaska provides insights into the cultural practices of subsistence hunting, fishing, and food sharing as a means of addressing vulnerabilities and adapting to changing conditions similar to those being experienced in the Canadian Arctic (Kofinas et al 2005). Communities in rural Alaska (as well as other areas of the Arctic) manage the burden of increased hunting costs and potential risks by depending on highly active and successful harvesters. Instead of all community members attempting to meet household needs individually, communities cooperate with other harvesters for greater efficiency. Community members provide in-kind contributions of fuel, equipment use, or other forms of exchange to so called "super-hunters" (Kofinas et al 2005). In return for the support they receive, these high producing harvesters, attempt to harvest a surplus of game and/or fish which can be shared through community and intercommunity food sharing networks.

In Russia, Norway, Sweden, and Finland, exposure-sensitivities of livelihoods and food security are largely related to the pastoral practices of indigenous Sami reindeer herders. Reindeer husbandry has elements of both subsistence livelihood activity and market related enterprise (Sect. 2.3). Methods are highly adaptive to

annual climate variability and weather, but there is evidence that changing environmental conditions are challenging these communities. In recent years herders have increasingly faced higher costs and loss of livestock due to warmer winters, more frequent freeze-thaw cycles, and heavier, wetter snowfalls that make foraging more difficult and expose herds to higher risks of disease. Adaptive strategies draw upon traditional knowledge and techniques to manage these challenging conditions, such as moving the herd to different foraging grounds. One contemporary response to adverse foraging conditions in Sweden is to bring supplemental feed in by truck, but this option is expensive and not available to all herders (Keskitalo 2008). Market conditions also influence resource management decisions which may enhance or constrain adaptive strategies undertaken in response to environmental conditions (Tyler et al. 2007).

Subsistence related activities, especially in North America, are still an important dimension of community life and contribute, often substantially, to household livelihoods. The infiltration of southern influences, opportunities, and institutions interacts with subsistence practices in complex ways, enhancing some activities but also adding new burdens and costs. Many subsistence activities are vulnerable to changing environmental conditions including climate change, but subsistence is also an important outlet for adaptations to other stressors or changes affecting life in Arctic communities.

7.2.3 Market-Related Enterprises

For reasons of history and geography, natural resource use and local economies are generally more oriented to market related enterprise in the Arctic regions of Scandinavia and northwestern Russia than in North America. Markets and population centers are more proximate, transportation infrastructure more accessible, and trade linkages well established (e.g., Norway: fishing, oil and gas; Finland, Sweden: forestry, reindeer husbandry). Communities along the remote northern coast of Norway, for example, have strong market ties to southern centers and the broader European Union. Some trading relationships such as the stock fish (dried cod) trade between the Lofoten Islands and Italy are centuries old.

The municipality of Norrbotten in northern Sweden provides an example of a relatively remote, culturally diverse region which exemplifies the interplay of exposure-sensitivities arising from social and economic forces (at multiple scales) and changing environmental conditions related to climate change. Examples can be taken for instance from Gällivare municipality in which natural resources such as forestry, reindeer husbandry, and mining have been traditionally important. These sectors are susceptible to pressures of globalization (e.g., increasing foreign competition, volatile markets, and changing technology) on the local economy and society in much the same way as other Arctic communities in the study. First, the region is an economic periphery; hence beyond employment, most of the economic benefits of primary industries (forestry, mining) are exported along with the

resource (Marchak 1995). Second, the region is susceptible to social demographic trends that see increasing numbers of young people leaving the region for southern urban centers (Persson and Ceccato 2001). Governance changes that took place mostly in the 1990s were intended to increase local autonomy and decision making especially with respect to local economic development by placing more responsibility in the hands of local and regional authorities; nevertheless, up to the end of the century the region was largely a recipient of state support and the public sector remained the largest single employer (Persson and Ceccato 2001). This broad context of exposure-sensitivities is being aggravated by climate change which is having its most notable effect on the forestry and reindeer husbandry sectors. Forestry is susceptible to disruption of harvesting schedules and transportation resulting from the effects of longer, warmer autumns and increasing winter thaws which translate directly into increased costs. Reindeer husbandry is also exposed to the impacts of climate change on transportation although the sensitivity is different due mostly to scale. Reindeer husbandry is particularly susceptible to conditions which (a) affect animal health (e.g., limits to winter grazing caused by winter thaw-freeze events and heavier snowfalls, reduced water availability from natural springs in summer, and increased insect pests which stress animals), and (b) cause disruption and increased difficulty during key migration times in spring and autumn when animals need to be moved between summer and winter feeding grounds (Keskitalo 2008). Current adaptive strategies such as importing forage supplements are costly and not available to all herders. Other adaptive strategies are more political in nature, involving Sami indigenous rights and resource governance issues including state interventions. Forestry strategies to contend with and adapt to long term changes in growing season – a potential opportunity to realize higher productivity – rest more with the decision making and planning capacity of industry and government rather than with local communities. As such governance institutions and market conditions are and will continue to play a key role in determining adaptive strategies and future adaptive capacity of forestry in these regions (Keskitalo 2008).

Enterprises built around tourism play an increasingly important role in many communities. Tourism helps counter declining contributions from the fishing sector in northern Norway or to supplement household income in Inuit communities in Arctic Canada and among Sami reindeer herders in Sweden. Tourism enterprises are vulnerable to a host of conditions ranging from external market forces and governance related constraints to the environmental impacts of climate change. Trophy hunting of the polar bear in northern Canada is an example of the often complex linkages between traditional, subsistence based activities, market related enterprises, and external cultural values and governance regimes. Currently, polar bears provide a lucrative source of income for Inuit guide outfitters catering to the U.S. and European markets. But this particular enterprise, itself an adaptation to past changes to Inuit life, is especially susceptible to foreign and international governance regimes. The recent listing of the polar bear as ‘threatened’ under the U.S. Endangered Species Act prevents hunters from bringing any polar bear parts into the U.S. (Platt 2009) which will substantially reduce income for certain Inuit communities. Should the polar bear be subsequently listed by CITES

(the Convention on International Trade in Endangered Species of Wild Fauna and Flora) it would become illegal to transport polar bear parts to any of the convention's 175 signatory nations, all but eliminating this particular source of income for certain Inuit communities in the Canadian Arctic.

Institutional changes led by international governance regimes and changing social values have had a different effect in Húsavík. This community in the north east of Iceland has long depended on commercial whaling and fishing as the foundation of local culture and economy. Whaling in Iceland is subject to changes in international governance regimes embodied in the International Whaling Commission. The exposure-sensitivity of the community to global scale governance institutions is set against a backdrop of other internal and external stressors including changes that have taken place in the Icelandic fisheries management system involving privatization through Individual Transferable Quotas (ITQ) of formerly common property resources. Fishing has seen erratic growth in production in recent decades at the same time that it has declined as a proportion of GDP and in importance to community livelihoods (Eythórsson 2000; Iceland Ministry of Fisheries and Agriculture 2009). A global moratorium in 1985 brought an end to commercial whaling and changes in social values and pressure from domestic and international environmental organizations superseded the end of whaling for consumptive use in Iceland by 1990 (Donovan 1989; Einarsson 2009). The community of Húsavík, however, has responded creatively over the past two decades and developed a successful whale watching sector which has subsequently formed the basis of a bourgeoning local tourism industry. The biophysical resource remains but the enterprises which whales support have changed. The adaptive strategies undertaken in Húsavík, particularly with respect to the whale watching industry, and also through adaptation in the fishery (e.g., changing fleet structure and conversions of former fishing and whale hunting boats into whale watching vessels) to respond to multiple pressures have been relatively effective (Einarsson 2009). The financial crisis that hit Iceland in 2008 has put the adaptive capacity of the community and nation to an unprecedented test and, in the short term at least, any concerns about the potential impacts of climate change may pale by comparison.

While connections to external markets and cultures engender exposure-sensitivities for some communities, these connections also provide a means of acquiring information and technology useful to the formulation of adaptive strategies. Norwegian fisheries-based communities, such as Kjøllefjord in Finnmark County and villages in the Lofoten Islands, have long histories of managing climatic variation and its ongoing impacts on local resources (particularly the influence of the Gulf Stream on cod and other marine species). Over the last several decades, stocks have fluctuated or declined as fish move to new spawning and feeding grounds in response to fishing pressure and to changes and variation in ocean conditions. Governance of fisheries has likewise changed in an effort to manage multiple stresses on the fishery. Fishermen have adopted new types of fishing vessels, navigation equipment, and fishing equipment. Efficiency measures in processing and shipping fish are ongoing to help compete in the global market place. Flexibility remains a key attribute of market related enterprises in order to

navigate multiple, ongoing changes in market dynamics, resource availability, internal and external governance regimes, and environmental change. Flexibility to react quickly to changing conditions, to make use of multiple types of knowledge and technology, flexibility to pursue new opportunities or new markets, and flexibility to think about and plan for uncertainty are increasingly important hallmarks of current adaptive strategies and future adaptive capacity (West and Hovelsrud 2009, forthcoming).

7.2.4 Community Infrastructure

Across the Arctic there is a broad range of exposure-sensitivities and adaptations related to infrastructure and the built environment. Types of exposure-sensitivities are influenced by landscape features the physical processes at work, and the types of infrastructure involved. Communities in northern Norway, Sweden, and Finland are generally well connected via transportation (air, road, rail, or ferry), energy, and communications networks, disruption of which creates vulnerabilities for community livelihoods and local enterprises that are dependent on the flow of supplies into the community and to the export of local goods produced for external markets. In many communities in Greenland and Arctic Canada, livelihoods are vulnerable to interruptions of the flow of goods, services, and clientele which may only be able to reach communities via infrequent barge service, ground transport that may only be available on winter ice roads or other seasonal routes, or by expensive air transport. Generally, the more remote a community is the more important subsistence activities are to household and community adaptive strategies.

In addition to the exposure and sensitivity of transportation or 'external' infrastructure linking them to the south, whether in Scandinavia, Greenland, or Canada, communities are also subject to the impacts of various biophysical processes and landscape hazards on 'local' infrastructure. Many of these processes are being compounded or accelerated by climatic changes taking place in the Arctic.

The community of Tuktoyaktuk is literally perched on the north coast of Canada. Residential and community buildings have been erected on a narrow peninsula that is highly exposed to the weather, waves, and ice of the Arctic Ocean. The shoreline is especially susceptible to erosion due to the prevalence of gravel and ice in the peninsula upon which the community is built. Adaptive strategies have included some shore protection and relocation of buildings that were at immediate risk. There are indications that the combined effects of reduced sea ice cover and increased storm activity brought about by climate change will increase rates of erosion (Johnson et al. 2003; Manson and Solomon 2007). There are concerns that the community may eventually have to be moved but the urgency of when this might occur is influenced more by external political and economic factors than the immediate physical threat. At present, the municipal government is focused on reinforcing existing shoreline protection measures. Whereas physical adaptations take place within the community, the capacity to follow through with many

adaptive strategies is dependent on political will and funding that must be accessed from territorial and federal governments. The case of Tuktoyaktuk illustrates that adaptive strategies are sometimes more a function of institutional processes and governance than a direct response to local or physical need.

In the case of Clyde River, Nunavut, community safety, local roads, building foundations, and water lines are at risk from a variety of landscape hazards associated with hydrology, melting permafrost, and slope stability. Adaptive strategies such as upgrades to waste water management, thermo-siphons, and adjustable building foundations (e.g., engineered pilings) are in use but not universal. Hazard mapping (Fig. 7.3) has identified zones of low, medium, and high risk areas for infrastructure in the community. Increased knowledge and understanding of local landscape conditions emerging from the combined efforts of community members and researchers is facilitating efforts to manage landscape risks as they unfold and will enhance the capacity of the community to plan and prepare for increased hazards in the future.

The ability of communities to take action based on scientific knowledge and monitoring of environmental change or based on direct experience with landscape hazards and infrastructure damage is constrained by the lack of resources to carry out remedial or adaptive actions. Repair, upgrade, or replacement of infrastructure typically involves the infusion of external resources and is dependent on applicable governance regimes and the associated political or institutional will to undertake specific actions and adaptations. Risks to infrastructure associated with permafrost degradation and erosion are predictable risks to significant investments. As with the case of Tuktoyaktuk, whether or not strategic, proactive adaptation takes place lies not with the physical or technical need but within the decision making processes and resource allocations of often remote governance institutions.

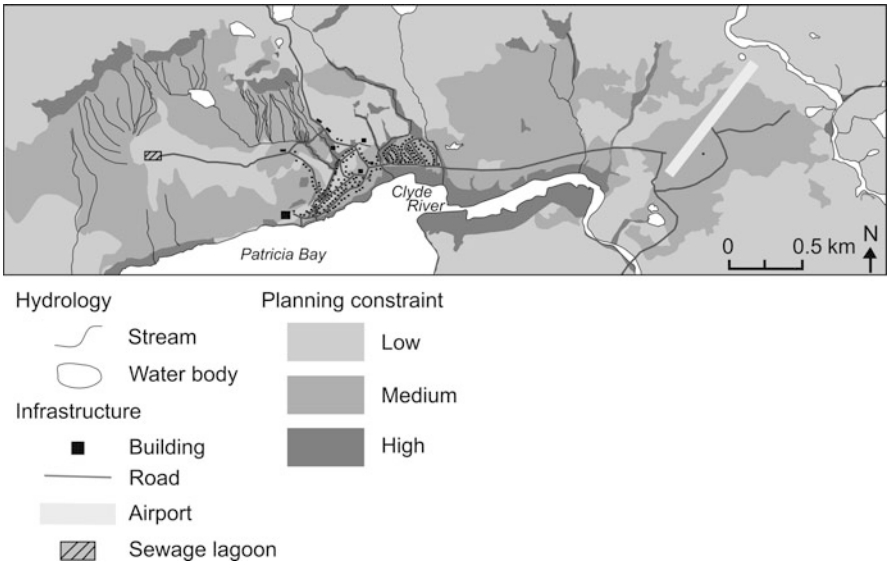

Fig. 7.3 Composite landscape constraint map of Clyde River (Trevor Bell 2009)

7.3 Adaptive Capacity

Adaptive capacity embodies the ability of a system to cope, recover, or adapt to any hazardous conditions (Smit and Pilifosova 2003; Smit and Wandel 2006) without losing options for the future (Folke et al. 2002). Adaptive capacity also relates to the ability of a system to expand its coping range in the process of responding to hazardous conditions (Adger 2006). Social factors which contribute to the adaptive capacity of a social–ecological system include society's access to resources as well as the ability of members of a community to come together and act collectively when faced with threats (Adger et al. 2004). In the context of community, adaptive capacity refers to the totality of local resources and capabilities plus external linkages and networks that may be used or accessed to respond to or cope with change or stress. Definitions of the variables or dimensions of adaptive capacity vary but include financial capital, equipment, technology, and communication networks, human capital including appropriate skills and knowledge, social resources, including social capital and related networks and relationships, and institutional capacity (see Matthews and Sydneysmith this volume) such as governance processes and structures that support decision making. Institutions, especially governance institutions, in effect make adaptive capacity real (Adger 2003) by providing both a context and a process through which adaptations can take place. Institutions shape how risks are perceived and responded to at both individual and collective levels, they play a central role in how local resources may be activated and mediate potential external interventions (Agrawal 2008).

Adaptive capacity is context (some would say "hazard") specific and varies often considerably across time and space (Brooks 2003; Yohe et al. 2003). It is best understood in terms of the various features and conditions through which it is shaped (Smit and Wandel 2006) including not only how it is constituted but also the processes that translate into adaptation (Brooks 2003). The factors determining such processes depend on the nature of the "systems that are adapting" including, for example, questions of scale (i.e., households, communities vs. nation states) (Brooks 2003; West and Hovelsrud 2008). The interaction of different systems across different scales is also an important condition of adaptive capacity. So while the primary focus may be on local conditions that affect adaptive capacity, consideration of broader social, political, and economic forces must also form part of the analysis (Brooks 2003; Vincent 2007).

7.3.1 Local Capacity in a Global Context

Adaptive strategies are examples of adaptation in practice exemplified primarily by local responses, plans, needs, or (re)actions implemented at the community scale. Although adaptation occurs locally, the capacity to adapt is the product of conditions, resources, and other variables that flow from multiple scales. The CAVIAR

case studies illustrate the multiscale nature of adaptive capacity and have identified the interplay between the local and the global as an important dynamic in the adaptive capacity of Arctic communities. Local leadership and knowledge, social networks, economic resources (e.g., human, financial, equipment), and local institutions are components of capacity which operate at a local scale. But adaptive capacity is also influenced by forces and events such as policy decisions and market fluctuations that originate or take place thousands of miles away. Adaptive capacity in Arctic communities may be enhanced by new knowledge, ideas and resources, or technology from southern sources, but there may also be negative effects. This section highlights several dimensions of community adaptive capacity in the context of global forces and influence, including the changing nature of traditional ecological knowledge, the limitations of local capacity, and the importance of linkages to external resources and higher order governance institutions.

The socio-cultural transition that has taken place with indigenous communities throughout the circumpolar north has altered the character and context of their adaptive capacity. Cultures are clearly not static but in the Arctic, as with indigenous peoples in many parts of the world, there is a relatively sharp divide between the nomadic hunters characteristic of Inuit society prior to contact with Europeans and contemporary Inuit communities. Notwithstanding the infiltration of institutions and practices from the south, traditional ecological knowledge (TEK) remains prominent in discussions of livelihoods and the survival of indigenous peoples in North America and Europe. In the context of managing and adapting to the rapid pace of climate change in the Arctic, TEK is an important element of local adaptive capacity. Traditional ecological knowledge provides a framework through which peoples with a long history in a place interpret, manage, and make use of the biophysical world around them. In the past, TEK was the foundation of household and community capacity to cope with environmental variation and manage the natural resources upon which their livelihoods depend. One concern about the influence of western science and other outside social and economic forces is that TEK is gradually displaced or at the very least, altered and its value to ensuring people's survival diminished. From this perspective, the erosion of TEK is a loss of adaptive capacity. From another point of view, the transformation of TEK through its interaction with "outside" forces is a *source* of future adaptive capacity.

Regardless of whether the future of TEK is cast in pessimistic or optimistic terms, two points emerge from the CAVIAR case studies. First, TEK is an important feature of northern identities and is widely viewed in Arctic communities as a defining characteristic of being an indigenous person (e.g., Notzke 1994; Cruikshank 2005). The social and cultural benefits that result from the maintenance, or in some cases the rebuilding, of TEK enhance adaptive capacity in both direct and indirect ways. For example, TEK is essential to being able to obtain food from the land and sea which has direct benefits for household livelihoods and community wellbeing. Less obvious, TEK provides a practical link to cultural values, traditions, and meanings that act to counter negative social and economic conditions such as unemployment/idleness and substance abuse. Many communities identify the maintenance of Inuit, Cree, Sámi, and other indigenous languages as a key

element of helping to ensure the survival of traditional ecological knowledge and its continued contribution to the capacity of indigenous communities in the Arctic. Language anchors culture, allowing it to shift or swing with changing conditions while maintaining vital connections with history and place.

Second, given that TEK is, by definition, experiential (Notzke 1994), new forms of knowledge and understanding are continually absorbed into the lexicon of local knowledge and capacity, whether introduced by outsiders in the form of western science and technology or brought about through exposure to new patterns of climate and environmental conditions. Traditional ecological knowledge is thus an evolving understanding of change, defined in terms of how it incorporates and *not* how it excludes external or "nontraditional" sources of "knowledge". Guns and snowmobiles, Geographic Information Systems (GIS), and radio equipment are examples of new technology and knowledge that have been readily adopted into traditional livelihoods. Such technology adds new dimensions and opportunities to the pursuit of livelihoods altering the application and thereby the nature of TEK in its contemporary setting. The evolution of contemporary TEK is not limited to the embrace of modern technology and gadgets. The inclusion of TEK in governance regimes, such as the various comanagement agreements which have been developed in northern Canada, institutionalizes the linkage between TEK and western science based models of environmental management.

The incorporation of technology, resources, and services from "external sources" into local indigenous community life enhances adaptive capacity to the extent that it reduces certain risks. The increasingly widespread use of GPS by Inuit in Canada is a recent example of technology that reduces the risk of being out on the land. Originally adopted for convenience and safety, GPS is increasingly important in the context of climate change as weather patterns, ice formation, and other "natural" signals traditionally used for navigation become less predictable. Similarly, the increased availability of foods from the south has altered food security and enhanced the capacity of communities to avoid the threat of starvation or extreme hunger when wildlife is scarce. On the other hand, of course, there are well documented negative health effects associated with increasing dependence on highly processed foods (Furgal 2008). The relationship between adaptive capacity and traditional ecological knowledge is complex although experiences from the CAVIAR project indicate that capacity is generally enhanced by drawing on both traditional and other sources of knowledge.

While arctic communities are adaptive in many respects, they face considerable forces of stress and change. The combined effects of climate change and general social and economic transformations are accelerated by the forces of globalization and stretch community resources and capacity. Adapting to or managing environmental change, specifically climate change, is not necessarily a top priority for local leaders often already overcommitted to other concerns. The stock of people and resources available are typically absorbed in managing day to day community or municipality issues such as care of the elderly, education of youth, employment and economic opportunities, and maintenance of infrastructure. There is a scarcity of capacity to take deliberate or planned action, especially in smaller communities.

But there is considerable knowledge and concern about environmental change. Enhancing adaptive capacity thus hinges on the articulation of local resources with external sources of support which largely arrive through the mechanisms and institutions of regional and national governance. For example, the town of Ivalo in the Inari region of Finland has strengthened its capacity to predict, manage, and respond to flooding of the Ivalo River as a result of closer ties between local officials and higher level agencies. These ties have been strengthened in the wake of a major flood in 2005. In the past institutional blockages and cultural differences between "more traditional" local leaders and the "technocratic bureaucracy" in Helsinki represented a major limitation on coordinated emergency response in the past. Removal of such barriers and improved cooperation and communication between the different levels of government reinforces the point that the linkages between local institutions (including local leadership) and external governance regimes are an important dimension of adaptive capacity.

7.3.2 Flexibility and Diversity

Flexibility and diversity of institutions, livelihood practices, economic activities, and other social processes are important, linked dimensions of adaptive capacity in Arctic communities. Arctic residents often cite their experiences with harsh environmental conditions and remoteness from major governance and economic centers as evidence of their self-reliance and ability to cope with difficult conditions and change. The knowledge and skills accumulated and passed down between generations include understanding of the need to be flexible in response to adverse conditions and unforeseen hazards or opportunities. Survival may depend on the capacity to shift activities, take a different route, adopt a new technology or revert to a technique or process used in the past. Diversity is also important in the sense of having a diversity of options, a choice in the course of action or response to stress and, subsequently, the ability to be flexible. The factors that enable and/or constrain flexibility and diversity, whether within a particular livelihood or among various, perhaps competing livelihood strategies have yet to be clearly defined, although interesting examples have emerged from some CAVIAR case studies that illustrate these important dimensions of adaptive capacity.

Inuit hunters in North America for example, readily substitute one species of game for another or shift entirely from reliance on terrestrial game to fishing or marine mammals to ensure an adequate supply of food for their households and community. They have both flexibility in terms of the skills, knowledge, and willingness to change their hunting practices, and they have options as to what, where, and when to hunt or fish. The need to make these choices, to alter and adapt hunting practices or travel routes, is increasing as climate change impacts (a) availability of game, for example, through changes in the patterns/timing of migration and (b) access to hunting grounds, for example, through changes in snow and ice conditions and the declining predictability of weather. Many such decisions and

adaptations are predicated on traditional ecological knowledge, however, as Arctic communities begin (or in some instances continue) to respond and adapt to the changing climate, TEK may be insufficient to help guide effective adaptations unless TEK itself adapts (Wenzel 1999). Will such knowledge be able to absorb and make sense of new conditions such as new wildlife migration patterns, less predictable ice and weather conditions, altered fishing grounds, or more challenging extreme events? Or will cultural models of weather and climate, (Kempton et al. 1995) especially of variability and cycles, trap communities in assumptions based on past experience and the belief that things will return to "normal" at some point in the future. Across the Atlantic, Sámi reindeer herders in Finland offer a slightly different perspective on the theme of flexibility, TEK, and adaptive capacity. The Sámi identify shifts in how "old" and "new" knowledge are used together and how the application of "old" knowledge has changed to incorporate the "new".

In contemporary times, introduction of new technologies and wage employment have added to the suite of choices and opportunities for community members to generate a livelihood from multiple sources. But it is unclear as to whether or not this sort of change represents an increase in the flexibility of livelihoods and, subsequently, an increase in adaptive capacity. On the one hand, the opportunity for paid work reduces dependence on subsistence activities and its associated risks. On the other hand, as youth spend their time in schools and adults engage in paid employment, they have less time to be out on the land (or ice) and fewer opportunities to make use of the diversity of resources that were available for their ancestors.

Along the northern coast of Norway, flexibility and diversity take on a different meaning in the context of adaptive capacity as compared to Inuit communities in Canada. The linkages between subsistence activities and livelihoods are less prevalent if not absent altogether. In the Norwegian context, household income and local economies have for centuries been built around the cod fishery, and local knowledge and identity are inextricably linked to such activities. In recent decades, however, the fishery has been in decline along much of the coast as a result of over fishing, international competition and, most recently in relation to climate change. Fishermen from the Lofoten Islands and in communities such as Kjøllefjord along the Finnmark coast report that flexibility is a critical component of being able to make a living from the sea. Flexibility includes the ability to respond to changes in resource availability, to invest in new technology, and to adjust fishing practices or activities to comply with changing regulations. Fishermen report that in the past the versatility and flexibility of their industry enabled them to adapt to variations in climate and cyclical shifts in the resource-base. Today environmental variability remains but the challenges fishing communities face are compounded by factors which constrain or limit traditional forms of flexibility. Increasingly, the diversity of livelihoods and/or local economies is a critical dimension of community adaptive capacity. Again, the town of Kjøllefjord is illustrative. Here local leaders have championed diversification by embracing the construction of a wind farm on the hillside above the town; they have pursued investment in the renewal of the agricultural sector, and supported the development of coastal cultural, and tourism initiatives connected to traditional fisheries. These efforts to diversify the local

economy are being pursued to fill the void created by outmigration and declining employment in land-based fish processing, and to create opportunities in other arenas that attract people to stay or even to migrate to the community (West and Hovelsrud 2009, forthcoming). It is within the human and social resources of people that many of the elements of adaptive capacity lie. The capacity of communities to adapt to changing conditions will be maintained or even enhanced to the extent that they are able to process the implications of change and maintain flexible livelihoods built around diverse activities and sources of sustenance and income.

7.4 Conclusions

This chapter has drawn upon case studies in the Arctic as part of the international IPY 2007–2008 CAVIAR project. The CAVIAR project offers a framework to conceptualize and investigate local conditions that contribute to defining vulnerability and adaptive capacity from community and scientific points of view. The CAVIAR framework provides a common language and set of concepts that are being deployed in the field by researchers in eight countries to facilitate efforts to compare and synthesize experience from a diverse set of social and ecological circumstances and disciplinary approaches. Project investigators are involved to varying degrees in participatory approaches and community engagement which aims to link research to community issues. The preceding discussion is thus a snap shot of ongoing processes of shared learning and research, some of which, in addition to providing new knowledge of the processes of vulnerability and adaptation, might enhance the adaptive capacity of the communities with which we work. The chapter has focused on a discussion of key emerging findings with respect to community vulnerability and adaptive capacity in Arctic regions.

Arctic communities are vulnerable to changing conditions in several ways. Local culture and social processes in Arctic communities have experienced significant changes because of the influence of social, political, and economic forces from the south. These pressures continue and in some respects are increasing in the context of globalization and climate change. In places where subsistence activities continue to be an important part of household livelihoods, communities are vulnerable to environmental conditions and institutional arrangements which may limit or affect the reliability and/or their access to resources vital for food security. Communities dependent on market-related enterprises through the exploitation of natural resources for external markets are sensitive to fluctuations in the resource availability, price, demand, and competition from other sources. High transportation costs related to remoteness increases their exposure to negative market pressure. Arctic communities have limited but critical local infrastructure upon which they depend, some of which is especially vulnerable to biophysical processes and increasingly influenced by climate change. The vulnerability of these communities

is often exacerbated by institutional arrangements that limit access to resources or otherwise constrain options and opportunities for adaptation.

The ability of communities to deal with these ongoing changes is related to a wide range of factors some of which emerge from local conditions, knowledge, and capacity, while others stem from the influence of institutional arrangements and governance regimes operating at local, regional, national, and global scales. Some of these factors enhance adaptive capacity in complex and interactive ways such as the role of traditional ecological knowledge in conjunction with western science and technology. Similarly, the flexibility and diversity of Arctic livelihoods and local economies is a key dimension of adaptive capacity in communities throughout the circumpolar region. As climate change and economic development increase pressures on key Arctic natural resources, local capacity on its own will likely be overwhelmed. Governance and the institutions through which it is delivered will be critical to successful adaption and survival of Arctic communities. Adaptive capacity will likely be high where local institutions are strong, have broad community support and good linkages to external governance institutions with an interest in and commitment to Arctic community well-being.

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