Grete K. Hovelsrud
Barry Smit
Editors

Community Adaptation and Vulnerability in Arctic Regions

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UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE

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This book is dedicated to Bob Corell for paving the way, for his never-ending inspiration and support, and for his unique ability to include us all, across cultural and scientific backgrounds.

Preface

The 'Year' That Changed How We View the North

This book is about a new theoretical approach that transformed the field of Arctic social studies and about a program called International Polar Year 2007–2008 (IPY) that altered the position of social research within the broader polar science. The concept for IPY was developed in 2003–2005; its vision was for researchers from many nations to work together to gain cross-disciplinary insight into planetary processes, to explore and increase our understanding of the polar regions, the Arctic and Antarctica, and of their roles in the global system. IPY 2007–2008, the fourth program of its kind, followed in the footsteps of its predecessors, the first IPY in 1882–1883, the second IPY in 1932–1933, and the third IPY (later renamed to 'International Geophysical Year' or IGY) in 1957–1958. All earlier IPY/IGY have been primarily geophysical initiatives, with their focus on meteorology, atmospheric and geomagnetic observations, and with additional emphasis on glaciology and sea ice circulation. As such, they excluded socio-economic disciplines and polar indigenous people, often deliberately, except for limited ethnographic and natural history collection work conducted by some expeditions of the first IPY. That once dominant vision biased heavily towards geophysics, oceanography, and ice-sheets, left little if any place for people, that is, the social sciences and the humanities, in what has been commonly viewed as the 'hard-core' polar research.

Enter IPY 2007–2008, the product of today's views on the role of science in addressing the issues of major societal importance, such as global climate change, ecosystem diversity, human wellbeing, as well as knowledge, public education, and representation. IPY 2007–2008, a program co-sponsored by the International Council for Science (ICSU), World Meteorological Organization (WMO), and supported by dozens of science agencies, governmental bodies, and international institutions had to grapple with these new realities. No wonder that the terms 'social sciences,' 'polar residents,' and 'human dimension' have been inserted in many IPY documents and that new IPY, unlike its three predecessors, features special field focused on local communities and human wellbeing in the polar regions. That very inclusion of social sciences and polar residents, particularly indigenous people, is widely viewed as one of the key achievements of this IPY and a hallmark of its program. The IPY 'Polar people' field now includes more than 30 international science projects and numerous educational and outreach initiatives. This book is a product of one of them called *Community Adaptation and Vulnerability in Arctic Regions* (CAVIAR, IPY project #157).

Though Arctic social/human scientists have participated in a number of previous large interdisciplinary initiatives, starting from the International Biological Program, IBP in 1964–1974, the IPY 2007–2008 social science field was, by far, the largest and the most diverse coordinated program in its history. In addition, the science scope of this IPY was remarkably different, since dedicated efforts were made to include synthetic cross-disciplinary studies and projects exploring the human dimension, ecological diversity, and community and ecosystem health. For the first time, physical, natural, social and humanistic scientists and local community-based experts worked together under a common multidisciplinary science framework. This new form of cross-disciplinary collaboration marks an extraordinary advance in our perception of the complexities of the polar regions and of the importance of synthesis, knowledge integration and data sharing in the understanding of processes that affect our planet.

IPY 2007–2008 also created the momentum to advance collaborative international research to a new level. All IPY projects include partners from several nations; dozens of local communities and all major organizations of polar indigenous people participate in IPY studies. Many projects are, in fact, coordinated programs created by many local efforts, with teams of researchers in several areas working under a concerted agenda, though with individual national planning and funding. CAVIAR, with its almost two dozen teams partnered with communities across eight polar nations, is a model of such collaboration, a micro-IPY in itself. A project of such magnitude and complexity involving dozens of researchers would have never happened had it not been for IPY. It marks a tremendous advance in social science scope and planning; it also helps bring social research structurally closer to the complex organization of modern natural sciences and interdisciplinary programs across the polar regions.

The CAVIAR project is a striking example, as well as a key driver of yet another important transition in polar research during the IPY era. Back in the 1990s, in the first decade of complex modeling of climate change, the prevailing way of thinking was to place 'humans' (not 'people' or 'communities') at the bottom of charts and diagrams illustrating the long chain of connections within the ecosystem. It was assumed that people would automatically respond to this or that projected impact that would be felt reverberating through the system, according to a certain computer-simulated scenario. Early climate change models were built that way; the task of social scientists was viewed as mainly to emphasize the 'human dimension,' that is, the ways those prospective impacts could be mitigated or moderated by certain strategies or services to the affected populations. The concepts of *vulnerability*, *resilience*, *adaptive capacity*, and *adaptation risks* were of course known, but they had not been integrated nor even connected to the studies of modern environmental change.

This is where we are to be grateful to the scientists of the CAVIAR project and to their colleagues, as they literally worked hard to turn that old vision on its head. Their approach called *community-based vulnerability assessment* starts with the interests and observations originating from local communities, not from physical scientists and their complex projected models, and it proceeds bottom-up to identify potential future exposures, that is, new conditions or risks that communities may face or are already facing. This new line of thinking operates with many more parameters of change, both physical and socio-cultural, and it puts much greater emphasis on what people see on the ground. In fact, the entire analysis literally starts from what people currently view as new or increased risks in their ecosystem and it proceeds to *future* risks, sensitivities, and prospective adaptive strategies only after the current adaptations are researched and understood. That puts to the forefront people's observations of what they see happening around them *today*, something that many physical scientists routinely discount as 'anecdotal evidence' compared to their satellite images, instrumental records, and complex computer simulations.

We invite the readers to make a virtual journey throughout sixteen case studies of the 'CAVIAR universe,' from Northern Scandinavia (Norway, Sweden and Finland) to Arctic Russia to Canada to Greenland, with a special purpose in mind. These case studies in community vulnerability and adaptation have been researched and are now presented under a common methodology. As such, they offer comparative and compatible stories of how people in twelve regions across the North deal with the set of realities brought by today's environmental change. This virtual journey offers a glimpse to a remarkable variety of people's responses, based upon their traditions, way of life, community political strength, local histories, and many other factors that are not on the modelers mind, at least not yet. Unlike climate scientists who often talk about the need to 'downscale' their global models to reflect local realities, the CAVIAR team argues that we should go in a different direction, that is, bottom-up. There is no simple way to judge which approach comes closer to describe future challenges to Humanity facing the warming planet, but the jury is still out. We hope the readers will agree.

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Without the CAVIAR research teams throughout the Arctic we would not have had a book and we are grateful for your hard work in and out of the field, and for your willingness to share your results in this book. Equally we would not have had a great research programme or a book without our local partners in the more than 26 communities throughout the Arctic. Not all of these are represented here, but the ones not included are also gratefully acknowledged. Without the interest, enthusiasm, insights and willingness to share, teach and open your homes to all of us, CAVIAR would not have existed. We thank you all and hope that with this book we give something back.

This book has been a fundamentally collaborative effort, and we are most thankful for the dedicated editorial assistance and astute commentaries of Mark Andrachuk, Jeremy L. White, and anonymous reviewers. In addition Bob van Oort, Stine Rybråten and Laura Fleming have provided invaluable support. Working with Margaret Deignan at Springer has been a great experience. She has provided solid, timely and superb support throughout the process. We thank all our collaborators for their spirit and interest.

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Chapter 1
Introduction to the CAVIAR Project and Framework

Barry Smit, Grete K. Hovelsrud, Johanna Wandel, and Mark Andrachuk

Abstract This chapter provides the research rationale for the CAVIAR case studies presented in this book. The CAVIAR project is a response to the incontrovertible need for analysis of how community vulnerability is shaped by various forces across the Arctic region. The research incorporates multiple sources of knowledge which enhances our understanding of what makes communities vulnerable or resilient to change. The goals of this project are; the application of a common analytical framework to identify the social and environmental factors, processes and interactions that shape the vulnerability of a selection of communities across the Arctic; to compare results across communities in order to identify commonalities and transferable lessons; and to improve our understanding of the relationships between localised vulnerability and multiple scales of decision-making related to adaptation. The theoretical basis and conceptual framework described in this chapter provides a structure for the remainder of chapters in this book.

Keywords Climate change · Arctic · Framework · Interdisciplinary · Community-based

1.1 Introduction

The Arctic is experiencing rapid changes in both socio-economic and environmental conditions. The Arctic Climate Impact Assessment (ACIA) projected unprecedented climate change for Arctic regions, and changes have already been documented by instrumental records and local and indigenous observations (Gearheard et al. 2006; Huntington and Fox 2005; McBean et al. 2005). The Arctic Human Development Report (AHDR 2004) demonstrated that

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Arctic peoples are susceptible to changing environmental conditions, and are already having to adapt. Among climate related changes are projected increases in temperature and precipitation, reductions in sea ice extent, and increases in the frequency and magnitude of hazardous conditions, including those associated with permafrost thaw, sea ice stability, and increasing exposure to storms along the Arctic coasts (Barber et al. 2008; Christensen et al. 2007; Couture et al. 2002; Johannessen et al. 2004; Kattsov and Kallen 2005; Sou and Flato 2009; Zhou et al. 2009). In turn, the presence, location, and distribution of animal species and vegetation dynamics will be affected (Anisimov and Fitzharris 2001; Derocher et al. 2004; Huntington and Moore 2008; Post and Forchhammer 2008). These changes have major implications for ecosystems and for people's livelihoods and wellbeing, and they will occur in the context of ongoing social, cultural, economic, and political transformations in northern communities (Anisimov et al. 2007; Fenge 2001; Ford and Smit 2004; Rattenbury et al. 2009).

While there is general agreement that changes in climate, and associated conditions, are likely to pose significant challenges for communities, the nature of these risks and the most effective means of dealing with them are poorly understood (Duerden 2004; Ford and Smit 2004; McCarthy and Martello 2005; Nuttall 2001, 2005; Schneider et al. 2007). The Community Adaptation and Vulnerability in Arctic Regions (CAVIAR) project was designed with the intent to document the particular environmental conditions to which local communities are sensitive; to assess the strategies employed to deal with changing conditions in communities across the Arctic; to identify the conditions that facilitate or constrain the adaptive capacity or resilience of Arctic communities; and to integrate information from local and indigenous knowledge with scientific knowledge to understand the nature of opportunities to better deal with changing conditions. Insights into sensitivities, vulnerabilities or resilience of communities generated through CAVIAR research are uniquely positioned for comparison across Arctic countries and are well suited for decision-makers and policy in Arctic regions.

The pan-Arctic CAVIAR consortium works in separate teams in all eight Arctic countries and is unified in terms of its rationale, goals, conceptual basis, analytical approach, integrative methods, structure for comparison and synthesis, and practical applications. This introductory chapter is based on the CAVIAR framework document (Smit et al. 2008), which was an outcome of the proposal document 'A Pan-Arctic Research Framework' (February 2006) and the CAVIAR Consortium Workshop (Oslo, October 2007). In this chapter we outline the CAVIAR framework that provided a context for case studies carried out during International Polar Year 2007–2008 (IPY), many of which are presented in this book. Through the use of a common framework, CAVIAR case studies have enabled an *ex ante* inter-community comparison and synthesis across the circumpolar north. The assessment of vulnerabilities and adaptations has been identified as a priority area for research by policy makers, local and indigenous communities, the Arctic Climate Impact

Assessment (ACIA), the Arctic Human Development Report (AHDR), and the International Polar Year planning committee (ACIA 2005; AHDR 2004; Government of Nunavut 2003; Rapley et al. 2004; ICARP 2005; NRI 2002; Watt-Cloutier et al. 2005). In particular, the following have been identified as important research questions:

- What aspects of people's livelihoods are at risk, and to what?
- What conditions are problematic for people and the ecosystems on which they depend?
- What changes can be accommodated by existing ways of life?
- What is the ability of local communities to manage changing conditions?
- What local and external factors influence vulnerability and in what ways?
- What are the critical thresholds of adaptability or resilience?
- How do social, cultural, economic, and political processes operating at multiple scales affect sensitivity to climate change and adaptive capacity?
- What is the effectiveness of adaptive strategies across the Arctic?
- How do conditions affecting communities and their adaptive capacities vary among communities?
- What can be done to enhance community adaptability?
- How can lessons be shared among Arctic communities?

CAVIAR has responded to the need for developing and applying a framework that analyses how vulnerability is shaped by various forces or drivers across scales from local to global. The research incorporates multiple sources of knowledge to enhance understanding about what makes communities vulnerable or resilient to change (Ford et al. 2008; Huntington 2000; Laidler 2006; Pearce et al. 2009; West and Hovelsrud in press). CAVIAR was designed to address the need for identifying practical opportunities to enhance communities' adaptive capacities, or to promote their wellbeing or sustainability.

1.2 Goal and Objectives of CAVIAR

The underlying purpose of CAVIAR is to better understand how Arctic communities are affected by environmental changes in order to contribute to the development of adaptive strategies and policies. The broad goal of the CAVIAR research program is to enhance the theory, empirical understanding, and practical application of processes that shape adaptation and vulnerability in communities across the polar region by:

- further developing the concept of vulnerability (e.g. Chapin et al. 2004; Smit and Pilifosova 2001; Turner et al. 2003; Tyler et al. 2007) and refining an integrative interdisciplinary research framework for vulnerability studies (e.g. Huq and Reid 2004; Keskitalo 2004; Kruse et al. 2004; Polsky et al. 2007; Smit and Wandel 2006),

- applying the framework to a selection of communities across the Arctic region to identify the social and environmental factors, processes and interactions that shape differential vulnerability and adaptive capacity,
- comparing results among Arctic communities to identify commonalities and transferable lessons, and
- improving understanding of interrelations between local vulnerability and decision-making related to adaptation, across multiple scales from local to international.

CAVIAR research is more than data collection or monitoring of change; it involves interdisciplinary integration and collaboration with Arctic community partners, in order to characterize vulnerabilities or risks, to document the processes and forces that facilitate adaptation or management of risks, and to identify and evaluate means to improve the capacity of communities to adapt to changing conditions. By undertaking studies in communities in all of the Arctic countries, using a common research framework and consistent methodologies, the program is able to compare results and synthesize findings across the circumpolar north.

1.3 Research Strategy

The research program has been undertaken by an international interdisciplinary team, representing all the Arctic nations. The team has built upon existing research initiatives, operating independently in their local (case study) applications, but with common goals, concepts, research framework and consistent methodologies. The comparison and integration is based on the case studies. Team members, along with stakeholder representatives, partner agencies and organizations and local communities, implement the CAVIAR research program. The main components of the CAVIAR program are outlined in Table 1.1.

1.3.1 Theoretical Basis and Core Concepts

Recent research in the human dimensions of global change and natural hazards communities has noted the importance of locally grounded, context-sensitive assessments (e.g. Flax et al. 2002; Smit and Wandel 2006; Stephen and Downing 2001). Although actions on adaptation are taken at scales from individual to national, community-based assessments are a necessary step to formulating effective strategies to address climate-related challenges in Arctic regions.

Several conceptual models of community sustainability, resilience, risk and vulnerability have common elements (Flax et al. 2002; Ford et al. 2006; Schröter et al. 2005; Turner et al. 2003). Given the importance of climate change in Arctic regions, and the formal recognition of vulnerability in the United Nations

Table 1.1 Main components of the CAVIAR program

Conceptual framework	Develop a conceptual framework for community vulnerability, including the role of exposures and sensitivities to multiple stresses and the adaptive capacities or resilience of communities.
Methodological approach	Refine a common methodological approach that is stakeholder-based, systematic, and draws upon traditional and local knowledge and scientific knowledge in order to document exposures and adaptive capacity or resilience (and their broad determinants) of selected communities in a consistent fashion.
Case studies	Establish procedures for case study selection and implementation of community case study vulnerability assessments with northern collaborators across the Arctic region.
Comparison and integration	Develop and implement a process to compare and integrate results from the case studies for a pan-Arctic assessment of community vulnerability and adaptability.
Policy relevance	Application to policy and decision-making relating to community adaptive capacity, by ensuring that the research scope and approach substantively include institutions and governance structures.
Outreach	Incorporation of on-going, substantive stakeholder engagement and partnerships so that outreach is an integral feature of the vulnerability assessment.

Framework Convention on Climate Change (UNFCCC) (Smit and Wandel 2006), CAVIAR employs the term 'vulnerability' as its central concept. CAVIAR is interested in the overall wellbeing or sustainability of communities and their susceptibility or vulnerability to changing conditions. *Vulnerability* refers to the manner and degree to which a community is susceptible to conditions that directly or indirectly affect the wellbeing or sustainability of the community. This includes the sensitivity of the ecosystem of which the community is part or on which the community depends. Use of this term does not presume that communities are particularly vulnerable – some may have relatively few or no vulnerabilities. Vulnerability is a function of both exposure-sensitivity and adaptive capacity (Adger and Kelly 1999; Ford and Smit 2004; Keskitalo 2008; Kofinas 2005; Smit and Pilifosova 2001; Turner et al. 2003; Wisner et al. 2004).

Exposure-sensitivity refers to the manner and degree to which a community is sensitive to and exposed to particular conditions, forces or stresses. It reflects the likelihood of climatic conditions or natural hazards occurring in a particular place over time relative to the situational characteristics of places and people which make them sensitive to the conditions or hazards. Thus, exposure-sensitivity is related to the susceptibility of people or livelihoods to a stimulus, the dynamics of the potential stimulus or stress, and the community's physical location, social and economic situation, governance and political systems. *Adaptive capacity* is closely related to resilience, and reflects an individual's or community's ability to cope with, adjust to or recover from an exposure-sensitivity. It is reflected in the community's management of current and past stresses, its ability to anticipate and plan for future change, and its resilience to perturbations.

A community's exposure-sensitivity and adaptive capacity reflect the interactions of local conditions and forces at *broader scales*. Broader environmental processes have local manifestations, and the particular local conditions which shape exposure-sensitivities and adaptive capacity reflect regional, national and global social and economic conditions or trends. The functional relationship between exposure-sensitivity and adaptive capacity will vary by context and over time, but it is understood that vulnerability is positively related to exposure-sensitivity and negatively related to adaptive capacity.

1.3.2 Methodological Framework

1.3.2.1 The CAVIAR Approach

The core research has been undertaken in case study communities. Communities were selected to cover a range of Arctic communities, and their selection was influenced by characteristics such as size, location, economic orientation, social-cultural composition, and practical matters such as access, local interest or research fatigue.

By employing a common framework and consistent methodologies, the case study data or insights are in a comparable structure. Such consistency is a necessary requirement for case studies to be included in the *ex ante* comparative meta-analysis (Rudel 2008).

One of the intentions of the research is to be beneficial and relevant to the communities, and to achieve this a close collaboration with community members and local stakeholder is critical (e.g. Gearheard et al. 2006; Hovelsrud and Winsnes 2006). The methodological approach for empirical studies of community vulnerability case studies is based on the principles outlined in Berkes and Jolly (2001), Ford and Smit (2004), Keskitalo (2004), Lim et al. (2004), Pearce et al. (2009) and Turner et al. (2003). The methods applied in CAVIAR are based on the notion that a crucial aspect of a vulnerability assessment is to gather and understand the stakeholders' own information on their exposure-sensitivities and adaptive capacity. The open, unbiased and active engagement of the community representatives and other stakeholders is a necessary element of this approach. This process is consistent with the principles of community based adaptation (CBA) and 'bottom-up' approaches increasingly used in vulnerability and adaptation projects (Dessai and Hulme 2004; Flax et al. 2002).

Background information on the community, also known as baseline information, is compiled and preliminary interviews with key stakeholders are undertaken to gain an appreciation of the broad features of the community that relate to vulnerability. If the case study needs to be limited in scope due to community size or some other consideration, the scoping phase may also identify major areas of interest or focus. This phase also establishes likely sources of information (records, documents, measurements, individuals, etc.), the procedures for selection of collaborators, and the community-appropriate processes for data gathering from the community members (sampling, interview schedule, focus groups, etc.). Depending on the community and, in some cases, the sector or group in the community, interviewees include residents, practitioners, administrators or group representatives.

Each case study broadly addresses a common set of questions:

1. In what ways are communities affected by changing conditions? i.e. How, to what and why are people and their livelihoods sensitive or vulnerable to changing environmental conditions (including climate) and socio-economic conditions?
2. How do communities adapt to changing conditions? i.e. What are the processes, players and strategies of adaptation or adjustment, by individuals, groups and organizations, and what are the implications of those adaptations?
3. What changes can be expected in the future in the conditions that affect the community? i.e. In what ways are the vulnerabilities likely to change in the near and long-term futures, and how will they affect the community?
4. What capacity does the community have to deal with future changes? i.e. What resources, institutions, and types of capital does the community have to adapt, what adaptive opportunities are there, and what are the limits and constraints on adaptation, on all levels?

In this book, a 'vulnerability case study' refers to an investigation of the four sets of questions for a particular case community. Some case studies focus on a selection of these questions, rather than cover all four sets. The CAVIAR framework is designed to:

- guide the analysis of these four central questions in each case study,
- provide a structure for reporting case study results, and
- facilitate comparison and integration across case studies.

Once a community has been selected, community members have endorsed the process, and local collaborators are familiarized (or trained) with the approach and methods, data gathering begins. The information sought relates to the items contained in the four research questions, usually in sequence from top to bottom in Fig. 1.1.

Figure 1.1 illustrates the relationships between the main categories of information needed in a vulnerability assessment of any community. The four core components of the framework correspond to the four questions presented above. The researchers first document past and *current exposure-sensitivities* (question 1) in order to identify the conditions that are of particular relevance to the community. They also (often concurrently) identify and document the *adaptations strategies and processes* (question 2) to describe the ways in which communities have managed the conditions to which they are exposed and sensitive. Together, these characterize current vulnerability. They also provide

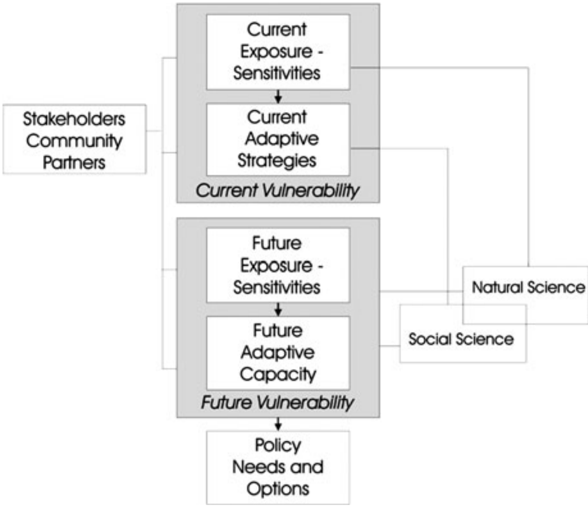

Fig. 1.1 Key elements in the CAVIAR vulnerability assessment framework

the basis for estimating future vulnerability (both *future exposure-sensitivity* and *future adaptive capacity*). This involves assessing the likelihood of changes in the conditions that are pertinent to the community, drawing on scientific projections of change in natural and social systems and characterizing the scope and limits to adaptive capacity. The assessment of future risks and prospects for adaption provides the basis for collaboratively identifying *policy needs and options* and the initiatives that could enhance the capacity of the community to adapt.

1.3.2.2 Current Exposure-Sensitivities

The first research task is to document the conditions and processes that represent *current exposure-sensitivities*. This requires the identification of forces, stresses or processes which affect the livelihoods or wellbeing of people in the community. It also requires providing evidence of the exposure-sensitivities and explaining the processes and trends that underlie them. Some conditions may be important for the whole community, while in other cases only as a certain group or sector may be sensitive to a change or condition.

For example, a community may be sensitive to changing sea ice conditions (timing of freeze-up and break-up, thickness, etc.) because of its dependence on sea ice for traveling to hunting grounds (providing food, livelihood) and the related cultural importance of participating in subsistence activities. Changes in the timing of freeze-up and break-up and less predictable ice conditions (e.g. thickness, location of leads and polynyas) introduce greater hazards for snowmobile travel. This exposure-sensitivity reflects the nature of the community's society and economy, technology, the physical location and the dynamics of ice, ocean and atmosphere. This exposure-sensitivity can be described by outlining the underlying processes, interactions among these processes, and evidence of these. This might include documenting the degree to which community members are reliant on hunting and on sea ice, and where current travel routes are. Insights may be gained from data on the contribution of animals hunted on (or via travel on) sea ice to the food and incomes of residents, and data on changes in sea ice dynamics and travel conditions (e.g. snowmobile vs. sled dogs). Relationships between sea ice dynamics and climate and ocean conditions could also be documented, as could changes in alternative food sources and the wage economy which affect the role of hunting in Inuit livelihoods. Other exposure-sensitivities might relate to resource development, wildlife dynamics and availability, or infrastructure and permafrost changes. It is important to note that, to ensure comparability between studies in CAVIAR, exposure-sensitivities are identified empirically from insights and evidence gathered in the community – they are not assumed a priori or derived arbitrarily or exogenously from hypotheses or models.

1.3.2.3 Current Adaptive Strategies

The second research task (Fig. 1.1) is to identify and assess the *current adaptive strategies* or management responses employed in the community to deal with the identified exposure-sensitivities. This involves describing and documenting the ways in which individuals, groups or organizations have adapted to the conditions and changes that have affected them. Understanding adaptations entails outlining the specific adaptive measures or actions and the broader processes of which they are part.

For example, adaptations to sea ice exposure-sensitivities might include changing travel routes, changing timing or location of hunting, seeking alternative income sources, securing alternate food sources, and employing remote sensing data and VHF radio and global positioning systems (GPS). These strategies can be documented and explained relative to the employment situation, available transportation technologies, food preferences, etc. In addition, adaptation strategies can be assessed according to their consequences and implications. For example, securing alternative food sources in a diet requires financial resources to purchase southern foods at the store, and these in turn have implications for people's health. Changing the timing or location of hunting may not be an option for people with insufficient time flexibility (due to participation in the wage economy) or who are unable to cover additional costs of equipment or fuel.

Information on aspects of current vulnerability (exposure-sensitivities and adaptive strategies) are acquired from community residents directly and from secondary sources such as existing documents, reports and other inventories, and data from community-based monitoring. In addition, researchers draw on instrumentally gathered records of conditions pertinent to the livelihoods and lives of community members (e.g. long-term climate records and federal population censuses). Information from these sources is integrated by interpreting the data relative to the research questions – that is, what is known about exposure-sensitivities and adaptive strategies.

1.3.2.4 Future Exposure-Sensitivities

The collection of information about future vulnerability (Fig. 1.1) involves both scientific assessments and community insights. Ideally, estimates of *future exposure-sensitivities* (question 3) will be determined via two routes. First, the conditions identified as current exposure-sensitivities are analyzed in order to estimate possible changes, trends or probabilities of change in those conditions in order to describe the ways in which existing exposures might change in the future. Second, possible changes in conditions from climate (or other) scenarios are specified regardless of whether they were identified by community residents or not. For example, future changes in travel opportunities relative to sea ice conditions could be estimated by applying scientific knowledge of ice dynamics to trends and expectations in break-up and freeze-up time relative to harvesting areas and travel routes. This could include insights from climate change scenarios linked to cryosphere and oceanographic models applied to the locations and conditions of importance a community. This analysis of future exposure-sensitivities could also include using information from those who rely on sea ice, such as hunters, to identify the types and degrees of change in ice conditions that residents would find particularly problematic, thus providing specific targets for probability estimates of future ice conditions.

1.3.2.5 Future Adaptive Capacity

The future exposure-sensitivities are then examined in terms of the community's *future adaptive capacity* (question 4), with information gathered from community members' responses to presented future exposures, from key informants involved in the institutions, risk management processes, resource management structures and policies related to adaptive capacity, and from social sciences that might bring insights from elsewhere on the nature of community adaptive capacity and resilience. The analytical task is to identify the conditions in the community (various forms of assets, capital, technology, institutional arrangements, etc.) that would either facilitate or constrain adaptation. This could include describing the ways in which economic conditions or institutional arrangements (for example) could accommodate the changing conditions, or perhaps are unable to deal with certain types of changes.

1.3.3 Community Vulnerability Case Study Methods

A variety of research tools and methods have been employed in community case studies to identify, describe and explain each of the items in the CAVIAR framework. The framework indicates the types of information to be gathered; this section provides an outline of ways in which the information has been acquired.

The information gathered in the four core elements of the framework (Fig. 1.1) matches the four research questions outlined in Section 1.3.2. These four bodies of information, if gathered in a consistent manner in each of the case communities, provide the 'data' to be analyzed and synthesized in the pan-Arctic inter-community comparative exercise (see Section 1.3.5). The comparison seeks to identify exposure-sensitivities and their driving forces that are common to several communities, and to indicate how and why these are distinct in some places or types of society/economy. The comparative exercise also serves to identify adaptive strategies and processes that have been effective (or otherwise) as a basis for sharing lessons among communities across the Arctic regions, and for relating findings directly to decision-makers and policy processes from the local to international scales.

Table 1.2 outlines key elements in the process of community-based vulnerability assessment consistent with the CAVIAR framework. The elements reflect what was done (e.g. assessing exposure-sensitivity), who did it (e.g. researchers, stakeholders) and what data sources were used (e.g. interviews, climate records).

CAVIAR case studies involve research with and about people in communities, and establishing mutually supportive collaborative arrangements was a necessary first step (Table 1.2). This usually entailed preliminary field visits for information exchange, approvals, research planning and scheduling, identification of local research collaborators, protocols, fees, etc.

The data gathering from community residents on exposure-sensitivities and adaptations (Table 1.2) involved a variety of methods frequently used in ethnography, sociology, social anthropology, geography, resource management, health research and sustainability and development initiatives. *Participant observation* and taking temporary residence in the community were part of the procedure in some of the cases. Commonly, *semi-structured interviews* were conducted in the local language (frequently by a community collaborator). In CAVIAR the interview usually had a loose structure, but generally aimed to acquire insights into:

- The general situation of the interviewee: livelihood, socio-economic situation, living conditions, etc. The subsequent four elements relate directly to CAVIAR's four questions and components (Fig. 1.1).
- The conditions, environmental and otherwise, to which the interviewee is sensitive, or which are important in some way, or by which the interviewee has been affected or impacted.
- The strategies, coping mechanisms or other measures employed by the interviewee to deal with, cope with, respond to or recover from the conditions identified, including the reasons for these strategies being employed and not others.
- The interviewee's assessment of future changes in conditions, including those provided by natural science scenarios, particularly as they relate to him/her.

Table 1.2 Activities, data sources and actors in CAVIAR case studies

Stage	Activities	Data sources	Actors
Facilitation/ legitimization	• Field visit to establish legitimacy/ acceptance • Identify local partners, collaborators, terms, issues, sensitivities, protocols and schedules	• Published literature • Key informants	• Natural and social scientists with community representatives and local collaborators
Current and past exposure-sensitivities	• Field visit • Data collection • Documentation	• Available secondary sources • Remote sensing info • Climate record • Archival records • Interviews • Focus Groups • Traditional/Local Knowledge	• Social and natural scientists with local collaborators
Current and past adaptations and capacities	• Field visit • Data collection • Documentation	• Available secondary sources • Remote sensing info • Archival records • Interviews • Focus Groups • Traditional/Local Knowledge	• Social scientists with local collaborators
Future exposure-sensitivities	• Field visit • Modeling • Projections • Probability estimation	• Scientific experiments and models • Interviews • Focus groups	• Social and natural scientists with local collaborators
Future adaptations and adaptive capacity	• Field visit • Social science predictions	• Social science models • Interviews • Focus groups	• Social scientists with local collaborators
Integration (overall vulnerability)	• Analysis • Interpretation	• Field results and secondary sources	• Natural and social scientists
Feedback/ dissemination	• Field follow-up visit • Media • Scholarly publications	• Case study outcomes	• Natural and social scientists with policy-makers and collaborators
Comparison/ integration	• Integration of circumpolar cases	• Individual case study outcomes	• Natural and social scientists with policy-makers

- The interviewee's expected ability to adapt to or deal with changes in conditions, including those broader factors that may be necessary for certain strategies or those that may constrain options.

A *focus group* format was also used in some cases to gather the information about exposure-sensitivities and adaptive capacities, either as an alternative or parallel exercise or as a follow-up method to interviews of residents or key informants. The information gathered from interviews with community members was supplemented by information relating to current and future exposures and adaptive strategies/capacity from other available sources including archival records, institutional measurements, and traditional or local knowledge.

In addition to information from community members, insights and evidence relating to vulnerability and adaptation were incorporated from other sources. For example, data on changes in the timing of sea ice break-up in or near a community may have been available from instrumental or satellite records, or from documents kept by local organizations, archives or businesses. Data on changes in food choices may have been available from the community retail stores, and information on changing diets may have been available from the health clinic or health surveys. Information on likely future changes in ice, wildlife, permafrost and climate has been acquired from natural science analyses and scenarios. Information on the decision-making structures and processes and their capacity to incorporate adaptations were often available from analyses of institutions and governance and from organizational respondents and other stakeholders. Data from these sources were combined with the information gathered from the community members themselves to address each of the components of the CAVIAR framework. In addition, an overall integration of the case-study findings is being undertaken (Table 1.2) to generate interpretations and summaries of the results.

The insights gained on the nature of vulnerability, on adaptation needs, and on constraints to adaptation, provide a robust basis for identifying practical interventions to reduce exposures and/or to enhance the community's capacity to adapt. The initiatives may involve risk management strategies, community planning, resource management plans or regulations, technology, and policies at levels from the community to national and international institutions. Ideally, the process of identifying and developing *adaptive strategies* is undertaken with the participation of community members and stakeholders.

The *feedback* phase is still in progress in some case studies and involves supplying the community with information gained from the research. In practice this occurs throughout the field research (keeping the community informed about the broad goals and findings), and especially after the results have been analyzed. A common form of feedback consists of a return visit to the community to provide a summary of results (and related insights from other work) through local radio, website, newspaper, community gathering/feast, school visits, briefing with local officials etc. – the appropriate means vary per community.

In addition, several community collaborators participated in workshops, conferences or media events beyond their own community to disseminate findings more widely and to influence policymakers, and to benefit from initiatives that take place occurring outside of their community.

1.3.4 Policy

The relevance of the CAVIAR research to policy is explicit and substantive. The research focuses directly on environment-society issues that are important to northerners, it includes decision-making processes and institutions as subjects of the research, and it involves policy decision-makers in the research itself.

The CAVIAR research program is directly policy relevant in several ways:

- It engages community representatives and decision-makers in the research process to ensure that the items analyzed are pertinent to community members and relevant to community decisions. This engagement orients the research to those issues that are policy relevant, and it facilitates the application of the results by decision-makers.
- A fundamental step in the vulnerability assessment methodology is to identify the ways in which the community's members, institutions and governance structures deal with stresses and environmental changes, so that analyses of adaptive capacities and adaptation options are undertaken explicitly in the context of actual decision-making structures and policies. The research includes rigorous analysis of policies and decision-making as part of the vulnerability assessment, contributing to the direct policy relevance of the results.
- The CAVIAR initiative includes partners representing organizations involved in policy making at several levels, ranging from international organizations, national and regional government agencies to indigenous peoples' organizations and community-based organisations (e.g. Hunters and Trappers Organizations). These partnerships not only facilitate CAVIAR research, but they also provide influential entry points to policy processes at all scales.

1.3.5 Outreach

The vulnerability assessment methodology in the CAVIAR consortium sought to actively engage people in northern communities. This meant going beyond the inclusion of community members as research subjects or field research assistants and involving them as collaborators and partners. This method represents an important outreach component, ensuring that research is locally relevant and that community members are part of the process and well informed of the findings. The CAVIAR team is further committed to dissemination in communities, employing means which are targeted to the respective audiences, including (but not limited to) community meetings, radio, magazines, schools, television, reports, brochures, and briefings.

1.3.6 Case Studies

Framework and methodological development were developed collaboratively within the CAVIAR consortium (through workshops, communications and document development). The case study research was conducted independently by research teams organized in national nodes, with primary research funds coming from the respective national agencies or bi-national agreements. In most cases, CAVIAR members acquired supplementary funds or resources for supporting CAVIAR research. Communities were involved in the field work at all stages, to the extent possible, and consequently became partners in the research. Consortium partners have developed their own partnerships with relevant researchers, institutes, organizations, and communities as part of their research activities.

The CAVIAR research program focuses on people and their livelihoods in communities. The term community has long had a range of contested meanings. For the purposes of CAVIAR, a northern/local 'community' is viewed as a collection of individuals and families sharing a geographic space, frequently being a town or village, with its associated formal and informal institutions. This interpretation of community includes all those who physically share the space for all or part of the year, regardless of diverse interest groups occupations, livelihoods, activities, and existence or lack of kinship ties.

It follows from the definition of a community as people in a shared geographic space with diverse membership and interests that there is no single voice for a community (Wallerstein 1999). Communities are not homogenous or monolithic entities, and thus the selection of people to represent a northern community was made with the intent to be representative (of at least some significant, defined portion) of the community. It was not expected or assumed that all people in a community have similar vulnerabilities. The research documented the types of exposure-sensitivities and adaptive strategies that vary within and between communities, as well as those that might be common in a community.

CAVIAR case studies were selected by individual researchers with knowledge and contacts in particular regions (in consultation with coordinating lead researchers) to be broadly representative of the range of communities in the circumpolar north. The case studies employed the common CAVIAR framework outlined, with the field methodologies adjusted to fit particular contexts and communities. The suite of vulnerability case studies presented in this book are displayed in Fig. 1.2.

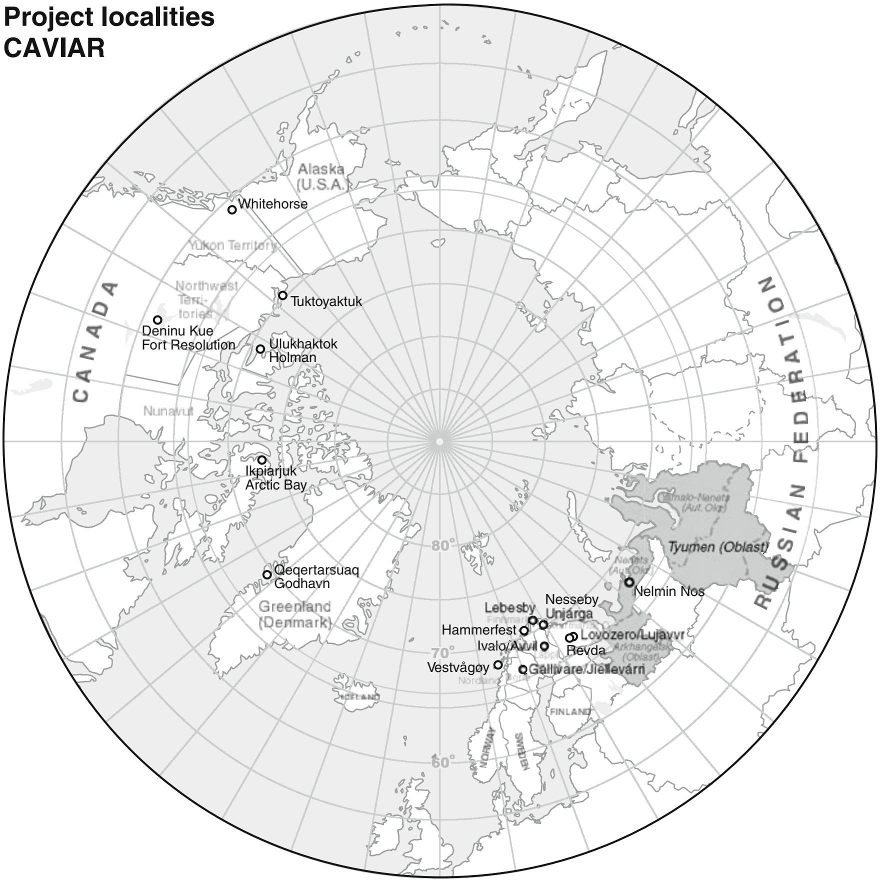

Fig. 1.2 The CAVIAR case study localities described in the book. *Source*: compiled by Winfried K. Dallman

1.4 Features of CAVIAR and Outline of this Book

The CAVIAR research program is distinctive in several respects. Research addressing each of these areas is not new, and several of them have been investigated in the Arctic context. What makes CAVIAR distinctive is that its scope and structure allow for all of these studies to be addressed in a systematic, integrated program. This is made possible by drawing on the experiences of researchers and practitioners who have developed the various elements and by focusing on a particular application (Arctic communities). The noteworthy features of CAVIAR are:

- It explicitly addresses issues that involve complex interactions among ecological and human systems and processes. Not only does CAVIAR consider physical, biological and socio-economic variables, but it systematically explores the links between natural and dynamic human systems.

- It is directly applied to human decision-making and policy relating to environmental changes and human communities. It brings integrated science to bear on adaptive decision-making on levels ranging from local to international.
- It is fundamentally inter-disciplinary, in that each case study involves social and natural science in addressing a common set of questions.
- It applies multiple methods in that it combines a variety of analytical tools and methods from both natural and social sciences for data collection, analysis and interpretation.
- It assesses current and past conditions and considers implications for the future – thus combining historical analysis, comparative static analysis and prospective analysis.
- It is community-based and community-engaged, to ensure that the research is founded on the experiences of local residents and that its findings are relevant to their lives and the environments in which they live.
- It is both place-specific in its provision of insights in each community case study, and regionally generic in its systematic comparison and integration of findings over many communities in the Arctic.

These themes (human-ecological integration, policy relevance, interdisciplinarity, past and future perspectives, community engagement, comparisons, etc.) do not represent independent goals of CAVIAR. Rather, they have enabled the project to address its core goal of identifying practical adaptation strategies and policies to help Arctic communities deal with changing environmental conditions. Overall, CAVIAR represents an ambitious and distinct program of interdisciplinary research to identify insights essential for the development of adaptive responses to changing conditions in the Arctic.

This book provides results from 16 case studies in Chapters 2–13. This introductory chapter has presented CAVIAR's objectives, underlying theoretical orientation, and shared framework and approach. In Chapter 2, Grete K. Hovelsrud, Halvor Dannevig, Jennifer West, and Helene Amundsen synthesize the consequences of changing climatic societal and conditions for three communities in northern Norway. Exposure-sensitivities and adaptive capacity are discussed in the context of fisheries and municipal planning, and downscaled climate projections are utilized for assessing future vulnerabilities. In Chapter 3, Mark Andrachuk and Tristan Pearce compare and contrast the communities of Ulukhaktok and Tuktoyaktuk in the western Canadian Arctic. The two communities have some similarities due to a shared culture and reliance on subsistence harvesting, but differ in their geographical setting and economic development which has shaped unique vulnerabilities in each community.

Chapter 4 by Tatiana Bulgakova documents reindeer herders' experiences with climate change in the Yamalo-Nenets Autonomous Okrug and Nenets Autonomous Okrug in Russia. Bulgakova highlights the flexibility and adaptability of the traditional reindeer herding economy and concerns among herders about the magnitude of stresses they will face due to climate change. In Chapter 5, James Ford, Trevor Bell and Dominique St. Hilaire-Gravel focus on infrastructure vulnerabilities in Arctic Bay, Nunavut, Canada. The study identifies several adaptive strategies that have been employed to minimize risks to infrastructure due to landscape hazards. Chapter 6 by Anna Stammler-Gossmann examines the social and cultural factors that influence the ways that communities in the Nenets Autonomous District of northwest Russia perceive and respond to environmental and societal change. In Chapter 7, Sonia Wesche and Derek R. Armitage reveal how relationships with water shapes current and future vulnerabilities for land users in Fort Resolution in the western Canadian sub-Arctic. The chapter concludes that future adaptation to climate change and pressures for resource development requires engagement of actors at multiple levels and incorporating different knowledge systems.

Chapter 8 is a presentation of colour photographs that showcase examples of culture, livelihoods and vulnerabilities in the case studies.

In Chapter 9, Monica Tennberg, Terhi Vuojala-Magga and Minna Turunen document experiences with an extreme flood event in the town of Ivalo in Finnish Lapland. The case study demonstrates how recent infrastructure developments have lead to greater flood risks for the community and how communication before and during flood events is a critical adaptation to future flood events. In Chapter 10, Ralph Matthews and Robin Sydneysmith draw on new institutional analysis as a means of assessing institutional capacity in Whitehorse, a city in Yukon, Canada. The chapter explores the processes by which adaptive responses take shape in relation to infrastructure, public health and safety, land use planning, emergency preparedness and the environment. Chapter 11 by Christina Goldhar and James Ford describes the vulnerability of food systems in Qeqertarsuaq, Greenland in the context of changing livelihoods and climate change.

With a focus on land use conflicts, Chapter 12 by Carina Keskitalo examines exposure-sensitivities and adaptive capacity in the forest-dependent Gällivare municipality in northern Sweden. The chapter reveals how stakeholders in forestry, reindeer husbandry and tourism are similarly influenced by each other, as well as land use regulations and changes in climate. In Chapter 13, Stine Rybråten and Grete K. Hovelsrud describe the relationship of sheep farming and reindeer herding with climate change. The chapter describes how recent landscape changes due to moth larvae outbreaks related to climate change influence livelihood opportunities and challenges for animal husbandry.

The book concludes with an integration chapter (Chapter 14) that summarizes the breadth of communities across the Arctic. The final chapter offers key insights from the case studies on exposure-sensitivities, adaptations, and adaptive capacity across the Arctic. The final chapter also reflects on the concepts and methods used in CAVIAR.

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Chapter 2
Adaptation in Fisheries and Municipalities: Three Communities in Northern Norway

Grete K. Hovelsrud, Halvor Dannevig, Jennifer West, and Helene Amundsen

Abstract In this chapter we focus on how changing societal and climatic conditions have consequences for current and future vulnerability and adaptation in three municipalities in Northern Norway: Hammerfest and Lebesby, in Finnmark County, and Vestvågøy in the Lofoten Islands, Nordland County. Through local consultations and discussions, fisheries and municipal planning were identified as having particular relevance in the case communities. Climate change is not perceived to be a major challenge locally, nevertheless, when climate projections are considered alongside locally defined and relevant socio-economic and climatic concerns that are particular to local contexts, multiple and interrelated factors emerge that are likely to shape future vulnerability. Focussing on coastal fisheries and municipal planning as two major arenas for change, we find that adaptation takes place along a number of dimensions and at several societal levels. Adaptive strategies occur in response to changing socio-economic conditions, to variable weather and environmental conditions, or to a combination of both. There are three interlinked factors that our empirical findings show are currently of concern for coastal fisheries: changes in bio-physical conditions (ocean temperature and fish distribution and behaviour); fisheries management and regulations (vessel size, species, quotas) and societal conditions (outmigration, market factors and transfer of knowledge). The interlinkages between these changes, and community responses to them, have first and foremost been captured and understood through local involvement in our research.

Keywords Coastal fisheries · Municipal planning · Northern Norway · Climate scenarios and elements · Local perceptions of change · Coupled systems

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2.1 Introduction

In this chapter we present results from case studies carried out in the municipalities of Vestvågøy, Hammerfest and Lebesby in Northern Norway (see Fig. 2.1). We frame the discussion of locally identified current exposure-sensitivities with respect to climatic, ecological, economic and societal trends in the context of fisheries and municipal planning. The coastal fishing sector was identified locally as being particularly appropriate for this study because the communities identify themselves as fishing communities, both historically and currently, and coastal fishing is one of the main activities in the communities. Municipal planning was also identified locally as an important focus because of the critical responsibility of local government for facilitating local adaptation.

Consistent with the CAVIAR Framework described in Chapter 1, we focus on locally relevant societal and climatic conditions and how these combine to create current exposure-sensitivities. In particular we investigate the relevant dimensions of exposure-sensitivities within the coastal fishing and municipal sectors and current local adaptation strategies. Based on our analysis of the adaptations that are currently being undertaken and an assessment of future exposure-sensitivities, we discuss communities' adaptive capacity to deal with future changes.

The chapter begins with a description of the societal and geographic context and background of the case study areas, and continues in Section 2.3 with a description of the methods we employed. In Section 2.4 we discuss

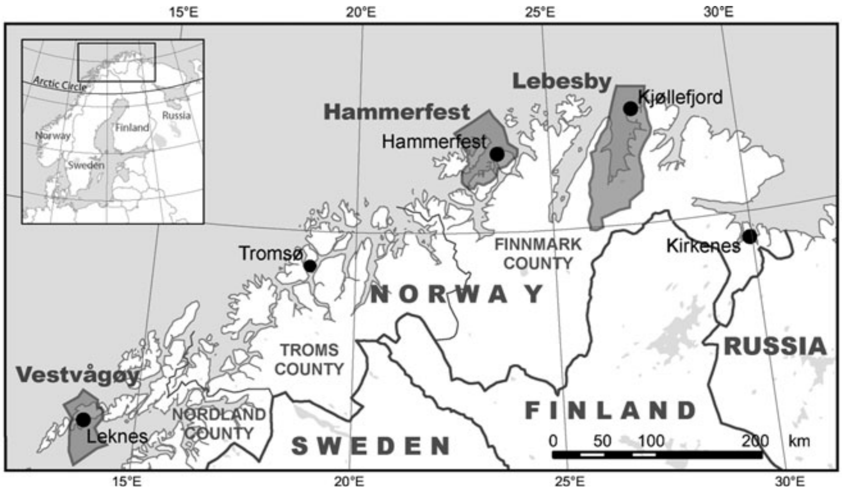


Fig. 2.1 The case study sites in Northern Norway. *Source*: Winfried Dallman

some of the findings relating to current exposure-sensitivities of the coupled climatic, ecological and societal conditions that were identified locally, and how they affect municipalities and their coastal fisheries. In Section 2.5 we discuss current socio-economic exposure-sensitivities with a focus on aspects of fisheries management and municipal planning that may facilitate or constrain adaptation and shape the vulnerability of the case study areas. Section 2.6 outlines some of the downscaled climate projections, which were made specifically for the case study areas, and discusses our local partners' reflections on how these projected changes may impact their livelihood activities, and the overall adaptive capacity of the municipalities. We conclude by reflecting on the importance of focussing on the interlinkages between societal and environmental conditions for understanding adaptation and vulnerability.

2.2 Background and Context

2.2.1 Northern Norway: The Background and Context of the Case Areas

The peripheral positioning of Northern Norway, both in a Norwegian and a European geographical sense, somewhat belies its economic importance. Northern Norway is perhaps one of the richest peripheral regions in the world in terms of the potential contained in its natural resources, such as fisheries and petroleum (e.g. Rydningen 2004). In a Norwegian context, however, it still lags behind other regions on several counts: education levels and numbers employed in the private sector are relatively low in the northern counties compared to the country as a whole, and the population growth is smaller or in decline (Nilsson 2004). The region relies heavily on natural resources for income, employment, culture and lifestyle, and historically technology has been developed with the aim of increasing the efficiency and yield of existing resources, such as stockfish and aquaculture, rather than being directed at innovations (Watten 2004).

The traditional combination of fishing and farming livelihoods (*fiskarbonden*), which was historically significant for culture and livelihoods (Brox 1966), has to some extent been replaced by modern, intensified agriculture, aquaculture, and public sector employment (Holm 1996; Karlsen 2004; Rydningen 2004). Coastal fisheries nonetheless continue to provide a large share of local jobs and income, as well as local identity and culture (e.g. Lindkvist 2000). The viability of coastal fishing communities is nevertheless closely connected to local and regional developments in fisheries policy and legislation.

2.2.1.1 Climate

Northern Norway has a mild climate compared to other regions at the same latitude, due to an influx of mild air and warm ocean masses from the Atlantic Ocean (the Gulf Stream). The annual mean temperature varies from 4°C in the coastal areas in Nordland County to minus 4°C in the interior of Finnmark County. Temperature and precipitation in Northern Norway fluctuate significantly within and across years, decades and centuries. Nevertheless, over the last 100 years an increase in the annual mean air temperature, with a rapid increase since the 1960s, has been observed (see Fig. 2.2) (Førland et al. 2009).

The ocean temperature in the Barents and Norwegian Seas shows major annual and decadal variations, primarily influenced by the fluctuations of the North Atlantic Oscillation (NAO) which determines the influx of warm, Atlantic water in the northern waters. Over the last 15 years the ocean temperatures have increased in both the Barents and Norwegian Seas (see Fig. 2.3).

2.2.1.2 Coastal Fishing Communities

Coastal fisheries, defined as activities that occur within 12 nautical miles of the continental shelf, have provided a foundation since early settlement in Northern Norway until the present, and remain important for employment, income and culture in many small communities in the region (e.g. Karlsen 2004;

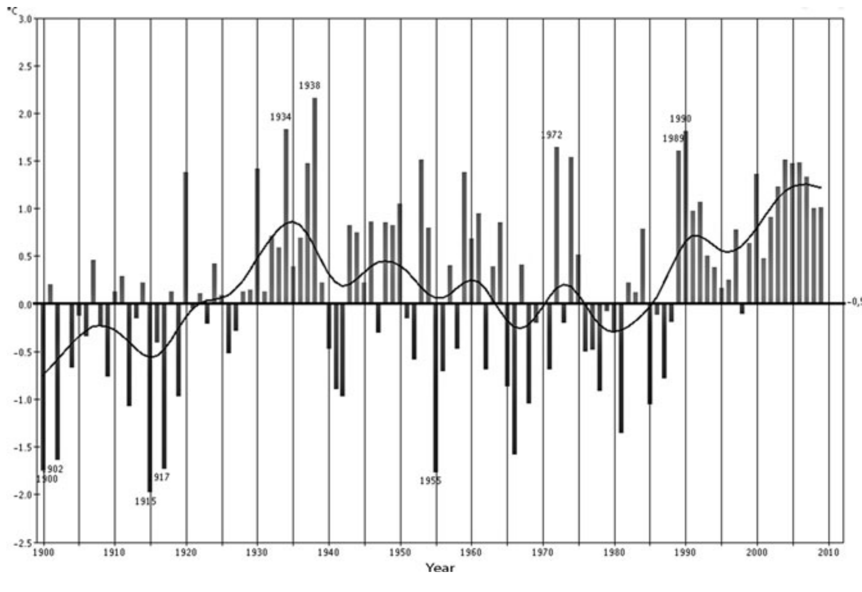


Fig. 2.2 Temperature development (deviation from normal temperature) in Northern Norway from 1900 to 2009. *Source*: Norwegian Meteorological Institute

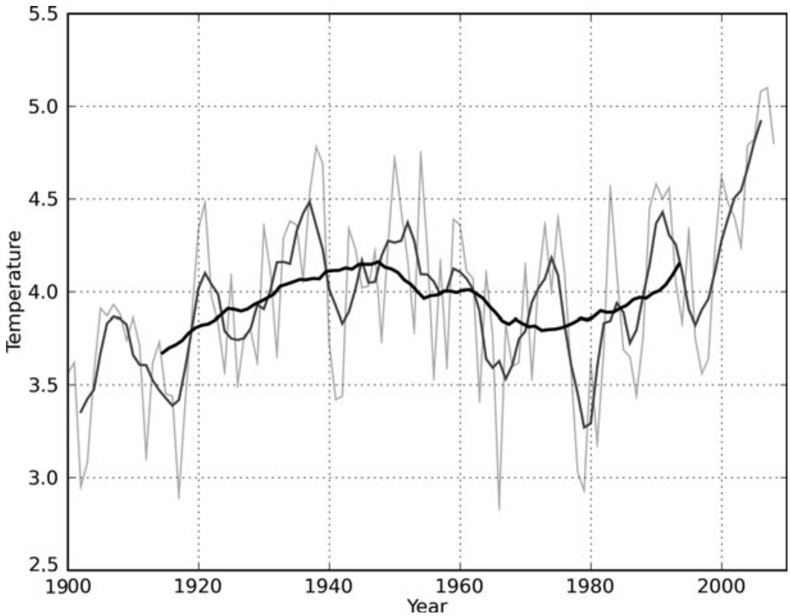


Fig. 2.3 Ocean temperature development in the eastern Barents sea in the 20th century. Light grey, dark grey and black curves display respectively annual, five year and 30 year mean temperatures in degrees celcius. Data from PINRO, Murmansk. *Source*: Bjørn Ådlandsvik, Institute for Marine Research, Norway

Keskitalo 2008; West and Hovelsrud 2010). Northern Norway is located near some of the world's richest cod fisheries and has for more than 1,000 years produced stockfish for national and international markets (Berge 1996). While the importance of fisheries to coastal communities in terms of employment has declined in recent years due to a number of technological, regulatory, economic and wider societal changes, fishing activities still remain a significant feature of the local economy (see Figs. 2.4 and 2.5). In addition to fisheries and related processing activities such as stockfish production, agriculture, aquaculture, small-scale tourism and the service sector provide additional jobs in our case study areas.

Economic, cultural, and recreational activities are closely connected to the natural environment, and communities are therefore particularly exposed to environmental changes, including those that are driven or reinforced by climate change. Generations of fishers have over time developed extensive local environmental knowledge, making them highly adaptable to the natural variability in climate and fish stocks. Today, fisheries in Norway are highly regulated and managed on many levels, differentiated by vessel length, gear type, species quota and fishing ground. Recent and ongoing structural reforms have contributed to a reduction in the number of fishers and fishing vessels, particularly in the coastal fleet (see Fig. 2.4).

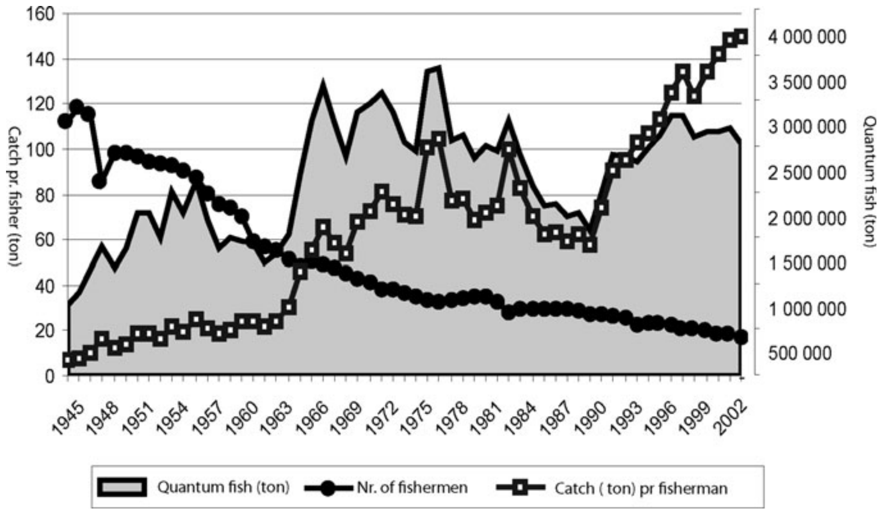


Fig. 2.4 Development in numbers of fishermen, catch, and catch per fisherman in Norway from 1945 to 2002. *Source*: MOFC 2006

2.2.1.3 The Municipal Sector in Norway

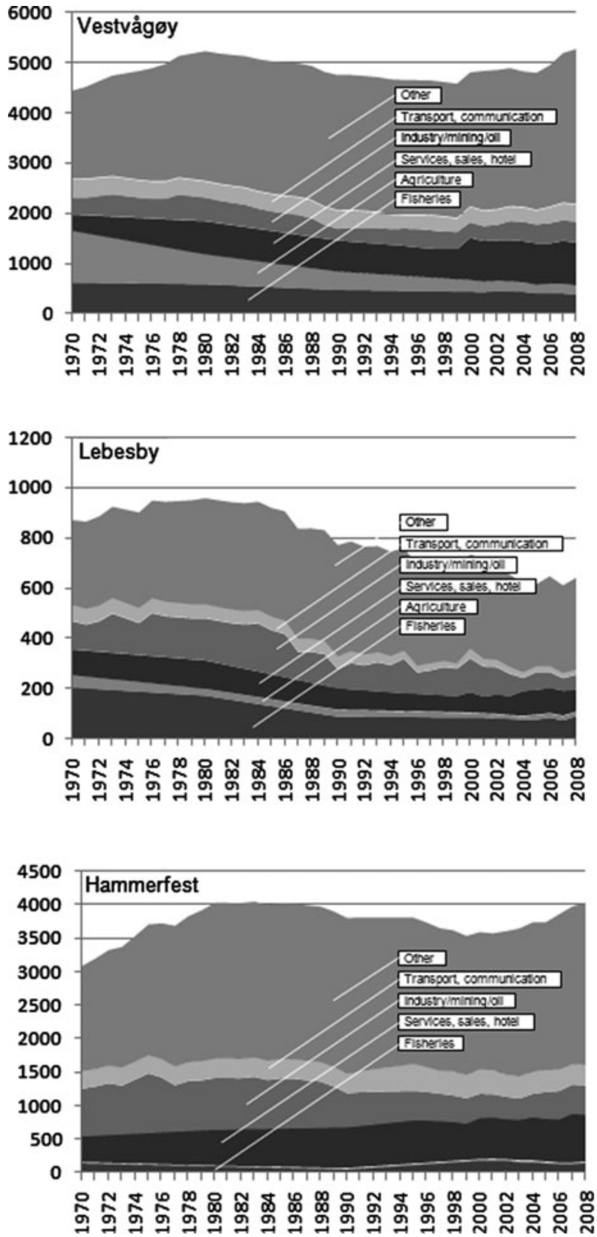
Municipalities (430 in total) are the local level of government in Norway and serve as a link to national management bodies and governance institutions. The municipal authority provides a number of important services for its inhabitants. These include elementary schools, local road maintenance, waste collection and management, emergency response, provision of social services, fire protection, water supply and local spatial planning. The services are highly regulated by national laws and regulations, and the majority of the municipal budget is spent on fulfilling mandatory obligations. Norwegian municipalities have the main responsibility for local land use planning, and for preventing damage from extreme weather events, such as floods and avalanches. Municipalities also have an important role in coordinating responses to future extreme events and damage through ‘rebuilding’ after an event (see Næss et al. 2005 for an overview). The tools available to municipalities include the prohibition of new buildings in areas prone to flooding or slides, and the construction of landslide and avalanche protection for existing infrastructure.

2.2.2 Case Area Descriptions

2.2.2.1 Hammerfest

Hammerfest municipality is located in western Finnmark at 70° N (see Fig. 2.1). Hammerfest is the northernmost city in the world and an important port for

Fig. 2.5 Development in employment composition in number of persons in the case municipalities from 1970 to 2008



trade, shipping and fisheries. The municipality has about 9,500 inhabitants with more than 75% living in the city. The natural resources derived from and beneath the Barents Sea, such as fish, oil and gas, and associated production facilities, provide the economic foundation for Hammerfest. Currently, fisheries and the liquefied natural gas (LNG) landing and production facility at Melkøya constitute the most important industries. The gas field outside Hammerfest was discovered in 1984, and the production of LNG started in 2007 (Store Norske Leksikon 2009). The development of the LNG plant has had a multiplier effect within Hammerfest, providing impetus for secondary services and provisions such as local tankers for distributing LNG, the development of a local gas-fired power plant, the supply of production inputs, as well as increased demand throughout the service sector. Bucking the demographic trend seen in other municipalities in Finnmark County, the population in Hammerfest has increased over the last few years, highly likely as a consequence of the construction of the LNG plant. Fisheries remain important in Hammerfest in terms of employment and maintaining local identity, culture and knowledge. The average age of the fishers is high, mainly due to young people seeking employment elsewhere, combined with the high initial entry cost associated with high quota prices and costs of purchasing fishing vessels. The discovery of LNG off shore and the development of the Melkøya facility have given Hammerfest an economic boost, both in terms of soaring real estate costs and an optimistic view of the future. Hammerfest is a vibrant municipality that is seeking innovative solutions to range of policy issues such as housing developments, harbour rejuvenation, environmental improvements and population stabilisation (see employment configuration in Fig. 2.5).

2.2.2.2 Lebesby

Lebesby municipality is located at 71°N, in the eastern part of Finnmark County, and is home to 1,350 inhabitants (see Fig. 2.1). From the original settlement until the present day fisheries and land-based fishing activities have provided the cultural and economic foundation for the municipality. While the number of fishers and vessels based in Lebesby have declined over the last decades in line with national trends, coastal fisheries remain important to the local economy and employment. In addition to fisheries and fish processing activities, agriculture, wind and hydropower, aquaculture, smolt production, coastal cultural and nature-based tourism, and the public sector, are important local employers in Lebesby (see also Fig. 2.5). The Nordkyn peninsula is also an important summer pasturing area for reindeer. The municipality has a number of social, economic and cultural resources to draw on, including the presence of creative innovators (‘*ildsjeler, idemakere*’), a vibrant coastal cultural society, a small but growing number of nature-based tourism operators and innovators, a new windmill park, and most recently, renewed central government economic support (*omstillingskommune*) aimed at increasing jobs, well-being and migration to the municipality. Nonetheless, the latter is an economic rescue measure that effectively weakens the municipality’s control over its budget and financial decisions, placing these in the hands of higher government levels.

2.2.2.3 Vestvågøy

Vestvågøy municipality, in Nordland County, is located at 68°N in the Lofoten Archipelago. It has approximately 11,000 inhabitants in a number of smaller communities, with the majority settled in the small commercial centre of Leknes and the fishing villages of Ballstad and Stamsund. The main employer in the municipality as a whole is the service sector. However, fisheries and associated industries are the cornerstone of several of the smaller communities in the municipality even though the total share of fisheries employment has been decreasing in recent decades. Agriculture is also an important sector, and tourism is growing rapidly, replacing fisheries in some communities as the main source of income (see Fig. 2.5). Vestvågøy is located near some of the world's richest Atlantic cod (*Gadhus morhua*) fisheries. The climatic conditions in the Lofoten islands are known to be highly favourable for stockfish production, and the region boasts a 1,000 year old tradition of exporting stockfish.[1]

As in the other case study communities, the fishery sector in Vestvågøy has been in flux due to changing fisheries management regulations and higher efficiency requirements that have reduced the number of fishers. The stockfish industry is also exposed to major annual fluctuations in prices and demand in international markets.

2.3 Methodology: Local Approach

Consistent with the CAVIAR framework described in Chapter 1 our research is driven by locally relevant questions. Our case specific research questions were initially framed in cooperation between researchers and local stakeholders, and the research was undertaken in collaboration with local partners. Our local partners include officials and elected representatives in the municipalities, fishers, fish buyers, employees in the fish processing industry, and officials at the Fisheries Directorate. Working closely with local partners is an iterative process in which preliminary results are presented to the community for feedback and adjustments. Our research began with an initial visit to the communities where we invited municipal officials and other community members to meet with us to establish legitimacy and face-to face contact (see also Keskitalo 2004). The research focus was determined in consort with the community and fieldwork was undertaken to identify current and future exposure-sensitivities, adaptive

[1] Stockfish is produced by drying the fish on outdoor racks. This conserves the fish. Different fish species may be used, but the most common is North Atlantic cod. Successful drying and preservation of the fish requires sufficient quality of raw material and appropriate drying conditions. The Lofoten-region fulfills both of these requirements and has for a long time been the world's largest exporter of stockfish. It is documented that the Lofoten stockfish trade began in 875 AD and in the medieval age it was the most important trade in Norway. The single most important market for Norwegian stockfish is Italy, which has imported stockfish for a century (Berge 1996).

capacities and strategies, and vulnerabilities to differentiated exposures, including climate change. This means that the particular research focus varied according to the specific concerns identified by each of the three case communities, but our common methodology allows for comparison between sites. A team of researchers has made repeated visits to the case communities (see Fig. 2.1), engaged in participant observation and conducted semi-structured interviews with elected and non-elected municipal representatives, the oil and gas industry, fishers, the fishing industry, farmers, reindeer herders, entrepreneurs, the tourist industry, store owners and 'people at the local pubs', as summarised in Table 2.1. During follow-up visits, the researchers received feedback from the local partners and communities on the preliminary interpretations and understandings of current and future exposures-sensitivities and current and future adaptive strategies and capacity articulated by the researchers.

The climate related observations were quite similar across the cases but were defined as relevant to community livelihoods and activities in myriad ways. Common to local definitions of important climate elements is that they often include more than one variable, such as precipitation *in combination with* certain temperatures. An example of this is freezing rain in winter, which is a shared concern amongst the sites as it creates dangerous conditions for navigation on roads and at sea, and interrupts important services such as electricity supply, and transportation. The Norwegian Meteorological Institute (met.no) has developed scenarios of locally identified climate elements where possible (see Section 2.6 below). The downscaling results were presented to the communities for feedback, and discussed in terms of present and future challenges and opportunities, and the capacity of the community to deal with current and expected changes in climate.

Table 2.1 Summary of research methods and interviews

Methods	Vestvågøy	Hammerfest	Lebesby
Semi-structured interviews	21	20	25
Town meetings	1	1	2
Group discussions	With farmers, fishers, and the municipality	With municipality, fishers, and local inhabitants	With local elderly, fishers, local inhabitants, and municipality
Other	Attended and observed community events and meetings, collected grey literature and documents	Attended and observed community events and meetings, collected grey literature and documents	Key informant discussions, participant observation on board fishing vessels and at community events, collection of grey literature and documents

2.4 Coupled Climatic, Ecological and Societal Components

In this section we describe how current climatic, ecological and societal conditions combine to create a range of exposure-sensitivities and adaptive strategies in the three case communities. We have structured the results according to climate- and social-ecological exposure-sensitivities. See Table 2.2 for a summary of the locally identified climate elements and associated weather conditions, and associated exposure-sensitivities.

2.4.1 Changes in Distribution and Abundance of Commercially Important Fish Stocks

Warming oceans are likely to affect the distribution and abundance of the regions' commercially important fish stocks, including cod, herring, and capelin, and to lead to an increased influx of southern species such as mackerel (*Scomber scombrus*) monk/goose fish (*Lophius piscatorius*) and blue whiting (*Micromesistius poutassou*) to the coastal waters of Finnmark. The three Norwegian case communities have all identified increased ocean temperature and its impact on fisheries as a factor that can be described as a current exposure-sensitivity. Coastal fishers are accustomed to high natural variability

Table 2.2 Current climate exposures as identified in communities

Climate or weather condition	Exposure-sensitivities
Increased ocean temperature (V, L, H)	Changes in fish distribution, abundance and species composition
Storms, extreme weather, and polar lows. (H, L)	Create hazardous conditions at sea, may hamper fishery activities and destroy equipment
Shorter winter season (V, L)	Affects the onset of the stockfish production season. Poorer conditions for snow dependent activities as winter tourism
Higher winter temperatures (V, H, L)	Affect stock fish production
Reduced snow depth and cover (L)	Poorer conditions for snow dependent activities
'0'degree conditions combined with precipitation (H, L)	Dangerous road conditions, higher risk of avalanches
Icing due to certain combinations of wind and temperatures (H, L)	Dangerous icing on fish vessels and oil- and gas installations
Rain in winter (H, L)	Road maintenance challenges, increased avalanche risk, floods
Increased winter precipitation combined with wind and higher temperatures (H, L)	Affects road maintenance and avalanche risk
Sea level rise and storm surge (V, H, L)	May threaten harbours, sea side buildings and roads

H = Hammerfest, *V* = Vestvågøy, *L* = Lebesby in weather, climate and the resource base. Recent observations by fishers of changes in ocean temperature and in the distribution of fish species are consistent with scientific measurements and results. The scientific results show that the ocean temperature in the Norwegian and Barents Seas fluctuates between cold and warm periods, but that the last 30 years show a rapid increase to levels higher than the long term mean, and in recent years, temperatures are the highest that ever have been recorded (Hanssen-Bauer et al. 2009).

Increased ocean temperature affects the production and distribution of marine biomass (Loeng and Drinkwater 2007), and a linear relationship has been established between ocean temperature and the distribution of spawning cod and herring (Sundby and Nakken 2008). In Lebesby, our local partners have observed a change in the distribution and behaviour of cod (*Gadhus morhua*) and saithe (*Pollachius virens*) since the year 2000, a period of relative ocean warming. They report that these species are currently found farther out to sea, in deeper waters, and correlate this change with fluctuations in ocean temperatures (West and Hovelsrud 2010). Coastal fishers in our case areas are adapted to major inter-annual, decadal, and multi-decadal changes in ocean temperatures and their corresponding effects on fish stocks. For example, the average decadal variation in ocean temperature in the eastern Barents Sea during the 20th century was 1.5°C (Sundby and Nakken 2008), well within the range of the 1–2°C warming that is projected for the entire Barents Sea by 2070 under a doubling of atmospheric CO_2 levels (Loeng et al. 2005). It is perhaps not surprising then that fishers do not consider themselves to be particularly vulnerable to climate change. In many ways they express great pride in being adaptive to constantly changing conditions. Nevertheless, the current distributional shift of stocks has created a number of exposure-sensitivities for the fishers as local knowledge about the location of important species is not as reliable as it once was, and this is viewed by some fishers as a challenge. Reliance on local experience–based knowledge of species interactions and of local ocean currents and weather patterns is fundamental for successful and efficient catches, as well as safety at sea.

In Hammerfest and Lebesby local fishers are concerned that they do not have quotas for species such as mackerel, whose abundance, due to warmer ocean temperatures, is increasing in their fishing areas. Many fishers sold their mackerel quotas to vessels from southern counties long ago. New species such as the Alaskan snow crab (*Chionoecetes opilio*) and pipefish (*Syngnathus acus*), have also been observed, both in Lebesby and Hammerfest (see also Chapter 13, this volume), but according to some fishers, this may be attributed to wider marine ecosystem imbalance, rather than ocean temperature change (West and Hovelsrud 2010). Moreover these species do not currently present a commercial opportunity. Fishers in Lebesby explain that the red king crab, an invasive species that has been fished commercially for the past several years, represents an important source of income, but it is also seen as an indication of a changing ecosystem with unknown consequences for traditional fisheries such as cod. According to current research the invasion of the red king crab does not appear to be related to increasing ocean temperatures (Sundet 2008).

In Vestvågøy, in contrast to the two Finnmark municipalities, the north- and outward shift in the cod fisheries is perceived by fishers, fish buyers and stockfish producers to present the greatest adaptation challenge for the fish buyers. The proximity of the fisheries to the landing facilities is a major determinant for stable landings and a fish buyer's success or failure, and as our local partners explain, landing facilities are closing due to a shift in the distribution of spawning cod. The closures have resulted in many fish buyers moving out of the region, leading to a loss of employment and income. In addition, some fishers point to the use of modern fishing gears, such as the '*snurrevad*' as responsible for the loss of fishing grounds. They also report an increase in herring abundance, which they attribute to the cod migration into eastern Lofoten.

Successful fishers, in general, have historically adapted to changes in distribution and abundance of commercial fish stocks. The fishers who survived the collapse of the cod stock during the 1980s did so by adjusting to fishing different fish species, fishing further out at sea, and working longer days. Currently some fishers combine tourism with fishing to increase and diversify their income. Inevitably there are constraints which limit adaptation possibilities, particularly with regard to changes in fish distribution and species. During the 1960s in Lebesby the traditional saithe (coley) fishery was affected by overfishing of the herring stock, its main food source. As a result the saithe retreated to lower depths. Pursuing the fish required adjustments to the dimensions of the not fishing gear traditionally used to fish for saithe. Not all fishers in Lebesby made the transition, and many sold their boats rather than invest in new technology. This is in stark contrast to the less conservative fishers of Måsøy, a neighbouring municipality, who adopted the new gear and are today recognized as regional leaders in the coastal saithe fishery (Tomas Sagen, pers. comm).

According to the fishers in Vestvågøy, adaptation to the northerly outward shift in the cod fisheries involves following the fish, and with modern equipment this is not perceived to be difficult. Fishing vessel insurance and management regulations however dictate just how far off shore the smaller fleet may fish, which restricts their adaptive strategy. The fishers in general display a high confidence in their ability to adapt to changes in fish stocks and weather conditions, however as the example from the saithe fisheries in Lebesby illustrates, traditions and cultural values may hamper introduction of new and beneficial technologies. Fishers can travel farther to catch the fish, however the same is not true for fish buyers. As one fisherman stated, 'the fisherman can follow the fish, but cannot bring the landing facilities with him'.

Various adaptive strategies have been developed to encourage fishers to land their catch locally, including offering a competitive premium price. The attainable price is not the only determinant of landing site, as trading fish is connected to a number of other long-term relationships. As an adaptive strategy to maintain good relations, some buyers may even buy fish despite a low resale price; others assist fishers in securing additional fish quotas tied to their vessels.

This reinforces the mutual bond between fish buyers and fishers. As one fish buyer and stockfish producer said:

> It is kind of a responsibility to the community, like a duty, to buy fish from the fishers in the community even if the market is poor. But then I also know that they will land their catch at my facility when I need it.

For some fish buyers in Vestvågøy this bond has been instrumental in their successful adaption to the northward shift in the fisheries activities. Recently, land based transportation from landing facilities near the fishing grounds to the fish buyers- and processors in less accessible locations has increased, and the local stockfish producers are increasingly sourcing their fish from other regions. The fishers' sales organization and/or the national government may subsidize the transportation in order to ensure buyers for the catch.

Throughout all our cases, fish buyers, landing facilities and fish processors are, albeit in different ways, all affected by the dynamics of sea temperature and species composition, abundance and distribution.

A number of social factors affect fishers and fish buyers/processors' exposure-sensitivity and adaptive capacity for dealing with climate variability and change. A fishing regulatory framework that is perceived and described by our local partners as being bureaucratic and unpredictable may limit fishers' flexibility and mobility to respond to climate change impacts on fish, while cultural values and individual preferences may affect the choice of fishing technology and species fished, either facilitating or hindering adaptation.

2.4.2 Living with Storms and Extreme Weather

As we have emphasised, people in northern Norway pride themselves on being used to living with storms and extreme weather. '*Vi står han av*' is a common phrase in the region, broadly translated as 'we stand tall in the face of storms'. Nonetheless, storms and extreme weather are discussed locally as affecting the fishing activities, the supply of fish to local fish processors and the subsequent shipment to market. Furthermore storms and extreme weather are a concern to the municipalities because they may threaten electricity supply, close roads and isolate communities. Recent climate modeling results suggest a future increase in strong wind events in the Barents and Norwegian Seas (Barstad et al. 2009).

The smallest vessels in the coastal fleet which typically employ the '*juksa*', type gear (a hand line previously jigged manually, now frequently automated) at less than 10–11 m, and usually consisting of a one man crew, are particularly vulnerable to gale force winds and bad weather. Storm conditions may prevent fishers from leaving harbour to hauling their catch in from traps or from nets left at sea, which may result in gear entanglement. This may have consequences for fish quality, and incur additional costs in returning to the fishing ground both in terms of time and money (West and Hovelsrud 2010). A combination of storm activity such as unpredictable polar lows, and fish moving farther north or off shore and into deeper waters, as a response to warmer ocean temperatures, can be described as a current exposure-sensitivity for coastal fishers.

Polar lows constitute one example of natural hazard to high-latitude operations such as fishing vessels, shipping, and oil and gas platforms, and are particularly hazardous partly because of the difficultly in detecting and predicting them using conventional weather forecasting tools. A polar low is a small, localized cyclone that forms quickly over open sea during the cold season within polar or arctic air masses (Hamilton 2004).

Polar lows are particularly important in the Hammerfest and Lebesby cases, where they occur more frequently due to the particular atmospheric and ocean interactions in the Barents Sea. In one interview an incident was reported of a rescue vessel leaving the harbour in Hammerfest in brilliant sunshine, and 15 minutes later, and a long distance from shore found itself in the midst of a major storm caused by a polar low. There was no indication or forecast that the storm was on its way, and it created potentially dangerous conditions for all the vessels in the area.

Our local partners in Lebesby and Hammerfest have explained in interviews and discussions that stormy weather often leads to road, port and airport closures, interrupting the transportation of processed fish out of the region. In addition, small fishing vessels engaging in recreational fishing for tourists have expressed concern about the increased storm activities. Storms present major challenges for such boat captains, in terms of safety, comfort, tourists' experience and evaluation, insurance, income and regulations.

In Vestvågøy few fishers were under the impression that the rate of bad weather, locally defined as too harsh to fishing, had increased in their area, although some reported that they 'compete' among themselves about who dare go fishing in the worst weather. According to fishers, polar lows do not generally occur in the Lofoten area and are therefore not a concern among coastal fishers in Vestvågøy. On the other hand there are reports of several accidents associated with bad weather and linked to a new type of fishing vessel, the so-called 'speed *sjark*'.[2] The accidents were caused by a combination of vessel overloading and lack of equipment familiarity, combined with heavy seas and strong winds. The fishers explain that because they have to travel farther out to sea to fish, they are also more exposed to weather. The accidents illustrate an increased exposure-sensitivity for the smaller coastal fishing fleet connected with warmer ocean temperatures, an outward shift of cod, regulations out of step with biophysical changes and new equipment.

There is a difference in the mobility of fishers in Vestvågøy compared to Lebesby, which manifests itself in how they respond or adapt to bad weather. In Vestvågøy and in Lofoten in general, the cod season lasts from January to

[2] The speed 'sjark' is a small vessel typically around 30 feet that is built for higher speed than traditional fishing vessels.

March. In late spring to early autumn many of the fishers from Lofoten go to Finnmark, a distance of nearly 300 nautical miles, taking three days of travel. If bad weather prohibits landing the entire cod quota in Lofoten, they can catch the remainder of their quota when in Finnmark, where the cod fishing is good later in the season. In Lebesby the fishers, typically fish closer to home during the winter cod season due to excellent fishing, harbour and landing conditions, and more variable weather conditions. However, some fishers travel south to fish for blue whiting in the summer months when the weather is better.

Icing conditions are a current exposure-sensitivity noted by many of our local partners across the case areas. Coastal fishers explain that during winter, the main cod fishing season, strong winds from both the south and inland are often cold. When these meet the warmer, moist marine air, ice may develop on fishing vessels and gear. Accumulation of ice on vessels and equipment may in rare cases lead vessels capsizing, and the fishers are acutely aware of the danger. The combination of wind, temperature and moisture represent hazardous conditions which until recently were not commonly forecasted. Instead the fishers rely solely on their own experience and knowledge for assessing the conditions.

Power companies are always on the alert for forecast of icy conditions, which may lead to accumulation of ice on power lines and potential power failure. In 2006, an offshore winter storm (‘*Narve*’) caused a major power failure in Hammerfest, revealing a high degree of sensitivity to storms of this nature. The energy company, currently in the planning stages of a regional supply line, has sought better projections for future wind and snow load conditions in order to better adapt to extreme events. The adaptive strategies against such storms by companies such as Statoil and Hammerfest Energy include a call for changing the national standards for acceptable weather, and seeking knowledge of future weather and climate projections.

Shifting wind directions and changing snow patterns have been identified by municipalities as a current exposure-sensitivity. Municipal planners and road maintenance crews are continuously monitoring current conditions and seek to improve their knowledge about weather and climate especially with regard to consequences for road access and maintenance, infrastructure and housing.

Both Hammerfest and Lebesby have only one major road serving their municipalities and are therefore highly dependent upon proper road maintenance and open roads for access and supplies. In Finnmark County in particular, many major roads cross mountain passes that are prone to severe snow and wind, and it is quite common for such roads to be closed or passable only with an official escort vehicle. As an adaptive measure in Hammerfest a tunnel, funded by the national government, will be built for the main road into town, to avoid road closure and secure an uninterrupted connection. Lebesby municipality, in partnership with neighbouring Gamvik and with regional and national financing, has built a new all-season road to lessen transport delays and road closures due to bad weather during the long winter.

Municipalities know that major snowstorms and icy conditions require sufficient adaptive strategies to reduce the vulnerability of their communities, some of which are remote and isolated. To meet the challenges, the municipalities are equipped with major snow removing equipment, skilled operators, and an in-depth understanding of the various road conditions and the consequences for motorists, community supplies and safety. Their adaptive strategies also include a careful monitoring of the conditions and weather forecasts, proper maintenance of equipment and a sufficient workforce.

2.4.3 *Winters are Not What They Used to Be*

Our local partners identified an array of changing winter conditions, which are described below (see Table 2.2 for level of detail).

2.4.3.1 Shorter and Warmer Winters

Local observations from our case areas describe shorter winter seasons with respect to reduced snow depth and cover. In Lebesby, the municipality increasingly supports and promotes winter tourism, in particular snowmobiling, connected to the coastal liner and passenger ship Hurtigruten. The snow is expected to arrive in November-December, and tourist trips are booked in advance for these periods. Since the year 2000, the snow has arrived later than usual on the Nordkyn peninsula. Such conditions have reduced the winter ski and tourist season significantly and the potential for employment and income for small, local tourism outfits. People in both Lebesby and Hammerfest use nature extensively for recreational and food gathering purposes, and a lack of snow, or a delay in its arrival, affects peoples' sense of wellbeing locally.

For the stockfish producers in Vestvågøy, shorter and warmer winters require an earlier start for the stockfish production. Traditionally the production started in mid March, however currently the cod may be hung on the outdoor racks (see Fig. 2.6) as early as the beginning of February. The ideal outdoor temperature for drying cod is around 4°C (Tideman 2008). Significantly lower or higher temperatures will damage the fish. Warmer winter temperatures make regions further north more suitable for stockfish production, which may lead to increased competition for producers in Vestvågøy. Historically more northerly regions have been too cold to yield the same high quality of stockfish as the Lofoten region.

The adaptation strategies to reduce the effect of unfavourable drying conditions include selecting only the highest quality fish for production to ensure the best price, and ensuring that drying conditions are optimal when the fish is initially hung. The producer can choose to divert more or less of the

Fig. 2.6 Stockfish on drying racks at Steine, Vestvågøy. (Photo: Halvor Dannevig)

landed catch to stockfish and use the remainder for more reliable, but also less profitable products, such as salted fish. Nevertheless, all stock fish producers consider stockfish production as a risky business. As one of them described:

> In order to be a stockfish producer, you need to be like an extreme sports athlete. You buy fish worth millions and let it hang out exposed to weather, cross your fingers and hope that it turns out all right.

2.4.3.2 Avalanches

Avalanches are a major concern in both Hammerfest and Lebesby, and can be characterized as a current exposure-sensitivity. In both places the major towns are nestled against steep hills, which are prone to both snow avalanches and rock fall, and an important adaptive strategy for the municipalities is to reduce vulnerability by building and maintaining avalanche protection. The combined effects of increased precipitation, warmer winter temperatures and wind, increases the risk of avalanches in winter (Hanssen-Bauer et al. 2009).

Hammerfest municipality considers itself to be exposed and sensitive to avalanches and has undertaken extensive adaptation measures to reduce its vulnerability. Hammerfest town, being located between a steep hill and the sea, has a limited area for housing development, and the pressure on the municipality is high for approving new buildings. Hammerfest has been quite active in increasing knowledge and expertise about avalanches by developing and updating risk maps (in collaboration with the Norwegian Geotechnical Institute, NGI), prioritising areas to protect, restricting new construction, and securing expert assistance and financial assistance from the Norwegian Water resources and Energy Directorate. With national financial support,

Fig. 2.7 Avalanche protection in Hammerfest. (Photo: Grete K. Hovelsrud)

slide protection has been built to protect more than 530 buildings located in the municipality (see Fig. 2.7), and a priority list for further protection infrastructure has been developed. In addition, the municipality participates in an inter-municipal agreement for avalanche early warning, reducing the costs for such services. Different conditions cause avalanches in different areas, and for Hammerfest wind from the southwest is a determining factor. By being in close contact with the Norwegian Meteorological Institute and avalanche experts the municipality is able to anticipate and prepare for potentially dangerous events.

In Lebesby, much of the town centre is located under a steep mountainside, exposing houses and infrastructure to avalanches and rockslides. A fatal snow avalanche event in the municipality in 1958 led to the first construction of avalanche protection a year later. Since that time avalanche barriers have been upgraded and extended a number of times, and the risk of slide events has been mapped by NGI. However, due to the high costs of constructing protection in all areas, the municipality has had to prioritize coverage in the most exposed and high-risk areas.

Some municipal officials express concern about freeze-thaw cycles that increase risk of rock slides in exposed areas, and those responsible for roads have identified icy conditions caused by freeze-thaw cycles, as particularly perilous, and thus, a current exposure-sensitivity. This is a challenge for municipal maintenance of road safety. Their current adaptive strategies include keeping abreast of forecasts indicating road icing, and attempting to forestall the risks by sanding or salting the roads.

Three municipal departments in Hammerfest, dealing with housing, the airport and harbours respectively, are concerned with how the prevailing wind direction and snow load should determine the orientation of new houses, and the location of the new airport and harbour. Careful consideration of the siting of these developments constitutes an acknowledgement of the need to adapt planning specifications in the light of new climatic challenges. The municipality has developed wind maps for all potential development areas, and has for some years, required that new housing developments take climate change into consideration both in terms of where and how to build. Through its collaboration with the Norwegian State Housing Bank Hammerfest municipality has developed climate adapted housing.

With the introduction of the new national planning and building legislation, more legislative focus is placed on climate related requirements for new housing construction, although direct reference to climate change adaptation is omitted. As demonstrated above, Hammerfest has previously devised its own adaptation strategies in response to local climatic and weather conditions, independent of legislative requirements, indicating a high degree of adaptive capacity.

Another concern in Hammerfest is rain on frozen ground, leading to river flooding as the ground cannot absorb excess rainwater. Lack of sufficient municipal drainage capacity, due to inadequate pipe dimensions, may lead to flooding within Hammerfest city. Our local municipal partners in Hammerfest also expressed deep concern about extreme precipitation in both winter and summer which increases the run-off into the harbour. This runoff is likely highly contaminated by sediments from closed polluted ship yards and fish processing industrial sites. This can be characterized as a current exposure-sensitivity and the current adaptive strategy involves monitoring the pollutant levels on the harbour sea floor to assess the rate at which pollutants trapped in the sediment seep out into the sound. The municipality is also looking into ways of securing the sediments, by studying how the problem has been dealt with elsewhere.

2.4.4 Are We Building Too Close to the Sea?

First came the harbour and then came the town – the harbour master in Hammerfest.

Our case areas are all located by the sea, and have extensive experience with storm surges, spring tides and waves crashing against docks, installations and ships. Sea level rise in Norway is currently counterbalanced by land rise which will not continue in the future, and long-term future projections indicate significant sea level rise (Hanssen-Bauer et al. 2009). Our local partners noted that storm surges and spring tides present risks to housing, docks, harbours and installations such as the Melkøya LNG plant, thus additional projected sea level increase will inevitably have future consequences for the communities. These structures and facilities have been based on historic sea level and historic storm surge maximums, and have not taken into account current and future increases in storm surges.

This is also true of the docks and harbour currently under construction in Hammerfest. This is in stark contrast to the requirements placed on housing developments to take into consideration provisions for storm surge water drainage. The new cultural centre in Hammerfest has been built on stilts in the harbour spurring discussions among locals on whether it has been wise to construct housing and other buildings close to or even into the harbour. Arguments in favour note that the options for constructing new buildings are limited because of the physiographic features of Hammerfest. Likewise in Lebesby, the recent construction of a modern dock to service the town and the coastal liner Hurtigruten, did not consider projections of future storm surge and sea level rise.

Traditionally docks and harbours were used for ships and cargo storage, whilst in modern times breakwaters are built along the shore and housing close to the docks. This resembles mal-adaptation, because during heavy storm surges the sea water may overflow the docks and into the houses located behind. Storm surge and spring tides have been identified as current exposures-sensitivities with respect to the harbours, docks and housing. The municipal planners and decision-makers have to balance the need for housing and development with national regulations and safety issues. Their current adaptive strategy is to anticipate projected sea level rise and storm surges in determining the minimum building distance and elevation from the sea. This was done by Vestvågøy municipality when they changed the plans for the new dock and fish processing plant currently under construction by adding 20 cm in height to the original plans. This was a result of the municipal planners of the dock inquired about projected sea level chart adjustments to 2050, and recommendations by the Norwegian Coastal Administration. The municipality combined the sea level projections for 2050 with local experience of salt water drain inundation during spring tide, particularly when in combination with on-shore winds. Following a precautionary principle and showing a willingness to pay the costs the municipality by adjusting the distance from the sea devised an adaptive strategy.

2.5 Socio-Economic Exposure-Sensitivities

Concurrently with discussing locally significant weather and climate elements, the researchers and local partners have identified non-climatic exposure-sensitivities shaping the vulnerability, adaptation and the adaptive capacity of the communities. These include social conditions, economic factors, demography (outmigration and age structure of the labour force), municipal capacity and institutions for natural resource management (e.g. Eakin and Lemos 2006; Smit and Pilifosova 2001; Tol and Yohe 2007). In Table 2.3 we present a summary of the locally identified current socio-economic exposure-sensitivities.

Table 2.3 Socio-economic factors

Socio-economic condition	Exposure-sensitivities
Outmigration (L)	A stable population base is crucial for maintaining viable communities and municipal services for fishermen and their families. Returning, educated youth are seen as a resource and basis for innovations in the fisheries and municipality to deal with change.
Aging fisherman population and recruitment (L,V)	Affects the continuity of coastal fishing activities, the attractiveness of the trade to youth, and the transfer of knowledge from older to younger fishermen
Fishing regulations- and policy (H, L, V)	Affects fishermen's ability to respond to changing fish stocks. Affects the cost of entering the fishing trade and the profitability of fishing activities. Affects the stability of supply of raw fish supplied to landing facilities throughout the year. Affects spatial and temporal distribution and availability of fish through regulation of fishing pressure in different seasons and regions. Has created incentives for possible unsafe vessels in a context of more extreme weather. Has led to concentration of fishing rights and increased profitability for some fishermen.
Legal factors (H, L) -Income tax regulations -Insurance requirements for fishing vessels	These factors may limit fishermen's flexibility to deal with variable and changing climatic, biological and societal conditions
Market factors -Price paid for fish to fishers (H, L, V) -Price paid for fish products - Fuel prices (V)	International market price for fish and fishproduct determines the profitability for fishers, fish buyers- and processers. Fuel prices influence the profitability of fishers.
Food authority regulations (V)	In 2004, new food security regulations were imposed upon fish landing facilities- and processors, which required substantial investment in buildings and equipment and imposed a demanding quality control regime.
Capacity of municipal departments (H, L, V)	Ability to cope with new situations, plan for climate change
Municipal economy (V)	Ability carry out non-mandatory tasks, support industry development

H = Hammerfest, *V* = Vestvågøy, *L* = Lebesby

2.5.1 A Fishery Sector Under Changing Management and Market Conditions

Our local partners involved in fisheries identify a complex set of factors that influence the overall profitability and the ability to make a living of coastal fishing, including the size of quotas for different species, the price of fish, the cost of fuel and fishing gear, the location of landing facilities, and national taxes and subsidies.

Coastal fisheries are increasingly integrated and exposed to global market mechanisms (e.g. Keskitalo 2008, 2009; Keskitalo and Kulyasova 2009). The current global financial crisis has led to a reduced demand for the exclusive Norwegian cod, which unfortunately has coincided with reported excellent fishing conditions. Fewer landing facilities, with weakened economic resources, do not have the storage capacity required to purchase all catches from the coastal fishers not being able to deliver their catch, and the coastal fisheries are suffering as a result. The important interplay between small coastal fishing communities and the broader social and economic contexts in which fishing activities are embedded illustrates the cross-scale challenges for adaptation in coastal fisheries: Supply of fish depends on environmental, including climatic conditions, while access to fish depends on fishing regulations, technology, choice, weather conditions, and price and cost factors (West and Hovelsrud 2010).

In the past coastal fishers were also farmers (‘*fiskarbonden*’) or held part-time jobs to ensure a stable year-round income. This was a successful adaptation strategy to a seasonal and variable resource-base (e.g. Brox 1966; Vea 2007). However, the current national income tax and quota systems for fishers restrict multiple incomes and encourage specialisation by requiring people to state a primary livelihood, and via financial and tax penalties for income earned in additional activities. This creates barriers for livelihood diversification that might otherwise help to enhance the adaptive capacity of individuals as they face a range of social, environmental and economic realities.

Another factor that contributes to existing exposure-sensitivities identified locally is the increasing debt rate of the coastal fishing fleet caused by the recent quota reforms (MoFC 2006). According to fishers, the increasing debt rate, caused by hedging in future fishing quotas, has altered the seasonality of fishing operations. Previously, the fishers in Vestvågøy were able to wait for the spawning cod to reach Lofoten, which normally occurred in mid-February. Currently, and because of heavy financial obligations, the fishers cannot afford to wait, and they travel north to catch the spawning cod as soon as the fisheries open on 1st January. When the cod finally reaches south to Lofoten, most fishers have already landed their full quota at facilities farther north, resulting in less cod being landed locally.

Stockfish producers and the fish processing industry face a complex set of non-environmental exposure-sensitivities, including food safety requirements as stipulated by the national authorities and the European Union, landed fish price and international fish market conditions. The stockfish industry, for example, is highly dependent on the Italian market, where the large annual fluctuation in price is closely connected to the quantity and quality of stockfish, and a range of factors influencing the demand in the Italian market.

The producers aim to reduce their dependency on the Italian market by developing new stockfish-based products, as well as creating and gaining entry to new markets for traditional stockfish. Furthermore, the stockfish producers are dependent upon good relationships with banks, to avoid bankruptcy should there be consecutive years with losses. The stockfish producers are at the whim of the Italian market and may end up buying fish at a higher price than it will sell for in a particular year, and resort to storing the fish until the price increases. As one employee in the stockfish industry said:

> Several years ago, a stockfish producer was not able to sell stockfish for three years. The first year passed, the prices were too low, and he did not sell. When next season came, he went to the bank and got a loan to buy fish for making new stockfish. But also this season the prices were too low, so he could not sell. And also this time he got a loan from the bank when the next season started, so he could buy the catch. Then finally he got a good price for his stockfish and could pay his debt to the bank.

Despite the economic challenges that fishers face, new market and innovation opportunities emphasising fish quality, and combined fishing-tourism activities, are some of the adaptive strategies that fishers and fish producers in the fish industry in our case studies are implementing to deal with the economic variability to which fisheries are exposed. In Lebesby the local landing facility is marketing high quality cod and red king crab products for export to Europe, Japan, and North America. Innovation of new products seeks to capitalise on locality, environmental sustainability and quality issues associated with the gear employed to fish and process the product. Several local fishers in Lebesby also combine fishing with tourism, and receive economic support (in the form of low-interest or interest-free loans) from the local landing facility and national innovation funds for entrepreneurs. The local landing facility in Lebesby has plans to open up its processing facilities to tourists to try to diversify its income and capitalise on the inflow of tourists from the coastal liner Hurtigruten.

2.5.2 Outmigration, Recruitment and Aging Fishers

The cultural, social and demographic factors that currently shape coastal fishing activities are perceived by our local municipal and fisheries partners to be of particular concern for their livelihoods. The socioeconomic exposure-sensitivities are further magnified when seen in combination with climate related exposure-sensitivities.

Outmigration to larger centres, an aging fisher population and declining recruitment to fisheries are three ongoing trends of concern in our case communities. Despite Norway's official national policy of maintaining a dispersed settlement pattern, outmigration from small, rural settlements to larger urban centres, continues. The population in Lebesby, for example, has been in decline for several decades, with a reduction of 15% between 1997 and 2008 (Lebesby kommune 2008). While Hammerfest, in the same county, has experienced a stable population, due to oil and gas development and production. Vestvågøy further south and with a more diversified livelihood base than Lebesby maintains a stable population, with many young people settling in the municipality. The Lofoten region, where Vestvågøy is located, has however experienced a steady decline in its total population. According to municipal representatives in Lebesby, a declining population is a problem on many levels, one important one being that it reduces the municipality's tax base, and in turn its ability to provide infrastructural support such as landing facilities, the docks and storehouses where the fish is delivered to the buyers, and services needed to support fishing activities, as well as social and economic support for fishers' families (West and Hovelsrud 2010).

According to fishers in Lebesby, and supported by municipal reports and discussions, outmigration is connected to the municipality's peripheral location and its dependence on a narrow range of economic and income opportunities, as well as a lack of interest amongst skilled young men and women in entering the fishing industry. Likewise in Hammerfest the local fishers are concerned that young men and women will be absorbed into the petroleum industry, thus reducing recruitment to the coastal fisheries. The young and educated are often not interested in pursuing fishing, with its irregular hours and variable pay, as a full-time career. Fishers also surmise that lifestyle choices and family dynamics have changed over the years, and as a consequence fishers with young families are less willing to accept being at sea, in small vessels, in rough conditions for any length of time. Many prefer instead a fishery where they can come home every day to be with their families, but this seldom gives a satisfying income if not combined with other jobs. Others take jobs aboard supply ships in the offshore oil and gas industry to earn money for purchasing their own fishing vessels, and are therefore not participating in the fisheries as hired hands, but wait until they can captain their own fishing vessels.

An aging fisher population further threatens the traditional basis for income and employment in the case areas. The average age of all fishers residing in Lebesby in 2007 was 49 (DoF 2007), and few youth are being recruited to the trade. The active fishers are concerned that lack of recruitment interrupts the transfer of fishing knowledge and skills between generations. Coastal fishers in Northern Norway rely primarily upon their own experience-based and locally transferred knowledge about weather, ocean and fish interactions, and adjust their activities according to their own observations, discussions with peers and local forecasts. Detailed local knowledge about environmental conditions is imperative for safety at sea and for success in catching fish, and without close contact between the older and the younger fishers this knowledge will not be transferred and over time may be lost. In Lebesby and Vestvågøy, the municipalities have various adaptive strategies to hamper outmigration, including creating jobs for the youth, providing support for entrepreneurs and affordable housing, and creating incentives for expansion in the coastal fishing fleets and relocation to the municipalities.

2.5.3 Fisheries Management

> It depends on whether the politicians want lights in all the houses in each cove and on each island, or larger boats which may deliver the fish locally and provide more jobs–*fisher in Hammerfest*.

Our case study partners describe fisheries management as influencing both fish stocks (by controlling fishing pressure on particular species in time and space) and fishers' adaptation to these changes. Fisheries activities are inherently flexible and adaptive in order to deal with a variable and migratory resource (see Coulthard 2009; Jentoft 1998). Norwegian fisheries are shaped by a range of institutions, such as the quota negotiation process and the market for first order sale of fish, and are highly politicized (e.g. Jentoft 1998; Keskitalo 2009; Keskitalo and Kulyasova 2009). Fishing is regulated for individual fish species, in time and space, according to vessel lengths and place of registration, and fishing zones are regulated by both national and international laws (Jentoft and Mikaelsen 2004). Norwegian fishing regulations have transitioned over the past four decades from an open, to a limited entry, quota-based fishery based on the precautionary principle and total allowable catch (TAC) (MoFC 2007). The Barents Sea – North Atlantic (NA) cod stock is managed jointly by Norway and Russia, with Norway having the rights to about 45% of the annually agreed quota for this stock (Fiskerirådgivning AS 2006). The annual cod quota is based on scientific assessments of the size and health of the fish stocks, which can be seen as a national adaptation strategy to ensure a healthy and sufficient stock.

A key effect of the introduction of the quota system has been an increase in the value of delimited fishing rights, strictly regulated and with partly saleable quotas. This has led to widespread structural changes in the Norwegian fishing fleet that have reduced the number of total fishers and fishing vessels, and concentrated fishing activities into larger centres such as Hammerfest (Karlsen 2004; Lindkvist 2000). Because of the declining employment in fisheries (in Hammerfest reduced by 50% and in Vestvågøy by 30% between 1970 and 1990), the productivity and income of the individual vessels have increased as a result of the structural changes (see Fig. 2.4) (Fiskerirådgivning AS 2006). Questions are raised among our local partners about the relationship between the Norwegian regional development policies and fisheries management that seek to ensure an equitable balance of fisheries participation and rights in different regions, economic efficiency and ecological sustainability. Recent changes in fisheries management have reduced the size of the vessels that may participate in certain fisheries such as the red king crab, making it possible for smaller vessels, often with only one fisher, to travel farther out to sea to fish.

The characteristics and features of fisheries management regulations determine the range of adaptive strategies available to fishers for dealing with the various exposure-sensitivities identified in Section 2.5. Adaptive strategies include finding ways to navigate institutional settings in ways that provide profitability and greater income security for individual fishers. Warmer ocean temperatures and changing fish distribution, abundance and species composition may provide new opportunities for local fishers in all three case communities. However, potential economic gains will depend on the species, its location, its market demand (and price), the availability of processing facilities that can land and process new species, appropriate fishing technology, and appropriate fishing regulations.

2.5.4 Municipal Capacity

All our municipal partners emphasize that they have developed adaptive strategies based on their experience in dealing with weather and climate over the years. We found, not surprisingly, that municipal officials were highly knowledgeable and had much expertise concerning local environmental conditions and how best to deal with them. However, several studies of municipalities and adaptation in Norway have concluded that few municipalities have prioritised a systematic approach for confronting the challenges of climate change (e.g. Amundsen et al. 2010; Næss et al. 2005; Vevatne and Westskog 2007). That Hammerfest and Lebesby have sought external expertise about avalanche conditions, and have invested in avalanche protection is both a reactive adaptation to historic events, and an adaptive strategy for future events. However the exposure is not directly attributed by the municipalities to climate change. Hammerfest has only recently started to include future climate change in its long term planning.

The municipalities are central actors in maintaining sustainable and functioning communities. They provide favourable conditions for local industries through infrastructure provision such as roads and harbours, and entrepreneurial business support, either directly through shared financing schemes or municipal ownership. In addition to dealing with the stresses of occupying a geographically peripheral location, an aging population, and outmigration, our case municipalities face multiple challenges connected with capacity problems and budget constraints.

A major and shared challenge for the three municipalities is a lack of adequate human capacity and finances to plan and prepare for new and different conditions despite their efforts to seek expertise and funding. As stated by one of our partners – 'the officials are so occupied managing their little piece of legislation that no one gets the broader picture'. Such fragmented organization and lack of capacity are identified by one of our partners as a major barrier for planning for adaptation to climate change. Both the large municipalities (Vestvågøy and Hammerfest), and the smaller one (Lebesby) have similar capacity problems. There are simply not enough human or financial resources available to carry out the different tasks required to maintain municipal services and at the same time increase expertise and knowledge in relation to potential climate change risks and opportunities. A common result is that the municipal human resources become exhausted. Across the cases, the impressive engagement and efforts of individual municipal officials is a major driver behind many of the current projects and increasing local expertise. The limited financial and human resources and burnout among engaged individuals (‘*ildsjeler*’) have consequences for the adaptive capacity of the municipalities to plan and prepare for current and future climate changes.

Lebesby municipality draws on a number of engaged inhabitants, including local innovators and entrepreneurs who are marketing the municipality through nature-based tourism, alternative clean energy investments and coastal culture and identity. However, our partners note that it is often the same individuals who sit on a range of voluntary committees and occupy leadership positions within the community. Without adequate compensation and support, over time these innovators may become discouraged and lose their motivation. The municipality has made efforts to diversify the local employment profile and create more jobs (e.g. via tourism), and maintain its population (the agricultural generation shift fund is one example) in order to make the community an attractive place to live and work, and to maintain a stable tax base. Here a sustainable and vibrant community is seen as a central social, economic and cultural value. In Hammerfest municipality, individual efforts and interests, in collaboration with external scientists, have led to a remarkable successful recovery operation to restore destroyed sea bed vegetation. The destruction of the coastal fish habitat is a current exposure-sensitivity for the coastal fishermen in Hammerfest, and the restoration effort is an adaptive strategy for the fishers in the municipality. Without the enthusiasm and efforts of individuals such projects would not have occurred. In Vestvågøy individual municipal officials also exhibit enthusiasm and engagement with respect to being involved in research projects such as CAVIAR to increase their knowledge, expertise and adaptive capacity.

Hammerfest municipality has had a substantial increase in revenue in connection with the establishment of the LNG facility at Melkøya, which is increasing the general adaptive capacity of the municipality, but has not yet resulted in expanding the local workforce, beyond the two employees dealing with climatic and environmental topics. Such topics appear not to be high on the political agenda in Hammerfest. Vestvågøy on the other hand struggles with the municipal economy and has been forced to make unpopular spending cuts, such as school closings. Lebesby has status as a ‘transformation municipality’ entitling it to subsidy from the central government, which is a type of financial assistance to counter declining revenues, high debt and outmigration.

Our municipal partners with extensive knowledge and deep engagement in local issues and conditions, have noted that they simply do not know how and where to find the relevant information about the consequences of climate change, how to develop adaptive strategies and how to inform the public. With a poor information flow from the national to local level, the municipalities are dependent upon individual engagement and ability to seek knowledge. Our findings show that it is not only the institutional factors which determine the adaptive capacity but the efforts of engaged individuals is also a critical factor across the communities.

2.6 Future Conditions

In our case studies we work closely with climatologists in an iterative process to develop the climate elements that are most relevant and feasible for downscaling. This is based on identification of relevant climate elements by the local communities. A main scenario was based upon output from the regional climate model HIRHAM (Haugen and Haakenstad 2006), but adjusted to the local topography by a method developed by Engen-Skaugen et al. (2007). In order to get a measure for uncertainty of the main scenario, the projected local changes in temperature and precipitation were further compared to the results from empirical-statistical downscaling (Benestad et al. 2008) from a large multi-model ensemble.

Table 2.4 lists of some of the relevant future climate elements as identified by the communities. The list reflects the weather conditions that our local partners are currently concerned with and their interest in how these develop in the future. Through discussions with climatologists we have been able to determine which of these elements can be downscaled for future projections, and which ones, such as wind, cannot. The table also shows that many weather related conditions of local concern occur when combining climate elements such as precipitation and temperature, above or below freezing. The process of

Table 2.4 List of climate elements identified in cooperation with local partners for downscaling of climate model projections

Climate element identified for downscaled projection	Result
Extreme weather and storms (V, H, L)	n
Polar lows (H, L)	n
Sea level rise (V, H, L)	y
Storm surges and wave height (V, H, L)	y
Low pressure trajectory (H)	n
Air moisture (V)	n
Precipitation - Extremes (V, H, L)	y
Precipitation- Monthly mean (V, H, L)	y
Precipitation – Rain combined with frozen ground (H, L)	y
Precipitation – Composition- snow, slate, rain (H, L)	y
Precipitation – Snow cover- and amount (H, L)	y
Temperature – Extremes (V, H, L)	y
Temperature – Monthly mean (V, H, L)	y
Temperature - Freeze-thaw and 'zero degree' conditions (H, L)	y
Sea temperature (V, H, L)	y
Wind- Extremes (V, H, L)	n
Wind, wave height and sub zero conditions (H, L)	n
Wind – strength and directions pr. Season (V, H, L)	n

H = Hammerfest, *V* = Vestvågøy, *L* = Lebesby, *N* = not possible to model and project, Y = projections is produced and discussed with local partners. Represented in the forms of maps, column- and line diagrams identification, which was a highly collaborative effort between scientists and local partners, shows that there are salient interlinkages between future projected climate change and societal conditions. In this section, we present some of the downscaled projections that have been presented to the case study communities for feedback and discussion. Being a work in progress we also present some of the case study communities' responses to the projected changes in climate, in terms of the implications and challenges such changes may signify. The downscaled climate projections are currently being discussed in the case communities and the final results will be presented in forthcoming publications.

2.6.1 Climate Projections and Local Implications for Case Communities

2.6.1.1 Ocean Temperature

An increase of 1–2°C in ocean temperature is projected for the Barents Sea by 2070 under a scenario of doubled atmospheric CO_2 levels (see Fig. 2.8) (Førland et al. 2009; Loeng et al. 2005). A sustained increase in average ocean temperatures in the Barents Sea region will likely lead to major reductions in the already reduced seasonal ice cover (Overland and Wang 2007) and may result in a shift in the location of the Polar Front, where warmer Atlantic and colder Arctic waters meet, to the north and east of its present location (Ellingsen et al. 2009). Potential changes in ocean circulation and a decrease in inflow of warmer, saltier Atlantic Water (see Koenigk et al. 2007; Wu et al. 2008) may also occur.

Future ocean warming is expected to lead to a northward shift in the distribution of cod spawning areas and to changes in the distribution of key commercial species, and a potential influx of southerly species (ACIA 2005; Drinkwater 2005; Loeng and Drinkwater 2007; Sundby and Nakken 2008). These changes may represent new opportunities for the fishers and communities, but may require adjustments in fishing technology, traditional or local knowledge, and in management regulations (West and Hovelsrud 2010). The fishery actors in all the three cases interpret future climate change in the context of continuously changing conditions, which they consider themselves to be highly adaptable to. Hence fishers do not perceive themselves to be negatively affected by climate change. Their future adaptive capacity, however, is not only determined by their current adaptability but by changes in fisheries management and market conditions. Fisheries regulations, while on the one hand potentially enabling greater geographic mobility in the future, may also increase the already hazardous occupation of coastal fishers, and add an unexpected exposure-sensitivity to the fishing activities (MoFC 2006). West and Hovelsrud argue that perceptions of being highly adaptable may be a barrier to adaptation (West and Hovelsrud 2010).

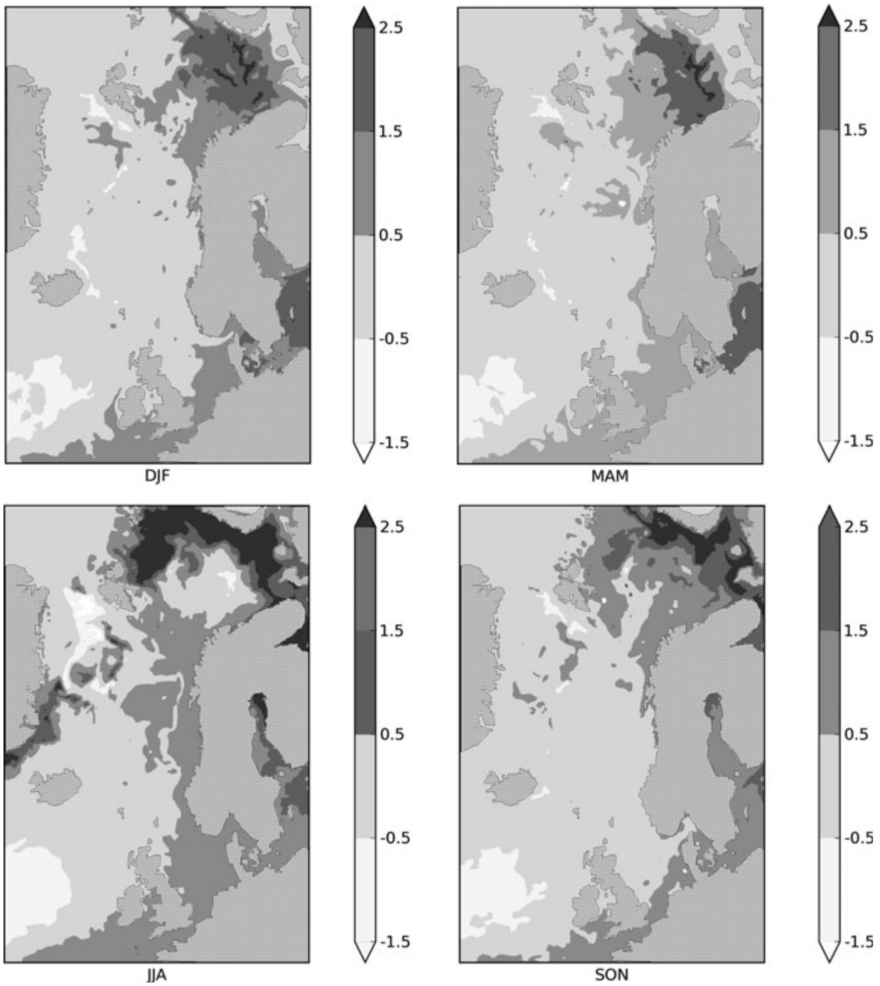


Fig. 2.8 Projected changes by season for sea surface temperature in the Nordic seas from 1986–2000 to 2051–2065. The north-eastern Barents Sea shows the largest increase, and the increase is largest during summer and autumn. The Mid-Atlantic shows a temperature decrease as a response to a projected weakened North Atlantic Oscillation. *Source*: Bjørn Ådlandsvik, Institute for Marine Research, Norway

Fishers in Vestvågøy do not perceive a northward shift of fish species as problematic, while Lebesby fishers view potential fishing further offshore in combination with storm activity as a potential challenge when considered in the context of current fisheries regulations and management. That a continued northward shift of species could eventually lead to less spawning cod near Lofoten and Vestvågøy, has not been identified as a future exposure-sensitivity by our local partners. However, the fishers recognize that new species such as mackerel and crab will be commercially important and may replace spawning cod.

A continued northward shift in the cod fisheries would create increased challenges for landing facilities in Vestvågøy, and is recognized as a contributing future exposure-sensitivity when combined with other non-climatic exposure-sensitivities such as market conditions and framework regulations. Combined, these could increase future vulnerability for the industry.

The municipality, in an effort to meet the future challenges posed by the northward shift in fisheries, has plans for developing and strengthening one harbour on the north side of island, to be closer to the northern fisheries (Vestvågøy municipality 2008). Similarly the municipality has plans to improve road access in two fishery communities, Ballstad and Stamsund, in order to facilitate transportation from landing facilities in the north to the fish buyers in these communities, as well as supporting fish buyers in the municipality to establish landing facilities further north. This kind of infrastructure development is dependent upon financial contributions from the national government.

2.6.1.2 Temperature and Precipitation

Regional climate simulations (HIRHAM 25) project an air temperature increase of 1°C in coastal areas in Northern Norway by 2050 and a 1.5–2°C increase in the eastern part of Finnmark county, with the strongest increase in winter temperature (Førland et al. 2009). Figure 2.9 shows the downscaled temperature projections for Vestvågøy. By the end of the century the temperature is expected to increase by 2.5–3.5°C for Northern Norway (Førland et al. 2009).

The future climate could reach a point where it is too warm and moist for optimal stockfish production in Vestvågøy. This is likely to have graver implications for the producers in Vestvågøy than further west, as the temperature increases more towards the east than the west. Producers point out that there has been stockfish production in the region for more than 1,000 years and therefore they do not perceive the projected climate change as a threat. Furthermore, the risk of a chronological mismatch between availability of cod catch and the drying season (as discussed in Section 2.4) could be ameliorated through existing strategies such as land-based transport. The stockfish producers are not particularly concerned about this potential climate development, indicating a high confidence in financial capacity.

For Northern Norway, the precipitation is expected to increase by 20–30% by 2050, with the largest increase in Winter and Spring (Førland et al. 2009). The combination of increases in both temperature and precipitation will change the composition and timing of snow and rain through out the seasons, as shown in Fig. 2.10.

Hammerfest municipality is concerned that increased precipitation in the future will increase run-off to the harbour, accentuating highly polluted sediments. Such run-off combined with increased wave action raises concern that pollutants trapped in the sea-bed will be released. A future adaptive response being considered is to reduce runoff from land and find ways to secure the

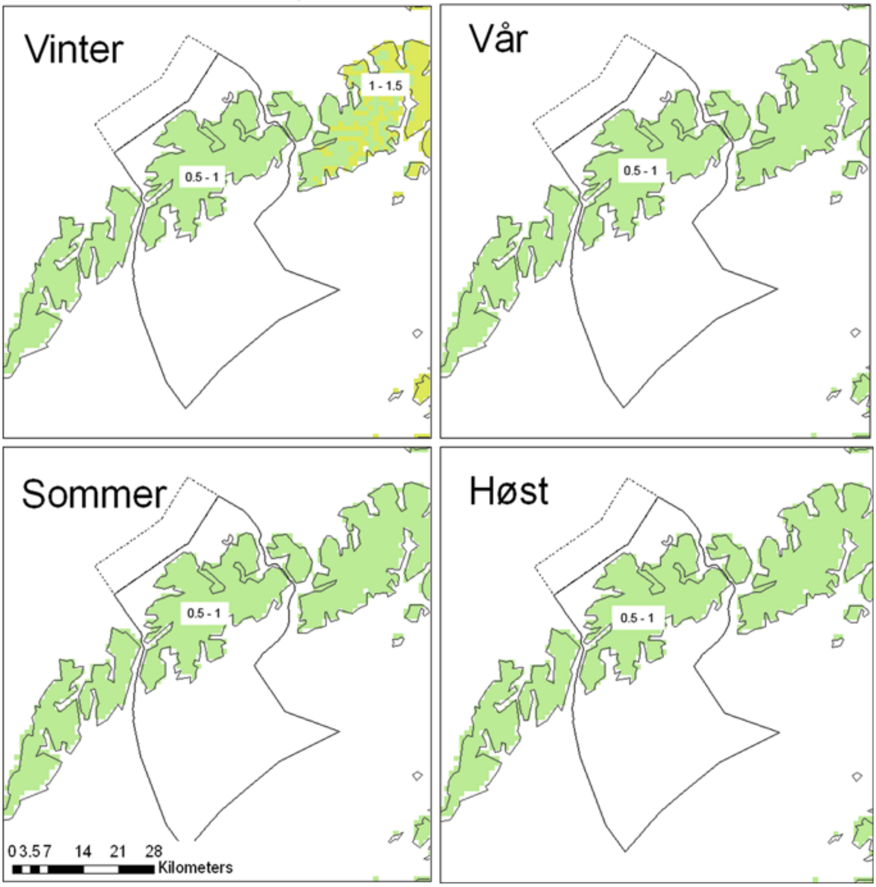


Fig. 2.9 Projected changes in mean temperature pr. season (Vinter - Winter; Vår - Spring; Sommer - Summer; Høst - Autumn) in Vestvågøy municipality from the period 1981–2010 to the period 2021–2050. Projection: ECHAM4/OPYC3 GSDIO. Emission scenario: IS92a. Downscaled to 25 km resolution with regional climate model HIRHAM and adjusted empirically to 1 km resolution. *Source*: Torill Engen Skaugen, Norwegian Meteorological Institute

sediments in the sea-bed. The municipality, inspired by successful measures near Oslo, has discussed the possibility of mixing sediments with concrete and constructing a breakwater in town.

Lebesby and Hammerfest municipalities note that if the future projections indicating less snow are correct (see Fig. 2.10), their snow clearing budget could be reduced, resulting in more money for other tasks. The new national regulations for snow load on housing and buildings have doubled the removing costs for municipalities. The road maintenance workers expressed great interest in how snow conditions may change in the future, and whether new adaptive strategies would be necessary. The projected warmer temperatures in

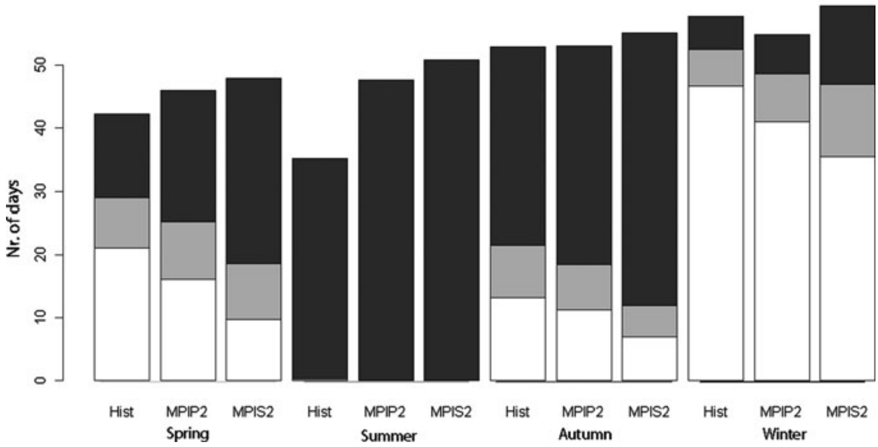


Fig. 2.10 Projected changes in composition of precipitation (snow, slate and rain). Each group of three bars represents a season. For each season, the *left bar* displays the period 1961–1990, the *middle bar* represent the period 1981–2010 and the *right bar* displays the period 2021–2050. *White colour* represents snow, *grey* represent slate and *black* represent rain. *Source*: Hans Olav Hygen, Norwegian Meteorological Institute

winter combined with precipitation will likely create more days with icing and freeze-thaw cycles, and the reduced snow removal budget may be used for sanding and salting the roads instead.

In Lebesby, a number of areas remain at risk of avalanches, including the local cultural tourism facility Foldal, where avalanche fears caused the evacuation of tourists as recently as 2009 (Kjell Wien, pers. comm). A potential increased avalanche risk at Foldal under climate change could pose a problem for museum tours and overnight guests in the municipality.

2.6.1.3 Sea Level Rise and Storm Surges

There are major uncertainties associated with global sea level rise (SLR), and it is widely recognized that models used in IPCC AR 4 underestimates future SRL (Hanssen-Bauer et al. 2009). For Norway it is also necessary to consider the land isostasy (land uplift) that has taken place since the last ice age when the Fennoscandian ice cap disappeared (Hanssen-Bauer et al. 2009). Here we have used estimates by Drange et al. (2007), who have calculated sea level rise and storm surge for 2050 and 2100 for all Norwegian coastal municipalities. These estimates have taken the isostasy into account. For Northern Norway, sea level is projected to increase by up to 35 cm by 2050 and up to 1 m from current maximum level, by the end of the century (Hanssen-Bauer et al. 2009). Storm surges are expected to increase by 2.5–4% by 2050 (ibid).

Discussions in Hammerfest revealed a concern about future increase in ocean swells and fetch as a result of less sea ice further north. The magnitude of fetch and storm surge have consequences for safety and preparedness in shipping and installations at sea, and for exposed harbours. Future changes in such conditions may call for new requirements and a heightened awareness of national government officials and local planners. Municipal planners in Hammerfest and Vestvågøy are increasingly concerned with future SLR and have taken this into account in land use planning. They are also discussing adaptive measures to deal with sea water intrusion into existing buildings. Farmers in the Laksefjord area of Lebesby expressed concern that SLR would cause inundation of salt water and threaten agricultural land that is located adjacent to the fjord.

2.6.2 Discussion of Future Conditions and Adaptive Capacity

When discussing future conditions in Vestvågøy there is one topic that overshadows climate change and most other issues: oil drilling in the Lofoten waters. The fishers are certain that the oil activity will result in a loss of fishing ground access, and that oil drilling possibly could harm the fisheries. Some claim that it will be the end of Lofoten as a major fishing and spawning region. In all case areas, fisheries remain according to our partners, a vital industry, even though the share of employment in fishing continues to decline.

The stockfish industry will likely be reliant upon innovation in order to sustain its current turnover and employment, in face of the other challenges mentioned in Sections 2.4 and 2.5, particularly market challenges. The projected changes in temperature would probably lead to higher frequency of failed drying seasons, and combined with more challenges with securing raw material as a response to the northern shift in cod fisheries, this will be a disadvantage to the Vestvågøy producers in the competition with producers further west and north. Willingness to innovate (e.g. by developing new stockfish products for Norwegian consumers), has been clearly demonstrated by some producers, indicating high adaptive capacity. The question remains whether these developments are sufficient to maintain the importance of the sector within the region.

Several authors note that future fisheries management and governance decisions may play a more important role than climate change in determining the fate of northern fish stocks (Hovelsrud and West 2008; Eide 2008; Vilhjálmsson et al. 2005). In partial support of this position we further argue that climate change represents an additional stress to current resource management regimes, which may increase local vulnerability. Fishing seasons, quotas and management of individual fish stocks do not take into account the variable weather patterns and longer-term climate trends which often determine when, where and under what conditions coastal fishing activities can take place. These are conditions that, according to fishers, scientists and managers are already being affected by climate change (Browman 2008). If regulations expand the fishing zones farther out to sea, and this coincides with an expected increased frequency in extreme weather conditions, it also increases the hazards for small, single manned fishing vessels, while at the same time giving access to more distant fish stocks. Climate change may therefore increase the need for flexibility in the fisheries because of the combination of a shift in fish species and interactions, and changing conditions at sea (Hovelsrud and West 2008). The fishers that are currently in business have proven to have high adaptive capacity to the changing regulatory frameworks of the past and present. But currently the regulations do not add to the adaptive capacity of fishers to future exposure-sensitivities. The future economic, social and environmental viability and sustainability of the coastal fisheries have consequences for the future viability and sustainability of the municipalities. Information flow and financial security are two major factors enabling municipalities to develop successful adaptation strategies for future exposure-sensitivities, and hence these two factors are crucial determinants of adaptive capacity to future exposure-sensitivities. The municipal budgets, albeit being solvent, are already strained, and preparing for changing climatic conditions that are uncertain is not a priority among politicians. It is, however, not sustainable for municipalities to rely on engaged individuals to reduce future vulnerability. It is also necessary to strengthen the local institutional capacity.

2.7 Conclusions

For the municipalities in our case areas to continue to provide the services and ensure community wellbeing, which they are designed to do, they will need better access to information about how to assess future climatic and societal changes. The case studies presented in this chapter were developed in close cooperation with our local partners in Hammerfest, Lebesby and Vestvågøy municipalities. We have found that local involvement is beneficial along a number of dimensions including to ensure proper focus, to increase local awareness about climate change adaptation, to provide necessary input to climatologists, and to highlight the complex linkages between climatic and socio-economic conditions. By involving local partners we have been able to unpack the high level of detail needed to understand how climate change will impact local communities. Through a description and analysis of the different exposures-sensitivities to change (climatic and non-climatic) we have increased our understanding of how these in combination have consequences for current and future adaptation and vulnerability. We have focussed on coastal fisheries and municipal planning as two major arenas for change, and have shown that adaptation takes place along a number of dimensions and at several societal levels. Many adaptive strategies occur in response to socio-economic conditions, some are implemented to deal with variable weather or environmental conditions, and others seek to address a combination of both.

Three interlinked factors are according to our empirical findings, currently of concern for coastal fisheries: changes in bio-physical conditions (ocean temperature and fish distribution and behaviour); fisheries management and regulations (vessel size, species, and quotas) and societal conditions (outmigration, market factors, and transfer of knowledge). The interlinkages between these have first and foremost been captured and understood through local involvement in our research. In many ways this is a classic example of that the whole is more than the sum of its parts. Climate change is currently not seen by our partners as the major driver of change locally, and we have found that fishers interpret the current changes in a familiar context of natural variability. Nonetheless, both outmigration and an aging fisher population challenge coastal communities' viability, and will likely strain the capacity to deal with the impacts of climate change on coastal fisheries. Without landing facilities, fishers and active fisheries, the municipalities' strong coastal fisheries identity and culture may decline. This may in turn reduce the attractiveness of fisheries investments necessary to meet future environmental and societal challenges (West and Hovelsrud 2010).

Municipalities operate in a world bound by regional and national rules and regulations and local responsibilities combined with deep knowledge and an affinity to place and people. The institutional role of municipalities vis-a-vis other institutional levels is clear, nevertheless we find that the engagement of individuals (*ildsjeler*), and their understanding of local conditions is invaluable for adapting to changing climatic and societal conditions in all of the case sites. We conclude that current and future exposure-sensitivities must be understood against a backdrop of multiple interlinked factors, across a variety of scales. The communities have, in terms of the topics covered in this chapter, displayed a high general adaptive capacity, but future adaptation will be contingent upon access to relevant information, innovation, finances and individual and institutional engagement.

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Chapter 3
Vulnerability and Adaptation in Two Communities in the Inuvialuit Settlement Region

Mark Andrachuk and Tristan Pearce

Abstract This chapter compares the Inuvialuit communities of Ulukhaktok and Tuktoyaktuk in the western Canadian Arctic according to the CAVIAR analytical framework. The comparison highlights examples of similarities and differences in exposure-sensitivities and adaptations related to subsistence harvesting and community infrastructure. Subsistence hunting, fishing and trapping on the land and sea ice continue to be valued activities for Inuit in Ulukhaktok and Tuktoyaktuk. In both communities, however, changes in seasonal patterns, sea ice, and weather variability have affected the health and availability of some important wildlife species and have exacerbated risks associated with hunting and travel. Infrastructure in Tuktoyaktuk is highly susceptible to damage due to degradation of permafrost and coastal erosion. The shorelines of the community are prone to erosion, particularly during strong storm events that have damaged buildings and roads in the past. A prominent difference in the capacity of these communities to deal with climate-related exposure-sensitivities is the diversity of their economies and extent to which they rely on subsistence harvesting. This comparison provides insight into the localized nature of vulnerabilities, and policies to support adaptation.

Keywords Subsistence harvesting · Infrastructure · Inuvialuit · Tuktoyaktuk · Ulukhaktok

3.1 Introduction

Inuit in the Canadian Arctic have experienced rapid social, economic, and political changes during the last half of the twentieth century (Condon 1987; Damas 2002; Hamilton 1994; Irwin 1989). These changes, including moving

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into permanent settlements, the introduction of new technologies (e.g. mechanized transportation), resource development, and land settlement agreements, have transformed Inuit lives and livelihoods. Additionally, Inuit are increasingly faced with challenges associated with climate change (e.g. Ford et al. 2008; Huntington et al. 2007; Pearce et al. 2010).

Some of the most dramatic changes in climatic conditions in the Arctic have been documented in the Inuvialuit Settlement Region (ISR) in the western Canadian Arctic. These changes are affecting communities, and scientists project that further changes in temperature, wind and precipitation will lead to greater variability in timing of seasonal events, increased permafrost degradation and erosion, decreased sea ice cover, and implications for the health and availability of some wildlife species important for subsistence (ACIA 2005; Anisimov et al. 2007; Cohen 1997; Furgal and Prowse 2008; GNWT 2008). Given the effects of current climatic changes and predicted future impacts, the development of adaptation responses has been identified as a priority by the scientific community (Ford et al. 2010; Furgal and Prowse 2008; Huntington et al. 2007; Pearce et al. 2010), Inuit Organizations (Nickels et al. 2006), and the Government of the Northwest Territories (GNWT 2008). This chapter outlines the nature of vulnerability to climate change, in the context of other societal changes, in two Inuvialuit communities, Tuktoyaktuk and Ulukhaktok. The chapter also documents current adaptive strategies being employed to deal with climate risks and discusses opportunities to enhance adaptive capacity to deal with expected future changes.

3.2 Study Locations

Case studies were conducted in the communities of Tuktoyaktuk and Ulukhaktok, two of the six communities in the ISR. Both communities are located on the coast of the Beaufort Sea, with Tuktoyaktuk situated on a peninsula east of the Mackenzie delta and Ulukhaktok on the western side of Victoria Island (Fig. 3.1).

While both communities are accessible via air transport year-round and boat during summer months, Tuktoyaktuk is also connected to Inuvik and the Dempster highway via an ice road from December until April. Table 3.1 provides an overview of the demographic characteristics of the communities. Both communities have young, growing populations that are primarily Inuit. While some residents speak Inuvialuktun or Inuinnaqtun, English is commonly used in both communities.

Similar to most communities in the Canadian Arctic, Tuktoyaktuk and Ulukhaktok have mixed economies composed of waged employment and subsistence harvesting (Table 3.2). Financial income is largely based on government and municipal services, seasonal employment (e.g. sport hunt guiding and tourism), arts and crafts, social transfer payments, and occasional employment

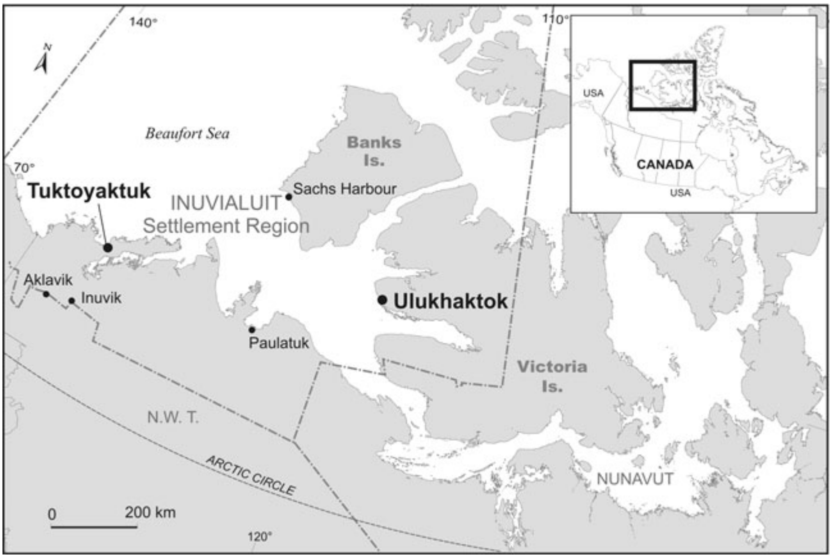

Fig. 3.1 Location of Tuktoyaktuk and Ulukhaktok in the Inuvialuit Settlement Region, NWT, Canada

in resource-extraction industries (Condon 1987; Pearce et al. 2010). Despite rapid socio-economic and lifestyle changes over the past half century, subsistence hunting, fishing and trapping on the land and sea ice continue to be valued activities for Inuit. In Tuktoyaktuk 57% of community members and in Ulukhaktok 76% of community members participate in hunting and fishing (Bureau of Statistics GNWT 2008). Harvesting and the consumption of country foods (locally harvested fish and wildlife) is a fundamental aspect of Inuit culture and are important to many families for food security (Collings et al. 1998; Pearce et al. 2010; Wein et al. 1996) (Table 3.2).

Table 3.1 Demographic characteristics of Tuktoyaktuk and Ulukhaktok. All figures based on 2006 census data

	Tuktoyaktuk	Ulukhaktok
Population	950	400
Proportion of population that is aboriginal	97%	99%
Languages spoken	English, Inuvialuktun	English, Inuvialuktun, Inuinnaqtun
Age Distribution		
Population 0–19 years of age	39%	44%
Population 20–39 years of age	29%	28%
Population 40–59 years of age	25%	22%
Population >60 years of age	7%	6%

Table 3.2 Species harvested and sources of employment in Tuktoyaktuk and Ulukhaktok

	Tuktoyaktuk	Ulukhaktok
Employment sources	Government, health services, social services, education, oil and gas industry, shipping, retail, construction, outfitters	Government, health services, social services, education, retail, mineral exploration, outfitters
Proportion of community participating in wildlife harvesting	57%	76%
Proportion of households relying on country foods as primary meat source	50%	46%
Species commonly harvested	Barren-ground caribou, beluga whales, Arctic cisco, broad whitefish, lake whitefish, inconnu, lake trout, Pacific herring, lesser snow geese, white-fronted geese, brant	Arctic char, ringed seal, bearded seal, lake trout, Peary Caribou, Dolphin-Union caribou, musk-ox, King Eider ducks, snow geese

While the means of harvesting are similar in Tuktoyaktuk and Ulukhaktok, the species available in each community differ. For example, beluga whales, Arctic cisco, and Pacific herring are commonly harvested in Tuktoyaktuk but not in Ulukhaktok. Conversely, Arctic char and King Eider ducks are commonly harvested in Ulukhaktok but not in Tuktoyaktuk. Musk-ox and seals are available in the areas around both communities but are harvested more commonly in Ulukhaktok.

3.3 Study Approach and Methods

Research was conducted in collaboration with community members in Tuktoyaktuk and Ulukhaktok and was structured using a vulnerability approach described by Ford and Smit (2004), Smit et al. (2008) and outlined in Chapter 1 of this book. This approach to vulnerability assessment is broadly consistent with the frameworks of Turner et al. (2003), Fussel (2007), Keskitalo (2008), and others. The vulnerability approach conceptualizes vulnerability to climate change as a function of exposure-sensitivity and adaptive capacity, current and future (see Chapter 1). Vulnerability is assessed at a local level and is conditioned by a synergy of social, economic, political, cultural and climatic conditions and processes, operating at multiple scales over time and space (Ford et al. 2008). Identifying climate-related conditions that are relevant to people, how they affect livelihoods, the adaptive strategies they employ, and how climate change might affect future activities, requires engaging local people in the research process (Pearce et al. 2010; Smit and Wandel 2006; Tyler et al. 2007). In both case studies, community members were involved in research design, development, and application – as research assistants, interpreters, cultural guides, and informants. The methods used to involve community members in the research are described in detail in Pearce et al. (2009).

In Ulukhaktok, 62 primary and 14 follow-up interviews were conducted with a cross-section of community members, and 40 interviews were conducted in Tuktoyaktuk. A purposive sampling strategy was used to recruit a sufficient representation of different groups in the community. A snowball sampling method was then used in which local research assistants helped identify people within identified groups willing to participate in the research, who then led to others who were willing to participate (Andrachuk 2008; Pearce et al. 2010). The interviews were complemented with informal meetings and numerous trips on the land with community members to learn first-hand how people interact with the local environment and to better understand how climatic changes are affecting them. Interviews were semi-structured and questions were open-ended to minimize interview bias or prompting and to allow respondents to describe their experiences and observations in their own terms (Ferguson and Messier 1997; Fienup-Riordan 1999). Semi-structured interviews are a standard method for collecting data in an open-ended format and have been widely used in northern research (Ford et al. 2006a, b; Noongwook et al. 2007; Huntington 1998; Riedlinger and Berkes 2001). Interviews, and subsequent analysis, were guided by the intent to identify current exposure-sensitivities, current adaptive strategies, future exposure-sensitivities and future adaptive capacity.

Collaboration with researchers in the climate science community and an analysis of secondary sources of information including climate records, books, published papers, and government reports was undertaken, and the information gathered was incorporated as appropriate in the assessment of vulnerabilities. After the initial periods of data collection, five subsequent visits were made to Ulukhaktok and one to Tuktoyaktuk to evaluate and review the results with community members, disseminate findings, and conduct other related research.

3.4 Current Exposure-Sensitivities and Adaptive Strategies

This chapter describes changing climatic conditions together with changing socio-economic conditions, with a focus on the ways that they are effecting *harvesting* and *infrastructure* in Tuktoyaktuk and Ulukhaktok. There is evidence of increased risks associated with travel on the land and sea ice, constrained travel access to hunting areas, compromised food security and health status of wildlife, and damage to municipal infrastructure and building foundations in these communities (e.g. Andrachuk 2008; Duerden and Beasley 2006; Pearce et al. 2010; Solomon 2005) (Table 3.3).

Table 3.3 Current exposure-sensitivities related to harvesting and infrastructure in Tuktoyaktuk (T) and Ulukhaktok (U)

	Exposure-sensitivities	Description
Harvesting	***Health and safety*** • Compromised travel routes to harvesting grounds • Increased travel risks	• Less predictable weather makes it difficult to know when conditions are suitable for travel (T,U) • Harvesters have become stranded, injured and/or have lost or damaged equipment due to changing sea ice conditions, rapid seasonal transitions (e.g. spring melt), and increased storminess (U) • Snow machines become stuck in melting snow (U) • High rivers block access to spring hunting and fishing grounds (U) • Less sea ice cover and thinner ice reduces access to hunting grounds (U)
	Food security • Health of wildlife and quality of meat • Availability of wildlife	• Fewer caribou have resulted in hunting regulations (T,U) • Poor quality of ringed seals = less country food and dog food (U) • Fish spoil faster in nets due to warmer water temperatures (U,T) • Fewer migratory fish and softer flesh that is more prone to spoiling (T)
Infrastructure	***Buildings and transportation*** • Permafrost degradation • Coastal erosion • Ice cover on Mackenzie River and Beaufort Sea	• Warmer summer temperatures cause increased permafrost degradation (T,U) • Building foundations are susceptible to permafrost heaving and slippage (T) • Coastal erosion putting several buildings at risk during strong storms (T) • Timing of supply barge affected by summer ice conditions (U)
	Municipal services • Damage to sewage lagoons	• Strong storm events cause flooding and inundate lagoons (T,U)

3.4.1 Harvesting: Current Exposure-Sensitivities

The dependence of Inuit in both communities on fish and wildlife for cultural and social activities, subsistence and employment makes them susceptible to climatic changes that affect hunting and fishing. In recent years community members and scientists have documented changes in temperature, seasonal patterns, weather variability, ice conditions (sea ice and river ice), wind dynamics and snowfall with implications for travel safety, travel routes, and species health. In Ulukhaktok changing sea ice conditions have affected travel routes on the sea ice to seal, duck, and polar bear hunting grounds, and earlier and more rapid spring melts have affected travel inland by all-terrain vehicles

(ATV) to spring fishing and hunting areas (Pearce et al. 2010). Less predictable weather and increased occurrence of extreme storms is also making it more difficult for harvesters to know when conditions are suitable for travel.

Travelling and harvesting on the land and sea ice is inherently dangerous but in recent years climatic changes have altered and, in some cases, increased the magnitude and frequency of hazard events (Pearce et al. 2010). In some cases harvesters from Ulukhaktok have become stranded, injured and/or have lost or damaged equipment due to changing conditions. Community members in Tuktoyaktuk have not reported the same disruption to winter travel routes, although they have reported that they are less certain about weather and ice conditions when harvesting animals that are found at greater distances from the community, such as polar bears or musk-ox (Andrachuk 2008). As a result of settlement in communities and changes in socio-economic relationships, most community members now spend the majority of their time in the community, not on the land where they could observe the development of environmental conditions. This is diminishing some community members' ability to predict weather and ice conditions and increasing travel risks.

In both communities a decline in caribou populations has resulted in hunting regulations and a decline in the number of harvesters obtaining caribou. Caribou is an important and preferred source of meat in Ulukhaktok but beginning in the late 1970s, there has been a dramatic decline in the Peary caribou (*Rangifer tarandus pearyi*) population on Victoria Island (Ulukhaktok harvesting area) (Pearce et al. 2010). A potential explanation for this dramatic population decline are the freeze and thaw events that have occurred during the migration period for caribou, hindering travel and making it more difficult for them to forage for food (Barry et al. 2007). The Bluenose-west and Cape Bathurst caribou herds (*Rangifer tarandus groenlandicus*) near Tuktoyaktuk have had similar declines within the last decade (Environment and Natural Resources 2006; Nagy and Johnson 2006). Some hunters contest these conclusions and believe that the herds have shifted their migratory routes, as they have in the past. Caribou is also a preferred meat in Tuktoyaktuk and provided a reliable source of income for many families in the community until moratoriums on sport hunting were put in place in 2007.

3.4.2 Harvesting: Current Adaptive Strategies

Inuit have a long history of adapting to changing conditions. In both Ulukhaktok and Tuktoyaktuk, Inuit adaptability is evident in the strategies being employed to deal with current climate related exposure-sensitivities (Table 3.4), but the feasibility of many adaptive strategies depend on non-climatic factors. Examples of adaptive actions being undertaken in Ulukhaktok to deal with changing conditions that affect harvesting include: the substitution of store

Table 3.4 Current adaptive strategies employed to deal with climate related risks to harvesting

Adaptive strategies	Constraints
Health and safety	
• Travel with extra supplies (i.e. gas, fuel, food, etc.) • Travel with VHF radios, GPS and/or satellite phone • Use alternative modes of transportation and travel via alternative travel routes in response to changing trail conditions • Travel in groups and leave itineraries with people in the community • Wait for improved conditions • Harvester assistance programs (e.g. IHAP) to provide harvesters with economic resources • Read environmental signs and weather forecasts before traveling	• High costs (i.e. gas, fuel, communication and transportation equipment) • Inability to access capital resources necessary to purchase harvesting equipment (i.e. boat, snowmobile, ATV) • Substance abuse saps material resources and impairs decision-making • Changing levels of traditional ecological knowledge and land skills • Employment limits the timing and duration of harvesting activities
Food security	
• Substitute less accessible species with those more locally available • Eat more store-bought foods • Inter and intra community trade of country foods • Empty fish from nets more frequently to avoid spoilage in warmer waters • Implement conservation plans and wildlife monitoring programs	• Preference for certain species which may become less readily available (i.e. caribou) • Inability to harvest country foods has social, cultural and health implications

foods for traditional foods when hunting areas are not accessible, sharing country foods, using alternative modes of transportation (e.g. ATVs instead of snow machines to travel inland in the spring) and routes to hunting grounds, switching species of wildlife harvested (e.g. hunting musk-ox instead of caribou when caribou are less abundant or farther from the community), and taking extra precautions and supplies when traveling on the land (Pearce et al. 2010). For the most part, these adaptive strategies can be described as reactive and autonomous to the individual or household.

Adaptive actions in Tuktoyaktuk have also included supplementing the decline of one species with another that is more accessible (e.g. harvesting more fish and musk-ox when caribou numbers are low), consumption of more store foods, purchasing traditional foods from full-time harvesters, and avoiding travel during adverse weather conditions. In both communities, adaptations have been reactive and little long-term adaptation planning has been undertaken to enhance adaptive capacity to deal with projected future changes. Access to capital resources, a key for many adaptive strategies, is largely influenced by the ability of individuals or families to secure consistent employment and is manifest through their ability to purchase boats, ATVs, snow machines, and firearms and ammunition.

3.4.3 Infrastructure: Current Exposure-Sensitivities

Infrastructure in Tuktoyaktuk is highly susceptible to damage due to permafrost degradation and coastal erosion. The mainland coast of the Beaufort Sea is characteristically prone to erosion, with average retreat rates of one meter per year (Carmack and Macdonald 2002). The shorelines of the community itself (prior to shoreline protection measures, which were initiated in the 1970s) are known to have eroded on average one to two meters per year, but erosion of several meters has occurred during individual storms (Couture et al. 2002; Hamlet of Tuktoyaktuk 1984; Manson et al. 2005; Reimnitz and Maurer 1979; Solomon and Hart 2000; Solomon et al. 1993). It is generally thought that since sea ice provides protection for shorelines by suppressing the development of waves, longer open water seasons are enabling greater rates of erosion (Carmack and Macdonald 2002; Manson et al. 2005; Manson and Solomon 2007; Rachold and Cherkashov 2003). Average daily energy acting upon shorelines has a relatively small impact on shorelines compared to strong storm events can cause considerable change in relatively short periods of time with winds blowing from the northwest (Atkinson 2005; Manson and Solomon 2007). Such events of rapid coastal retreat tend to occur in the late August and September in Tuktoyaktuk when strong storm events are more frequent (Couture et al. 2002; Johnson et al. 2003; Manson et al. 2005; Reimnitz and Maurer 1979). Unlike in Tuktoyaktuk, infrastructure in Ulukhaktok is situated on stable land with low ice concentrations in the permafrost; nonetheless, warmer temperatures and melting permafrost has caused some damage to building foundations.

3.4.4 Infrastructure: Current Adaptive Strategies

Adaptations to infrastructure exposure-sensitivities in Tuktoyaktuk have been ongoing since the mid-1970s and have focused on shoreline protection measures (Table 3.5). The community, with support from territorial and federal governments, has attempted to slow rates of erosion through a variety of means, including sand bags, concrete slabs and boulders (Johnson et al. 2003). The concrete slabs and boulders have been the most effective and the community has now covered the most erosion-prone stretches of shoreline. These shoreline protection strategies are limited because the local government does not have the financial means to undertake these projects on its own. Shoreline protection has also been limited by a lack of rock and other materials in the community's vicinity. Boulders have been trucked to Tuktoyaktuk via an ice road during winter months and placed on the shoreline once ice recedes. As of 2009, an all-weather road that leads

Table 3.5 Current adaptive strategies employed to deal with climate related risks to infrastructure

Adaptive strategies	Constraints
Building foundations and municipal services	
• Install shoreline protection to prevent or slow erosion (T) • Relocate buildings at imminent risk from damage due to coastal erosion (T)	• Destruction of shoreline protection infrastructure as a result of wash-over, altered sedimentation, and erosion of tundra anchoring points (T) • High cost of climate proofing
Roads and transportation	
• Greater insulation for roads, airstrips, and buildings to protect against permafrost thaw	• Local availability and cost of aggregates

inland to a gravel source has commenced construction and will alleviate some of the logistical constraints. Another adaptation strategy employed by the community has been to relocate or remove buildings that have been put at imminent risk due to coastal erosion. These actions have only occurred in a handful of instances because community planning has focused on shoreline protection.

3.5 Future Exposure-Sensitivities and Adaptive Capacity

In accordance with the CAVIAR framework, current exposure-sensitivities in Ulukhaktok and Tuktoyaktuk were considered relative to future climate change and socio-economic projections to provide insights on potential future vulnerabilities. The future exposure-sensitivities presented here are intended to illustrate a range of possible impacts and stresses that may be experienced in these communities. Projections for warming in the Arctic vary under different climate change scenarios but there is general agreement that the ISR is likely to be facing warmer summer temperatures, less extreme cold during winters, increased precipitation, increased storm frequency, reduced sea ice thickness and cover, and greater variability of weather and timing of seasonal events such as spring sea ice break-up (Carmack and Macdonald 2002; Christensen et al. 2007; Hinzman et al. 2005; Kattsov and Kallen 2005; Lemke et al. 2007; Nuttall et al. 2005). These projected changes are considered here in light of current exposure-sensitivities, with emphasis placed on their implications for people.

3.5.1 Harvesting: Future Exposure-Sensitivities

Climate change is affecting sea ice thickness and dynamics, precipitation, and other factors that are important for the health, breeding success and movement of wildlife (Table 3.6). Several researchers have suggested that alterations to the timing of these conditions and seasonal events (e.g. timing of sea ice

Table 3.6 Future climate change projections and possible future exposure-sensitivities related to harvesting

Future climate change projection	Future exposure-sensitivities
Health and safety	
• Increased frequency of extreme climate events (Kattsov and Kallen 2005) • Reduction in sea ice cover and volume (Barber et al. 2008; Serreze et al. 2007; Sou and Flato 2009) • Later freeze-up and earlier break-up of lake and river ice (Walsh et al. 2005) • Increased precipitation in the spring (Kattsov and Kallen 2005)	• Exacerbate risks associated with travel on the land and sea ice. • Compromise travel routes on the sea ice to hunting areas. • Increased risk of becoming stuck-stranded in melting conditions • Compromised travel routes to spring hunting areas (e.g. fishing at inland lakes) • Less time spent on the land with implications for social well-being.
Food security	
• Decline in polar bear population and health (Derocher et al. 2004; Stirling and Parkinson 2006) • Loss of polar bear habitat (sea ice) (Durner et al. 2007) • Decline in ringed sea population and health (Harwood et al. 2000; Smith and Harwood 2001) • Continued decline in caribou populations (Gunn 1995; Post and Forschhammer 2008)	• Loss of income from sport hunting and the sale of furs and pelts • Less country foods

freeze-up and break-up) will have the most profound influences on ecosystems and wildlife, although predictions of precisely how these changing conditions will affect wildlife are difficult because little is known about the adaptability of particular species (Anisimov et al. 2007; Carmack and Macdonald 2002; Hinzman et al. 2005). Despite limitations in predictability, there are concerns that degradation of habitat or feeding conditions will cause dramatic declines in many wildlife populations that Inuit depend on for subsistence and livelihoods (Durner et al. 2007; Ono 1995; Solomon 2007). Furthermore, projected reductions in sea ice cover, more unstable sea ice conditions and trends towards later freeze-up and earlier break-up will likely continue to exacerbate risks associated with travel on the sea ice and compromise travel routes to hunting grounds.

3.5.2 Infrastructure: Future Exposure-Sensitivities

Future exposure-sensitivities for Tuktoyaktuk's infrastructure may arise due to instability of permafrost under buildings, flooding and coastal erosion (Table 3.7). Couture et al. (2002) estimated that more than 40% of

Table 3.7 Future climate change projections and possible future exposure-sensitivities related to infrastructure

Future climate change projection	Future exposure-sensitivities
Building foundations	
• Longer summer season and stronger storm events increase potential erosion (Johnson et al. 2003; Manson and Solomon 2007) • Permafrost thaw due to warming (Manson et al. 2005; Furgal and Prowse 2008)	• Damage to buildings and associated costs for repair • Cost to relocate buildings close to eroding shorelines
Municipal services	
• Strong storm events coupled with sea level rise cause flooding (Couture et al. 2002; Manson and Solomon 2007)	• Road closings inhibit movement of trucks that deliver propane and remove sewage
Roads and transportation	
• Warmer temperatures and increased fall precipitation cause shorter season for ice road	• Shorter time for access to Tuktoyaktuk via ice road and higher cost for goods

Tuktoyaktuk's buildings were constructed using 'shallow' foundation systems that are very susceptible to frost heaving and slippage. Projections of climate change indicate that warmer summer air temperatures and long summers may lead to permafrost melting and cause significant damage to buildings within the next 50 years (Furgal and Prowse 2008; Manson and Solomon 2007). These risks can be alleviated to a large extent by construction techniques that minimize disturbance to the upper layer of permafrost and do not transfer heat to the ground.

Shoreline protection has slowed the recent rates of erosion along Tuktoyaktuk's shoreline. Future rates of erosion are difficult to project since it is unknown how recent shoreline protection measures will respond to extreme storm events. Several climate projections are particularly relevant for coastal processes and rates of erosion, including warmer summer temperatures, longer open water seasons, increased frequency and intensity of storms in late summer and autumn, and sea level rise (Manson et al. 2005; Manson and Solomon 2007). Estimations of future erosion of Tuktoyaktuk's shoreline indicate that within 25 years, several buildings will be damaged or destroyed (if not relocated) and the community's inner harbor may be exposed to storms and rapid erosion due to deterioration of a spit at the north end of the community and a small island at the mouth of the harbour (Couture et al. 2002; Johnson et al. 2003). Given Tuktoyaktuk's location on low-lying land and potential increases in storm magnitude and frequency, the community also faces flood risks. Extreme storm events could flood most of Tuktoyaktuk, including houses and the sewage and garbage lagoons (Couture et al. 2002).

3.5.3 Future Adaptive Capacity

The future capacity of community members to deal with climate change will likely depend on factors already influencing adaptation. These include, but are not limited to, access to income, changing levels of environmental knowledge and land skills, and flexibility in harvesting practices and institutions (e.g. harvesting quotas).

In both communities, access to income is a key factor determining whether or not people are able to participate in subsistence. Mechanized transportation is expensive to purchase, operate, and maintain and fuel prices continue to rise. Together with the cost of ammunition, food, and other supplies, participating in harvesting activities can be an expensive undertaking. Climatic changes which require adaptations that necessitate economic responses (e.g. alternative travel routes requiring additional fuel, changing mode of transportation – snowmobile to boat) further exacerbate financial stresses affecting subsistence. Access to income sometimes limits participation in subsistence and adaptive capacity to deal with changing conditions but it also represents a strategic policy entry point to enhance adaptive capacity to deal with expected future climate change. For example, harvester assistance programs, job focused skills training, economic diversification, and greater educational opportunities are initiatives that could be commenced or, if already underway, could be further invested in. Providing harvesters with stable sources of income would enhance their involvement in subsistence and also strengthen their capacity to adapt to changing climate conditions.

An important component of Inuit adaptive capacity to deal with variable environmental conditions is the traditional environmental knowledge and land skills generated through hands-on experience and transmitted among generations. Hunters manage the risks associated with hunting by taking precautions, knowing what equipment to take and what routes to travel, and being aware of critical signs in the environment (Pearce et al. 2010). However, community members in both communities are concerned that the knowledge and skills necessary for safe and successful hunting are no longer being generated or transmitted effectively. Younger generation Inuit are spending considerably less time involved in subsistence activities outside of organized land camps and occasional hunting trips and there is a concern that youth are at greater risk of harm from changing environmental conditions because they are not well-equipped to deal with them. Possible initiatives to address this concern include integrating environmental knowledge and land skills into school curriculum, developing a harvester-mentorship program, and/or holding skill development workshops in the communities. Currently, research is underway in Ulukhaktok to document what knowledge and skills are (and are not) being successfully transmitted to younger generation community members. This will provide an indication of the knowledge and skills to target in skill development initiatives. Citing the growing population of Inuit youth and declining population of elders, initiatives to address the loss of environmental knowledge and land skills need to be addressed without delay.

In Tuktoyaktuk, the availability of funding is a central factor influencing adaptive capacity to deal with infrastructure risks and damage. The municipal government relies on transfer payments and approval from the territorial government for any undertakings related to shoreline protection. The federal government has also contributed funds in the past but does not have jurisdiction or responsibility for address community infrastructure damage. This situation creates a dilemma where the ability of local decision-makers to address these challenges is strongly determined by the political will and support from remote government bodies.

3.6 Conclusions

Exposure-sensitivities in Ulukhaktok and Tuktoyaktuk are associated with the reliance of community members on harvesting for livelihoods, subsistence and cultural fulfillment. In Ulukhaktok, current exposure-sensitivities include increased risks associated with travel on land and sea ice, compromised travel routes to hunting areas and changes in the health and availability of some wildlife important for subsistence. Current exposure-sensitivities in Tuktoyaktuk include compromised food security and health of wildlife as well as difficulties in preparing and storing traditional foods. While adaptive strategies are not the same in both communities, in both places they have been characterized by substitution of food sources (alternative wildlife or store-bought foods when preferred wildlife are not available), altering timing and modes for travel and harvesting, and taking extra precautions when traveling and harvesting. Tuktoyaktuk has also experienced risks to infrastructure due to shoreline erosion and degradation of permafrost that are exposure-sensitivities for buildings and other infrastructure. The community's primary means of adapting to these risks has been to install shoreline protection measures that are intended to slow rates of erosion.

Future exposure-sensitivities were estimated based on current conditions and projected changes due to climate change and other forces. Changes in the timing of seasonal events (break-up and freeze-up of sea ice), sea ice dynamics, wind patterns and precipitation will alter and degrade habitat for wildlife in the ISR. Declines in the health, breeding success and movement of wildlife in the future will generate further challenges for Inuit who depend on wildlife for livelihoods, food and culture.

Adaptive capacity for dealing with these exposure-sensitivities is variable within each community. In terms of harvesting exposure-sensitivities, flexibility in harvesting practices, access to income, the generation and transmission of traditional environmental knowledge and land skills, and wildlife management through quotas and other measures influence the capacity of community members to adapt. In relation to infrastructure exposure-sensitivities, limited financial resources constrain the community from taking proactive adaptive plans and actions, such as relocating the community to more stable land. These determinants of adaptation represent strategic policy entry points to help reduce vulnerabilities and enhance adaptive capacity to deal with expected future climate change.

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Chapter 4
Climate Change, Vulnerability and Adaptation Among Nenets Reindeer Herders

Tatiana Bulgakova

Abstract The case study presented here concerns two geographical areas: the Yamalo-Nenets Autonomous Okrug (Tyumen Oblast) and Nenets Autonomous Okrug (Archangelsk Oblast). The question that prompted this study was how the Nenets reindeer herders perceived the effect of climate change on reindeer husbandry. This chapter presents local understanding of reindeer husbandry related exposure-sensitivities, climatic influences on reindeer herding and local reactions to recent climate change. Herders consider that not only climate warming, but also weather instability and abruptness, resulting in the formation of ice crusts inhibiting reindeer forage access and phenological shifts and in turn contributing to both pasture overgrazing and the loss of new-born calves, are the most frequent and severe hazards occurring in recent years. The traditional reindeer herding economy has proved flexible and adaptive to the changeable environment; however the combination of current stresses may prove too severe a test. Nenets reindeer herders, despite developing means to adapt to climate change, are on the whole pessimistic about the future of a reindeer herding economy.

Keywords Reindeer husbandry and health · Reindeer pasture · Adaptive strategies · Weather instability · Emic approach · Conversations about weather

4.1 Introduction

The Nenets, indigenous people in Russia (population 41,302), inhabit areas between the Kanin and Taymyr peninsulas, around the Ob and Yenisey rivers and most of them live in the Yamalo-Nenets Autonomous Okrug (Tyumen

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Oblast) and Nenets Autonomous Okrug (Archangelsk Oblast). The case studies presented in this paper relate to both regions and are based on field material consisting of interviews concerning indigenous local knowledge about the influence of climate change on reindeer herding from an emic perspective.[1] The goal of the paper, in line with the emic approach, is to discuss and understand the climate change related vulnerability, perspectives and adaptation strategies of Nenets reindeer herders, from the viewpoint of those who are involved in the processes under study.

The research strategy largely consisted of interviewing the Nenets reindeer herders (two elders and two young herders) and their professional housewives, (*choomrabotnitsa*)[2] (four all together) from the Nenets Autonomous Area and the Yamal-Nenets Autonomous Area (2008). These interviews combined constitute two case studies, each chosen from different regions. One presents the information collected in the village of Krasnoye and the town of Naryan-Mar in Nenets Autonomous Okrug (three reindeer herders and four herders' housewives). The information about reindeer herding in Yamalo-Nenets Autonomous Okrug was received from a reindeer herder, who permanently lives and grazes his herds in Priuralskij district, but travels to Saint Petersburg for short stays. Besides the interviews, this chapter is based on a survey of local media publications concerning this topic.

The influence of climate warming on reindeer husbandry is little discussed in official circles, and scientific discussions in Russia almost entirely neglect climate change. The subject is rarely touched upon in official public statements, or discussions in meetings, congresses, and the mass media. This situation is in stark contrast to the wide spread discussions concerning damage to the pastures caused by the oil producing companies and other industrial activities. 'When in the congresses, Nenets people argue about the deficiency of winter pastures', the reindeer herder Denis says, 'they affirm that it is caused by building the roads in the territory of pastures and by extracting oil there. They also say that the oil-production enterprises receive good benefits from their industry, but they pay too little to them, to the native people who live here.' 'Why our native people do not usually say anything in such meetings about climate change, about what is happening in nature itself?' wonders Denis. 'Maybe some of them do not realize how much it harms the reindeer husbandry. Maybe they do not pay enough attention to it, do not feel it in the right way, do not observe it well, I do not know!'

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[1] Emic and etic are terms used in cultural anthropology, to refer to kinds of fieldwork done and viewpoints obtained. An 'emic' approach supposes a description of ideas in terms meaningful to the actor. In this case an emic account comes from a person within the culture. It presents the herders' and their wives' understanding of the issues discussed here. Emic approach is opposite to 'etic' account that is a description of ideas of an observer.

[2] Chumrabotnitsa is reindeer herder's assistant who is a house (choom) keeper. Her duties are to meet reindeer herders, feed them, dry and mend their dress, and so on. In Soviet time it became a official profession.

Conversations about weather with Nenets at an official level also present certain distinctive characteristics. The natives discuss related topics cautiously, which from their viewpoint implies an incorrect attribution of blame to weather and climate. In some cases they prefer to hide some apparent information or manipulate it, thus avoiding the climate topic. This peculiarity of indigenous peoples' attitude to the conversations about climate change was also noticed by other scholars. Marino and Schweitzer noticed that 'not talking about climate change proved the best method for understanding local concepts of change' (Marino and Schweitzer 2009, 210). Referring to Wisniewski, they also noted that 'when hunters or other local experts are asked to speak about the environment, it can require breaking strict hunting taboos of talking about the future or being irresponsibly presumptive about a changing and sentient natural world' (Marino and Schweitzer 2009, 215). This cautious attitude in talking about weather is explained by the belief that there are spirits which influence weather and thus any complaint about weather actually constitutes a protest against the spirits. That is why Nenets reindeer herders usually prefer give any reason to explain the challenges caused by climate change rather than explanations connected with the environment itself. If asked about the harshest weather conditions the Nenets reindeer herders would always say that the weather was as good as it should be, because it was God who gave them such weather and that is why they have no reasons to criticize weather and complain about it. 'If this is the case, so it is necessary!' said the reindeer herder Denis. 'The only thing is that we ourselves should be able to get out of any difficulty. We must cope with any problems, even if unfortunately not everybody can be equal to the task.' 'If a reindeer died because of weather conditions', Denis continues, 'a herder would never say that his animal perished on account of weather; he would say that it was his own fault. The herders never complain; even last year, when lots of reindeer died because of snowfall, they only blamed themselves.' The informant told me about a recent tragedy, where due to heavy spring tides (a recent and frequent phenomena) and sudden spring warming, a big snow avalanche slipped from the flank of a hill in Priuralskij district in Yamal. The avalanche flow washed away an entire *choom* with all its dwellers resulting in the death of the herder's wife and all his children. Only the herder himself survived. But neither the herder, nor anyone else accused nature and climate for the tragedy. The people explained to the others that it happened because the victim obeyed the Protestant missionaries who advised him to burn his sacral sledge, where the herder kept his idols. My informant also inclined to that interpretation. He said: 'It was the missionaries who actually caused that tragedy,' said Denis. 'We lodged a complaint to our administration that people, who come from England and from France, forced us to change our life.'

Despite the fact that native people avoid talking about global warming and its negative influence on reindeer husbandry, they are fully aware of it. Conversations on this topic are just limited, not completely forbidden; thus I had opportunity to collect the information I needed. Circumstantial and indirect inquiries helped me to establish some facts, which revealed Nenets reindeer herders' real attitude to climate change, exposure-sensitivities and their understanding of how to adapt to it.

The material presented in this chapter is divided into five sections. The first four concern the seasons and employ an identical structure. They first describe findings about current exposure-sensitivities of Nenets reindeer husbandry, and conclude by explicating current adaptive strategies in use by Nenets reindeer herders. The fifth section concerns the displacement of the annual biological cycle as a result of climatic change. The future exposure-sensitivities and the future adaptive strategies are discussed in the conclusion.

4.2 Current Seasonal Exposure-Sensitivities and Adaptive Strategies

4.2.1 Winter

4.2.1.1 Winter Exposure-Sensitivities

The beginning of the winter season in the Nenets Autonomous Okrug is considered to be in mid-November, when the rivers and lakes are frozen to such an extent that they become accessible for reindeer transportation. Recently however, freezing has occurred much later than usual. In mid-November 2007 the local newspaper of the Nenets Autonomous Okrug wrote: 'The residents of the Nenets Autonomous Area hardly are able to remember another year, when it was still possible to boat down the Pechora River,' (Kiselev 2007b, 4). In the end of November 2007 the same newspaper wrote: 'It is really dangerous to walk out to the Pechora River ice. From the beginning of its freezing-over already two people have drowned in the river,' (Tonkiy liod 2007). People drowned because they underestimated the degree of warming and did not believe that in November river-ice, at such high latitude, could still be very thin. In the same publication the Department of the State Inspectorate of small-size ships warned people: 'The thickness of the river ice is minimal now. Because of temperature drop and current warmth, the ice freezes on the river very unevenly, and is not strong enough.' The newspaper gave an advice to its readers not to go out onto the river ice until mid-December (Tonkiy liod 2007).

By mid-November, the Nenets Autonomous Okrug is normally covered by a thick blanket of snow. In the recent years there has been not only far less snow, but also thaws and winter rains. In late December 2007, the regional newspaper reported that 'the polar village Khorej-Ver has been already readied to meet Santa-Claus and Snow Maiden. The villagers had set up two New Year's trees; they have rehearsed the merry round dances and learned the New-Year songs. Everything has been made ready, except frosts. Only frosts have not yet come' (Budet prazdnik 2007).

Instability of weather is another feature of recent years. Due to a sudden frost, following a thaw, a crust of ice develops over the snow blocking reindeer access to lichens and mosses, an essential forage source. Sometimes such ice becomes further covered with snow and reindeer have to dig snow out. Thick ice-crusts, have been witnessed, which covered wide territories in Yamal in the beginning of winter 2006–2007. This severely decreased reindeer access to forage and constituted a life threatening situation. (Stammler 2008, 85). Since October 2006, Stammler writes, unprecedented snowfall and hard frost started, but on 6th November 2006 it rained for 12 h and right after that temperature fell to 40°C degrees below, which led to ice-crust development. 'We watched, – Stammler writes, – how reindeer with difficulty broke through the ice-crust to reach lichen and how they hurt their legs,' (Stammler 2008, 85). Other authors also wrote about that event. V.N. Adaev noticed that weather in Western Siberia became less predictable. In 2005 the rivers were covered with firm ice almost until New Year, but in 2006 hard frosts arrived in October, and were followed with intense snowfall. He also mentioned the 12 hours of rain on 6th of November 2006 which resulted in a firm crust of ice over the snow (Adayev 2007, 85–86).

Another winter problem is pasture degradation. Even if there is no crust over the snow, a lack of concurrence between the beginning of winter pastures grazing and appropriate weather conditions leads to an additional difficulty for the reindeer herders. Despite the fact that in recent years the winter cold has arrived later than usual, the reindeer herds still come to the winter pastures at the same time of year as usual. If it is still warm, and there lies little snow, the reindeer can eat almost all the moss on the pastures including the uppermost layer of soil. It seems that this way of using pastures is traditional one. V. Adayev points out the difference between the Nenets and Khanty practice of using pastures in tundra. Nenets let their reindeer eat all the moss on the pasture grazing their reindeer on the same place 'until it blackens,' but Khanty reindeer eat only tops the moss as they change their pastures much more frequently (Adayev 2007, 100). Traditionally Nenets reindeer herders offset the negative effects of this practice by changing the territories where they roam, with the intent of letting the used pastures lie fallow (Adayev 2007, 100). In warm and light snow conditions, pastures become degraded due to the easy access to forage to such an extent that the moss will not re-grow for a long time. As Denis says, at first he considered conditions were better with a warm winter with little snow because his reindeer can get moss and are always full. However the elder herders told him that in exploiting the easy access to their forage in winter the reindeer often eat the moss together with the roots which impoverishes the pastures. After that, as the elders said, the exhausted pastures can take 30 years to restore, if nobody touches them. Should the herder not have another territory to go to, in subsequent years he will nevertheless have to return to the same territory leading to further degradation.

The moss covered pastures, as Yuzhakov and Mukhachev write, are indeed the most vulnerable pastures in the North, and are especially difficult to restore. The researchers affirm that the growth of moss is only 3–4 cm per year, and the restoration of the overused pastures averages 20 years (Yuzhakov and Mukhachev 2001, 75). There is also a serious risk of permanent loss of winter pastures suited to reindeer through overuse. Yuzhakov and Mukhachev point out the possibility of pastures de-lichenification, in other words, they affirm that overusing the moss pastures can lead to the replacement of lichen and moss fractions by grassy ones. This process is negative for the reindeer because it reduces the availability of high-energetic forage in the most arduous period of the year (Yuzhakov and Mukhachev 2001, 73).

There are also some social factors besides warming winters which contribute to pasture degradation, which is especially apparent in Priuralskij region in Yamal. Reindeer herders wish to avail themselves of the advantages of modern culture winter closer to the villages. The herders rest there and store the goods necessary for the next season, communicate with other herders, and so on. This leads to the congregation of big herds on the limited territory around some of the settlements, such as Laborovaya, Beloyarsk. In addition, the herds of the large reindeer farms (cooperatives, stock companies) spend winter on the unprofitable lichen nearby the same settlements and cause noticeable damage to the pastures. Wild reindeer never migrate for wintering in big herds. They graze in small group (20–40 heads) and rarely return to the places where they were before, in the search for new fresh pasture (Yuzhakov and Mukhachev 2001, 84).

The pastures and the routes of the herds' migration are traditionally distributed among the trading stations. Entitlement to specific territories is not fixed anywhere, it is only remembered, and usually herders try to occupy the same places as they did in the previous seasons. Formerly, if a herder broke this unwritten law and used someone else's territory, it was not aggressively contested and the place was conceded to the newcomer. However given current pasture shortages, relationships between the herders have become increasingly strained. Should a herder now dare to move his reindeer to someone else's place, it leads to mutual enmity. Diminution of the pasture area and pasture overexploitation can lead to the social conflicts. 'If my pasture has become impoverished by the end of winter,' says Denis, 'I need some other places where my reindeer can find at least some moss, but I must not move to the other people's pastures.' 'There are lots of mutual complaints, especially before spring, when everyone suffers a shortage of pastures. "You have too many reindeer and occupy too large pasture, but I have no place to go. You force me out!" So by spring, hostility appears among the reindeer herders.' Cases of crossing the invisible boundary between the adjoining herds have recently become frequent. 'If one herder's pasture has become impoverished, what he should do?' asks Denis. 'Where should he go? One herder moved his reindeer to someone else's territory, and there were quarrels and threats. I heard those threats. That herder's neighbour came to his *choom* and shouted: "If you are not going to be off, I will break your sledge, and I will beat you unmercifully! You will come out the worse for it! Only try to do it again!" That neighbour did not only threaten him, he also drove his reindeer from his territory. After that the rumour was spread among the neighbours, and the people blamed that herder, who tried to drive the alien reindeer away from his territory, protecting his pasture. Not the trespasser, but the victim was represented as the guilty one.'

Herders try to keep their herds at a certain distance from other herds to avoid the reindeer mixing as separating the herds by lasso is a difficult process. Territorial limitations on pasture land breeds resentment from private herd owners toward the big state farm herds for, in their opinion, the farm herds aggravate pasture degradation. 'The private herders,' says Denis, 'need reindeer to survive, to sell and buy some goods for their families, but nobody knows what the state grazes reindeer for. Are they grazing reindeer for money, for someone's profits, for all the country, for the district? I do not know what for! But it is they who have occupied the largest squares here!'

The social conflicts exacerbate pasture overuse. As the herder who comes to the winter pastures first is able to occupy the best place, the territorial distribution varies each year and competition ensues for the winter territories closest to the settlements. Traditionally, the proper time for coming to the winter pasture was early December but because of the concern over shortage of winter pastures, now the herders try to arrive much earlier, ahead of other herds. 'In the past, people gathered on the pastures by December, but now they are already there in October. There are no signs whose pasture is situated where, so that the first to arrive can occupy any place he chooses. The next one, who comes later, has to step aside. That is why they rush; they hurry to occupy, to take up a better place. If I arrive at the winter pasture in December, as I did it before, I will not be able to find an appropriate place. Soon the herders will arrive at the winter pastures in September or even in August!' The competition results in herds' remaining in the winter pastures much longer than before and aggravates winter pasture degradation.

A further condition, which contributes to pasture overuse, is connected to the end of the Soviet system and the subsequent transfer to the market economy. The planned system provided additional winter forage for the reindeer. The elder herder Pieter considers that in the Soviet time conditions were better for the reindeer herders because the Soviet collective farms brought some salt and some mixed additional fodder for reindeer. The specialists-veterinaries emphasized the importance of mineral additional fertilizing, which is especially important in winter and spring time. 'By spring the mineral dearth becomes redoubled by the acute shortage of micro-organisms in the forage, which the reindeer compensate because of the inner reserves of their organisms,' (Yuzhakov and Mukhachev 2001, 85).

Another reason, which restricts pasture access and exacerbates overuse is the seizure of some of the most important and unique pastures through the process of industrial development of the region, especially in Yamal. Thus warming winters interacts with other factors to contribute to further pasture degradation.

4.2.1.2 Winter Adaptive Strategies

In winter, the main reindeer herders' strategy concerns the search for additional pastures. To avoid the troubles with ice-crust the reindeer herder has to find the territories less touched with ice. To prevent pasture overuse in light snowy weather he has to change the pastures more often than usual. ‘Earlier it was much easier,’ complains Denis. ‘There was no necessity to fuss beforehand and to look for the fresh untouched places to circumvent such possible difficulties with ice crust.’ The reindeer herder Ivan says the same about such searching for places free from crust: ‘A herder should have high standard of knowledge, he should be a professional, “an academician” in order to be able to take everything into consideration, to be acquainted with everything, to know where and how he can go, to which direction and where exactly he is right now. Can you imagine what a spacious territory it is; and he must know each span of it.’ With the first signs of an ice crust appearing over the snow, reindeer herder should scout the entire area around to know where to move the herd if necessary. Stammler mentions that in such circumstances, to which he was a witness in November 2007, the reindeer herders first tried to find out about ice-crust presence on the adjacent territories and than moved their herds to the less damaged places (Stammler 2008, 85). Denis says that sometimes he managed to find a proper place for his reindeer, but another herder also found the same place at the same time. When I asked about possible conflict between those two herders, Denis answered that the trouble was not a conflict; the real problem was to find an appropriate place.

4.2.2 Spring

4.2.2.1 Spring Exposure-Sensitivities

As our informants asserted, after warm winters and light-snowfall, the first heavy snowfalls have recently only appeared in spring, March and April. Sometimes the snowfalls last till June. In the local newspaper, they wrote that people had begun preparing for the holyday ‘Winter Seeing-off’ and the spring carnival ‘Pancake week’ begins, but only then people finally faced the real winter, and the frosts set in. The newspaper wrote that in the past all the signs of spring appeared at the same time. The sun after the polar night came into view together with the certain birds such as snow buntings, which were considered to be the messengers of spring. Now everything has been dislocated: the sun should be the sign of spring, but there is no warmth and the birds are late.

The heavy spring snowfall causes lots of problems for the reindeer herders. Despite the fact that March and April are really cold, the reindeer feel that it is already the time for thawed patches and green grass to appear, but instead they find only a hard crust of ice over snow. The herder Pieter said that reindeer felt discomfort at that time and began to run around ineffectively searching for grass. Denis affirms that ‘in spring the reindeer do not want to eat moss any more; they scatter around and look for some verdure. They love snowdrops, flowers. They are tired of moss. But there is still no verdure, it is cold.’ The veterinarians recommend that the herders spread the spring herd widely over the pastures and try not to disturb the reindeer so that they are able to recuperate from winter nutritional deficiencies and to be well- nourished by the time mosquitoes arrive (Yyzhakov, 82). However, due to the recent long springs, reindeer, which continue to dig up moss from under snow, become weak and rapidly lose their weight.

Another feature of recent spring climate is weather instability. The herders affirm that in the past the weather was much more stable, it was cold in winter and the cold weather did not return after the arrival of the spring warmth. Recently everything has been intermixed. The cold, which did not come in its allotted winter season, commences later in spring. Especially dangerous for the reindeer is the occurrence of abrupt frost after the spring thaw causing the formation of an ice crust over the snow or ground. In such cases the reindeer are unable to get forage from under the snow. This phenomenon has become more frequent in recent years. In 2007 Stammler was witness to a period of February rain, which resulted in an ice-crust covering the entire south of Yamal. He wrote that as a result, during spring migration to the north, all the herder brigades which spent winter in forest tundra had to traverse spaces covered with ice-crust. A lot of reindeer weakened and as a consequence that year[3] herders lost 30% of their herd (Stammler 2008, 86).

The most crucial spring period for the reindeer herder is calving. The weight of calves rapidly increases this time. The herders explain that after the warm weather has set in the female reindeer give birth onto thawed patches, free from snow, however in recent years, there have been two main threats to the reindeer. Firstly, following the birth of the calves, warm weather has arrived too quickly leading to fast snow thawing precipitating sudden floods. Water inundates everything around, and the ‘small calves try at first to follow their mothers, but then they remain behind and get stuck in the brushes. Poor things, they hang around over the bushes’ and perish (Ulyana). Another trouble of the late springs is that the calves are born into cold weather. Some reindeer give birth in their usual time (mid-April), but it is still really too cold for the new-born calves. The herders say that in case of cold weather some reindeer can refrain from giving birth, but most calves are born either into the cold weather possibly soon followed by frost. In those cases some calves die, as the herder Pieter says, before their mothers even have time to lick them. Even if the birth process successfully happens in a warm period, sudden return of the cold and snowy weather may be life threatening to the calf. ‘Sometimes the snow in spring is up to my chest,’ Pieter says, ‘How reindeer can find their forage? The reindeer are digging and only their tails stick out of snow. But not one calve is visible under the snow.’ ‘Sometimes sudden snowstorm begins after calves are born.’ Pieter considers that current spring weather instability is the most dramatic he has seen in his working life.

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[3] In the beginning of the same winter season, that is in November 2006 there was also rain which resulted in ice-crust. The lost of 30% of reindeer was a consequence of these two winter (November and February) rains. (Stammler 2008, 86).

Even if the calves born into the cold weather survive, many of them are likely to die later. As Stammler noted, ‘it is important for the deer that the weather is warm enough and that the female finds a snow-free patch of ground where the newborn lies during its first few hours of life, if it lies on snow, it can catch cold or get pneumonia, and generally dies soon afterwards. In 2001, due to cold weather and snowstorms (*burany*) in Northern Yamal, more than half of all newborn calves died in the household I was staying with. Many neighbours told the same story’ (Stammler 2005, 110). The herder Denis elucidates why it happens. ‘If it was warm and suddenly snowstorm comes, it harms the calves’ lungs. They are not yet strong enough and ready to breathe in the snowstorm and then their lungs ‘swell up’ after that. Denis considers that not a single calf born before the snowstorm would be able to survive. Pieter described a blizzard which started immediately after calving. There were already lots of newborn calves and some additional herders came to help us with the calves but suddenly an intense snowstorm broke out, and nobody could leave the *choom*. People had to sit indoors the entire day. By the end of blizzard, there was snow up to their chests and of calves were covered with snow and had died.

4.2.2.2 Spring Adaptive Strategies

In case of heavy snowfall herders’ adaptive strategies consist in searching for places with less snow and better protection from heavy winds such as a hole, a river bank or a mountainside. The main thing is, as they said, not to leave the herd on the flat. To avoid the danger of losing the reindeer during a spring blizzard, the herders have to stay with their herds constantly and to watch the animals. The herder Peter told me: ‘When it whirls, and I cannot see anything, I must not stir a step from my reindeer’s side; otherwise I risk losing the entire herd. I have to follow them every moment. Once I dropped my stick (trochee), [4] and it was covered with snow in a moment and I had to go farther with no trochee.’ If because of unstable weather ice-crusts may appear necessitating as search for less damaged pastures. The herder Denis complains that for him it is a hard-work going around looking for the new places for his reindeer. ‘But that herder, who is too lazy to do it, risks losing his reindeer,’ he says. ‘If a herder was lazy today and did not go to search for a better pasture, his reindeer are doomed to death!’ The herders pessimistically said to me that in spite of all their attempts and diligence, they have lost reindeer in such weather conditions and have no ideas how to avoid tragedies involving the death of reindeer, and especially their new-born calves.

To lessen the risks connected to instable spring weather during calving, additional workers come to the tundra to help the herders; however this can only partially improve matters. In instances of floods following calving the workers collect those calves at risk of drowning. The calves try to seek safety on

[4] Stick which is used for driving reindeer.

the tops of knolls and in bushes, but only a few of them, as the herders say, can be actually saved. A similarly ineffective method of rescuing calves is used after heavy snowfalls. Herders try to determine the place of location those calves, which are covered with snow, by watching their mothers. If a female reindeer circles a certain place, it means that the calf is there under snow. There also can be found small holes in the snow which serves as a sign for a herder to dig there to find calf. Unfortunately, as my informants said, most of the calves dug out that way, were already frozen and dead.

4.2.3 Summer

4.2.3.1 Summer Exposure-Sensitivities

All informants affirm that recently the summers have become much hotter than usual. Sometimes hot weather lasts for short periods for only for a week or a month, Ulyana says, but people and reindeer suffer from it. Herders recollect it as one of the most difficult times of the year. The hottest time is usually, as they say, in the end of July, but after August 2nd (the day of the saint prophet Ilea) Nenets await cooler and foggier conditions. On that day some games and competitions are arranged. Denis says that this day everyone and everything in nature breathes with relief, because the troubles of the hot summer are already behind and the long-awaited coolness has come. Hot weather is considered to be no less disastrous in the tundra than a winter ice-crust. The anthropologist Andrew Golovnev describes one of the sultriest summers in Yamal this way. 'Heat in tundra is rather tormenting then blessing.... In the central part of the peninsula in latitude of the mouth of the Yuribei River it was possible to bathe and to lie in the sun. ... It was difficult to breathe, and each unnecessary movement caused perspiration. The Nenets elders were lying in their *chooms* being half-sick and refused even to talk. When they went out of the *choom* (for all that they did not forget to put on their fur jumpers) they could hardly walk,' (Golovnev 1995, 310). Not only reindeer, but people also did not adapt well to the higher temperatures and barely modified their traditional way of life or habits, such as changing their fur dress to something cooler. Both in the Nenets Autonomous Area and in the Yamal-Nenets Autonomous Area informants complained that in summer they suffer from dry weather. They told us that the pastures can be burnt by the sun and subsequently the valuable moss fodder would fail to recover and be replaced by some other sort of vegetation instead. Golovnev confirms that in latitude of the Yuribei River it became possible to find glades of ripe cloud-berry, but many of the grassy and moss pastures, best suited to reindeer, had been burned down (Golovnev 1995, 310).

Due to arid summers many lakes in the tundra have dried out leaving only some small puddles in the place of the former deep lakes. Olga says: 'There was a big lake over there. You could see it before, but now there is only a puddle on that place left. All the lakes have become shallow.' Golovnev writes that the permafrost marsh hummocks are now thawing out and slipping down under the riverside and lakeside slopes. He also refers to the rumours that in one place a landslide crushed a reindeer and in another place it destroyed the sacred worship place (Golovnev 1995, 310).

Summer heat negatively influences reindeer health. One of the troubling features of summer is water shortage. According to Denis, reindeer prefer to drink water from sources that smell of soil such as bogs, ponds or partially dried up lakes. They refuse to drink lake water as the clean lake water does not have taste they like, but in dry hot summers the bogs and ponds are almost completely dried out. This causes lots of problems and sickness for the reindeer. Mostly, as the herders affirm, they suffer from heart and lung diseases.

Summer heat itself wearies reindeer and renders them sick. Reindeer lack sweat-glands, and are thus unprotected against the heat. As the herder Ivan explained, any scratch or abrasion can become a cause of suppuration and serious sickness for the reindeer impaired by the summer heat. The herder Denis affirms that it has become almost impossible for reindeer not to hurt their legs in recent arid summers. 'Because of aridity, even twigs have become dry and sharp, they can injure reindeers' legs, and it causes sickness.' The prevailing summer disease is '*kopytka*' disease, which is accompanied by the cracking of reindeers' hooves. This disease can affect reindeer in any season, but in summer and especially those hotter than usual, *kopytka* becomes more common and is transmitted further.

Another disease, exacerbated by climate change, is bronchopneumonia. It affects those calves which are born before the arrival of snowstorms in spring, but it may also occur in too hot summers. Despite of summer heat, there are still some places where snow can be found. The reindeer weary of summer heat rush towards the snow and because of the sudden change of temperature encountered they get bronchopneumonia. During summer some herders may not notice anything wrong, however as autumn approaches the disease can adversely affect the animals. As explained by the *choom*-worker Ulyana, the effects of bronchopneumonia may be revealed during slaughter. Ulyana told me that during the latest slaughter they selected two calves, because they were smaller than others, and decided to kill them. Her role was to cut reindeer carcasses, to cut out their liver. It happened that she had to butcher the two small calves. 'I took out their internals. What do you think? The hearts were completely covered with pus. I managed to cut out of the entire heart matter from one of the calves, but I could not even find the heart of the other one. Everything inside it was totally overgrown with something. It was right that they decided to slaughter them, because they would not be able to survive the winter as the temperature drops.' The main specialist of the farming department in the Nenets Autonomous Area[5] said that because of animals' diseases the farmers received eight kilograms less meat from each reindeer than usually due.

[5] Sergey Kiselev

A further summer related problem, which may intensify with climate change, is reindeer emaciation due to harassment from mosquitoes and other blood-sucking insects. The intensity of mass attacks by blood-sucking insects can be so strong that its can lead to the death of reindeer which stray from the herd. Denis relates: ‘There are lots of mosquitoes and swarms of midges. They torment reindeer. They totally cover them. Insects stop up their eyes and other open places. The reindeer become rabid and franticly run around. It is really difficult to calm them. They are not able to stay at one place.’ Trying to escape the insects, reindeer bunch into the big compact circles and revolve like a big ‘merry-go-round’ instead of seeking a better pasture. As a result, the reindeer trample down strips of the summer pastures to such extent that, as the informants say, not one blade of grass is left there. The hotter the summer is, the less the reindeer eat. The herders affirm that in really hot weather reindeer do not even eat at all until it becomes cooler and then they rest and graze quietly.

A further concern caused by excessive summer heat is that calves are often separated from their mothers whilst attempts are made to escape the insects. Efforts to find each other are hampered by tiredness which harms the calves’ health, due to loss of milk.

Computing the really shocking loss of calves in summer 2007, Kiselev explains that climate change is responsible for the most part. He writes: ‘I can say that in 2007 the weather really blighted our reindeer herders. Because of hot July the deer farms lost a lot of the young growth. In several farms the loss consisted more than 500 heads. Generally, in the Nenets Autonomous Area, non-productive loss of the young growth was 3,500 heads. It is a big number! Each of the calves perished could give an animal yield next year. In meat equivalent the loss consisted nearly one hundred tons of meat’ (Kiselev 2007c, 4).

Because of climate warming other dramatic changes are happening in the regions where Nenets live. On the one hand, there are floods and, on the other hand, fires. Some lands on the Barents Sea coast are inundated to such extent that in 2001 the inhabitants of one of the villages Staryi Varandey were removed from there by force. To the south of the Nenets Autonomous Area there are summer fires. The herders say that the peat bogs and forest-tundra catch fire in summer, and smoke travels to their location. In addition, animals such as bears, polar foxes, gluttons (wolverine), escape to the tundra to evade the fires in forested areas. Some of these animals are predators, dangerous for the reindeer and others (like polar foxes) are the carriers of diseases to which reindeer are vulnerable. In some places, the fires also ignite the winter pastures. Moss, a valuable reindeer forage source may take up to 30 years to restore following a fire, which further aggravates the lack of winter pastures.

Another disturbing feature of climate change is the appearance of such phenomenon as summer tornados and hurricanes. The elders affirm that they do not remember any such incidents in earlier days, and everyone says that these are signs of climate change. Nowadays, as my informants say, tornados have become frequent. The summer winds can be so strong, they say, that they even blow cloudberries off their stalks. Maria remembers that once, on a quiet sunny day they noticed that the water in the lake began 'boiling' and waves appeared. By the evening the heavy wind 'struck'. 'One of our herders wanted to strengthen our *choom,*' she said, 'but he did not have time for that. He flew away together with the *choom*. Nobody could hold that *choom;* indeed there was no time for that.' Fortunately nothing too bad happened to that herder. Ulyana remembers that once, at night, when all her children and she were sleeping in bed, she awoke to discover that there was no *choom* above her, and that they were all already lying in the open air. The blast tore off her *choom* and carried it away. 'I did not even have time to put my dress on; I just quickly wrapped myself up into a blanket. No *choom* any more! It has been taken away! The stove fell right to the bed. Fortunately I had water nearby to put out the fire. There was no *choom*, and mosquitoes attacked us. Disgraceful mosquitoes! Our neighbours were more successful. They did not sleep and had time to grasp their *choom*.' After that case Ulyana could not sleep quietly any more and woke up with any capful of wind. Once, as Ulyana said they were preparing for travel and had packed all their goods. They then saw the tornado coming and hid their children under the sledges. Lucky, they said, the whirlwind did not carry their children away. Another time when they noticed the tornado approaching they had time to put in place additional measures to secure their *choom,* but, as Ulyana remarks, it only partly helped them: 'The puff was so strong that one side of the choom was raised. I grabbed the poles inside the choom. How could I hold them in place? No strength to hold them! The wind could carry them away together with me.' Ulyana considers it was a miracle that her *choom* was not carried away that time.

Tornados are not dangerous for the adult reindeer, but as the herders say, they can carry away a calf. The herders affirm that some of their calves were taken away by the wind. Sometimes hurricanes are accompanied by hail. The herders described hailstones as large as hen eggs. Big hailstones can hurt both people and reindeer. If people are not in *chooms* during hailstorms, they hide their children under the sledges.

Information concerning the variation in summer fog conditions differed according to region. Yamal Nenets did not notice any change in foggy weather. They affirm that after August 2nd, when it becomes cooler, the fog begins. On the contrary people from the Nenets Autonomous Area assert that recently there have been fewer fogs than before. Ulyana explains that in foggy weather it is difficult for a herder to gather his herd. 'When a reindeer has a possibility to eat, it does not look at other reindeer. To eat and especially to eat something extremely tasty like mushrooms is the main thing for it. So each reindeer goes wherever it wants. As a result, it can lose its herd, stick to someone else's herd or stay alone.' In foggy weather it is more difficult for the herders to look after their reindeer and prevent them dispersing. Ulyana remembers foggy weather which lasted for more than three weeks. 'It was such a feeling that we were closed within a locked lodgement and that we do not have place enough. Later when everything was over we felt that it became easier to breathe, we could see a wide space around: other chooms, sea and ships.' Foggy weather is also unpleasant because of an increasing intensity of blood-sucking insects. In fog conditions mosquitoes are active even at night and it is tiresome both for the herders and for the reindeer. Therefore any decrease in foggy weather as a result of climate warming is a positive development.

4.2.3.2 Summer Adaptive Strategies

The current adaptive strategy employed to counter the diseases aggravated by hot arid summer weather is veterinary medicine. The administration of the Nenets Autonomous Area and the Yamal-Nenets Autonomous Area began to distribute medicine to prevent *kopytka*. The herders are given special training in how to use the medicine and heal their reindeer. 'Zoo-technicians explain to us what we should do in case of that disease,' Denis said. 'So, all the herders know everything. When we did not have that medicine, a lot of reindeer perished. But now there is not such big loss of herd. We have even some increases of livestock. I am interested in treating my reindeer well. If I had treated my reindeer well in summer, I preserved their lives. Next winter I can slaughter them, sell their meat, and buy a new apartment for my family.'

Current adaptive strategies against the attacks of the blood-sucking insects consist in the following. First, the herders try to drive the reindeer to a high and windy pasture. This is in accordance with natural reindeer behaviour. In the cases of insect harassment they try to escape for open windswept places.[6] In such places there are fewer insects and is cooler for the reindeer. Thus for the herder, the main priority consists in watching for the wind direction. 'If you lost your attention and stopped watching the reindeer,' Denis explains, 'your herd will have moved toward the wind and you could loose it. When it is hot, the reindeer go against the wind. Trying to run away from the mosquitoes, they are searching for the more windy places. In our herd, there are usually two herders on duty, five male reindeer in their harnesses, and two dogs following. In the evening and in the morning we exchange the herders, the reindeer and the dogs. April to July are the 4 months of the most intensive work.' The second approach to managing insect attacks addresses gadfly infestation. The main specialist in the farming department Sergey Kiselev said that veterinary measures help to reduce reindeer morbidity from gadfly invasion. The herders confirm that prior to treatment there were more gadfly larvae in reindeers' skin, but after the injections the number of gadfly lessened.

Feeling pity towards the animals suffering from heat and insects, the herders use some less effective means, for example sometimes herders even take reindeer into the *chooms* to allow them to rest from the heat and insects. In the *chooms* the animals stay well and quietly, the herders say.

[6] 'If the weather is too hot reindeer tend to stay no the windy slopes and the tops of the mountains the whole day and come down to the valleys to feed only' (Kitti et al. 2006, 151).

Current adaptive strategies to address summer tornados and hurricanes consist in careful watching the weather in order to strengthen the *choom*. People have observed new tornado forewarning signs. They say that the lake water becomes reddish and moves as if it is boiling. Unfortunately they regret that they can only see the signs too late, when there are only several minutes left before the whirlwind starts. At the same time they complain that strengthening the *choom* is not always enough to protect it against the strong wind. My informants proved that whirlwinds and hurricanes are new and recent phenomena in their respective areas. The traditional Nenets *choom* is not adapted to such weather cataclysms. The elders never mentioned any whirlwinds. There was nothing like that in the earlier days, they say; otherwise people would have adapted the traditional *choom* to such extreme scenarios.

4.2.4 Autumn

4.2.4.1 Autumn Exposure-Sensitivities

All our informants affirm that autumns have become warmer and longer. The stable blanket of snow does not appear in mid-October, as before, and similar to spring the weather is characterized by temperature instability. After plentiful snowfall there can ensue thaws and even rain, followed by either an ice-crust formation or snow disappearance. Oleg explains that this it is especially noticeable in the latitude of Krasnoye village, however to the north of Krasnoye the weather is usually colder. Nevertheless, all the regions have registered a change of climate, weather instability (winter rains and sudden frosts after them), and in the most recent years, very little snow until the New Year.

Autumnal inconstancies in weather and especially ice-crusts create real difficulties for the reindeer to survive. As Pieter said, trying to get food, reindeer injure their muzzles against the icy crust; they hurt their legs against ice to such an extent that they tear fur off their legs. Weather instability in autumn negatively influences reindeer health and some perish. Ulyana said that the reindeer looked quite healthy at that time, but suddenly some of them got sick and unexpectedly died. She remembers her son’s reindeer, which seemed healthy and well-fed. It was prepared for slaughtering (‘and nobody burdened it with any job’), but before slaughter, it started losing its weight (‘it suddenly became slender and slim’) and just before the slaughtering date it died. It happened, as Ulyana considers, because it often rained that time in autumn, rather than the usual freezing weather. This case is quiet common, and many reindeer die before slaughter. The regional newspaper reported that the farm ‘Voshod’ (‘Sunrise’) went bankrupt. This was due to a drastic fall in the number of reindeer brought to slaughter. Instead of the expected 950 reindeer, only 91 heads were slaughtered (Kiselev 2007c, 4).

Warm temperatures may cause serious losses to the reindeer herders in one of the most critical periods of their activity, during the slaughter period. In the Soviet times, those chosen for slaughter were outrun to special places, such as

Naryan-Mar city or to some villages, because the meat could be sold immediately in those population centres, thus avoiding unnecessary meat transportation. However because of the late freezing-up of rivers many long-established herd migration routes have become impenetrable.

4.2.4.2 Autumn Adaptive Strategies

Reindeer herders have found different approaches to adapt to these stresses. The first is to delay the slaughtering campaign.[7] The herders kept their herds whilst awaiting cold enough weather, which did not arrive, and only then drove them to the slaughtering place. In 2006 the regional newspaper of the Nenets Autonomous Area wrote that the slaughtering campaign turned out to be really abnormal. It started only on December 12–15th, which is a month and a half later than usual (Kiselev 2006). In the following year, 2007, the newspaper had to write again, 'Because of the warm weather anomaly, the slaughtering campaign started much later than usual,' (Kiselev 2007b). Kiselev writes that because of the present cataclysms in nature, they had to prolong the process of reindeer meat storage until February 10th. He writes that even the elders do not remember such a delay of the slaughtering campaign. It started three weeks later than usual and lasted for almost 4 months (Kiselev 2007c, 4).

The negative result of the postponement strategy is that during autumn the reindeer usually become thinner. Thus delay in slaughter, in addition to the hardship and distances travelled to reach a slaughter facility, contribute to loss of reindeer weight. In 2006 the regional newspaper wrote that because of the slaughtering delay the herds can lose weight, but only by a negligible margin. Next year the newspaper's tone became more serious, and stated that due to the warm weather anomaly and the slaughtering delay, the herders incur losses, as reindeer appreciably lose their weight (Kiselev 2007a). The farm 'Izhemskij olenevod' ('Reindeer herder of Izhemsk') brought to slaughter more reindeer than expected, but despite this the total weight was 15,000 kilograms less than anticipated.

Another climate adaptation strategy is the practice of building special service centres for slaughtering, supplied with refrigerators and essential equipment for meat preservation. As Kiselev emphasized, the establishment of such service centres is a way to make reindeer herders' work less reliant on the vagaries of the weather (Kiselev 2007b). The positive outcome is that in having such centres the herders are freed from the necessity of driving the slaughter herd long distances. A reindeer husbandry support project delivered storage refrigerators to several herders, and the newspapers optimistically reported that as a consequence, even in the above-zero temperature the quality of reindeer meat should not be

[7] Stammler also wrote about the same trouble, which is doubled by the climate warming. 'The earlier slaughtering is done the better will be the slaughtering weight and the meat quality. However, early slaughtering is risky, since a rise in temperature to 0°C or above can destroy the entire meat stock in the absence of large freezers and processing facilities' (Stammler 2005, 117).

impoverished (Kiselev 2007b). Unfortunately not all the herders were provided with either service centres or refrigerators. It was assumed that the several neighbouring teams could gather at one service centre. However this under-estimated the effect of the unpredictable weather. The refrigerators were prepared in the village of Krasnoye, but by the appointed date none of the neighbouring teams, even the closest ones, had brought their herds. This was because the river near Krasnoye, even by December, was still not coated with ice (Kiselev 2007b). This adaptation strategy actually failed because it did not take into account other exposure-sensitivities (like possible late river ice-coating).

A further negative point with respect to the specially equipped slaughter centres is native peoples' attitude to the slaughtering process. Despite the fact that there are slaughter centres right near them, the Nenets herders prefer to slaughter their reindeer themselves. Denis explained it this way: 'I drive my reindeer to such centres only in extreme cases, if I do not have enough assistants in my team. In the slaughtering centres they kill the reindeer sorely and cruelly. I would not like to watch how they were killing those reindeer, which I myself have bred. The people, who work there, do not care about the reindeer. The reindeer should be slaughtered in the right way. When I was a boy, my grandfather told me: "Never kick reindeer! Do not beat them if you have no any serious reasons for that! Do not also beat dogs!" Otherwise you will lose all your reindeer, and your grandchildren would not have any reindeer any more. People should not kill reindeer cruelly!'

The third adaptation alternative is meat transportation, organized by the local administration. This strategy was based on the supposition that the reindeer can be slaughtered far from the service centres, and then transported by helicopters or where possible, by the heavy haulers. In some cases this plan failed because of a sudden and unpredictable rise in the temperature. In autumn 2007 some herds, which were far from any service centres, started slaughtering at the allotted time in the expectation that of meat transportation by the helicopters, however after slaughtering the weather suddenly turned warm and a lot of the meat was spoiled. Khanzerova described it so, 'We feel sorry for the reindeer herders from Kanin. They are really unlucky this year, because their slaughtering campaign was conducted in the warm spell. There was lack of the refrigerators, and the meat lost quality,' (Khanzerova 2007). Thus the strategies described above, to adapt to warm autumns, are not effective enough because they do not take into consideration the entire complexity of exposure-sensitivities.

4.3 Phenological Shift

One of the results of the climate change is the shift of two seasonal cycles, the natural cycle of changing seasons and the reindeer life cycle. The two cycles had previously comprised an integrated system. However now autumnal warmth lingers and spring comes later, it is as if time has drifted. At the same time the reindeers' biological clock and some social habits have not shifted in tandem. The old herders continue wearing their fur clothes in the hot summer weather and the female reindeer carry on giving birth to their calves in the allotted time in spring, when the sudden fall of temperature provides little opportunity for their calves to survive. The integrated system of weather-reindeer-human interconnectivity has become dislocated.

In early spring it is important to move the herd to the calving pastures in good time. As Yuzhakov and Mukhachev indicate, 'delay in reaching winter pastures can lead to the fact that mass calving would begin far from the calving pastures. It will inescapably lead to calve mortality, especially if on the way to the summer pastures there is a water barrier,' (Yuzhakov and Mukhachev 2001, 81). Recently at the time when the herd should be moved to the calving pastures it has still been cold. Really high snow cover prevents migration to and lack of available spring grass in the calving pasture provides a further reason to delay the herd in the winter pasture. As the herders affirm there is no moss either, it would not be possible to feed the reindeer in the spring pasture prior to the arrival of stable warmth. Thus because the late spring migration is delayed an additional burden is placed upon the critical moss winter pastures. The month for migration to the North was traditionally April, but now migration may be postponed till late May. As a result calving happens in the winter pastures, and consequently calves have to make the perilous journey to the North, overcoming hazards, including tundra river crossings. This contributes to significant calve mortality.

Another shift happens in summer. Due to the delay in leaving the winter pastures, the herds are not able to reach the high, open and windier summer pastures before the arrival of blood-sucking insects. 'By the end of June', Denis explains, 'I supposed to be close to the summer pastures, but because of those delays I am still in the beginning of my road to them. This road runs through the low-lying lands, and the blood-sucking insects' flight begins when my reindeer are least protected against them.' In addition to the insect attacks and heat, the reindeer have to carry the heavy sledges loaded by the provisions bought in the village and stocked for the entire period of migration. As a result of these factors, the loss of concordance between the seasonal rhythm and the life cycle of the herd makes the late migration to the summer pastures much more difficult than usual.

Regardless of these impediments, the herder has little alternative but to bring the herd to the summer pastures. Denis elucidates that the area between the winter and summer pastures has lots of disadvantages in comparison with summer pastures. Firstly, it is situated in the hilly forest-tundra, where it is not easy to watch all the reindeer, whereas the summer pastures are located in the plains, where one can watch the reindeer far around. Secondly, unlike in the summer pastures, there is not enough wind in the forest-tundra, and hence lots of blood-sucking insects. Thirdly, the grass in the summer pastures is much better for reindeer than the forest-tundra vegetation.

It would seem intuitive that because of climate change the reindeer summer season should be prolonged, however it is paradoxically shortened. The herd not only comes later to the summer pastures, it has to leave earlier than usual. Our informants referred to the two reasons for that. First, the habitual mode of the activity is still strong. The herders have no foreknowledge about the temperature of the coming autumn. Should the freezing weather arrive at its usual time, unlike in recent years, they risk not reaching the winter pastures in time. The second reason is the increasing competition for the use of winter pastures, especially for those ones situated near the villages, as they say 'near the civilization.' Attempting to occupy the winter pastures closest to the villages before the other herds, the herders bring their herds there much earlier, 'Now in October and in November the herds are already wintering. Why do they start wintering so early? They all want to stay closer to the civilization!

As moving to the winter pastures has shifted to an earlier date, and because the duration of the stay in summer pastures has shortened, people, reindeer and dogs do not have enough time to rest in summer pasture. 'I have just come here (to the summer pasture)', complains Denis, 'but I already have to return back. I return not rested. When I went to the summer pasture, mosquitoes tormented me, but when returning, I have troubles with the lame reindeer afflicted with "*kopytka*" '.

4.4 Discussion and Conclusion: Historical and Future Exposure-Sensitivities and Adaptive Strategy

From our informants' perspective, some features of climate change, and unusual weather phenomena are not completely new in their regions and, with the exception of tornados, have happened in the past. The information about similar events was preserved in the historical sources. Those sources kept the information about fires in taiga zone, which occurred on account of natural factors such as an abundance of dry wood due to long periods of hot and windy weather. The researchers consider that because of human activity fires have become more frequent since the 17th century, but they lack evidence to prove it. There does however exist some data concerning forest fires in 1826, 1840, 1860, 1900–1901, and 1926 (Gololobov 2000, 230; Polyakov 2002, 68). This indirectly points to possible excess summer warmth in those years present also in the tundra.

The formation of ice-crusts over the snow is also not a completely new experience for reindeer herders, but as Adayev emphasizes, in the past ice crusts did not occur over such large areas as has been seen in recent years, and it is evident that the frequency of such events has noticeably increased (Adayev 2007, 85–86). The historical records have noted periods distinguished by warmer temperatures. This includes the second quarter of the 18th century, as a result of a change in winter temperatures. This warming was more considerable in higher latitudes (Khantemirov and Surkov 1996, 271). Only since the mid 20th century has warming been so rapid and temperatures reached such high figures (Adayev 2007, 19). Additional information has been preserved about cold periods. According to A.M. Maloletko, the late 16th and early 17th centuries saw a stable and prolonged fall of temperatures with moderate levels of precipitation. The first quarter and the last decade of the 17th century were very inclement and the peak of the cold spell was reached in 1770s. The 19th century, especially its beginning and the first decades of the 20th century were also sufficiently cold (Maloletko 1999, 47).

The disasters resulted from unstable weather and sudden warming were in the past very rare, and stories about them, as about other extraordinarily events, passed from one generation to another. Our informants affirm that nothing, to their knowledge, similar to the recent climate changes has ever been observed before. The intensity of abnormal weather phenomena is increasing, and what was earlier infrequent is now becoming constant.

The administration has refused to acknowledge that some herders' troubles were caused by climate change. At the same time they recognized the existence of stresses such as pasture degradation, loss of meat during slaughtering, and discussed possible preventative measures. The adaptation strategy they suggested transpired to be unsuitable for coping with the real reasons underlying the difficulties. According to our informants, the administration proposed a reduction in the reindeer livestock population, which would solve, as they thought, the problem of winter pastures shortage, and require the resettlement of some herders to the villages. The herds to be initially cut were private herds, and the state herds were to be preserved. That proposal raised vehement objections amongst private herders who did not accept the official position concerning the administrative means for lessening number of the herds and the means of to restore the pastures. Although in official meetings climate warming is not mooted as a serious concern pertaining to the loss of reindeer, in confidential conversations, the herders do emphasize its significance. The implications of restrictions and reductions in the population of private reindeer livestock have ensured that the herders are fraught with the threat of not only losing reindeer but also their jobs. 'If you have lost your herd,' Denis says, 'if you remain with no reindeer, you would be nothing! You would not be fit for any other job. Your entire life would be broken. You would not be able to think about anything else apart from it. You have children to bring up, you have some other troubles! It would be intolerably difficult! Now even with no official reduction of the herds, the cases when the reindeer herders lose their reindeer, happens more and more frequently.'

The private herders can themselves cope with some of the difficulties caused by climate change, because the foundation of their adaptive capacity has always involved the flexible use of the vast tundra territories and openness to economic innovations (Adayev 2007, 85). Despite the fact that each herd became accustomed to its own migratory route, herders have periodically change the location of the seasonal pastures in order to reduce the burden on the natural resources (Adayev 2007, 97–98). In extreme cases herders may chose wintering places far to the north from the regular winter pastures. Delaying the slaughter date, as a contingency against seasonal dislocation, is yet a further example of the adaptability of reindeer herding praxis.

The situation is complicated by the combination of both climatic and anthropogenic factors, which threaten the reindeer herding economy. The reindeer herders have experienced an increased burden being placed on the environment and habitat in the tundra, and an increasing dependence on external economic and cultural influences. All those factors threaten the traditions of Nenets reindeer herding. Despite the acknowledgement that reindeer herding should be considered as highly adaptive, both with respect to natural and anthropogenic influences, today it is confronted by an especially hard test, because the level of unfavourable impacts affecting reindeer herding is currently extremely high (Adayev 2007, 89). My informants consider that those external negative factors are going to accumulate, and their prognosis concerning the future is rather pessimistic. When I asked the elders how they thought climate change would affect the future reindeer herding economy, they usually said that the conditions would progressively get worse. If everything continues in the same way, some of the herders say, we are going to lose reindeer husbandry in about 30 years. The similar prognosis was received by the other researchers from their informants; 'As it gets warmer and warmer, the permafrost will melt and our land will be a permanent swamp and we won't be able to do anything – no pastures, no hay fields, just the high areas will remain, if it continues, then the permafrost areas will stop being frozen and it will all melt,' (Crate 2009, 143).

The threat of global warming to reindeer husbandry in the Arctic tundra is clearly recognised by those herders and associated officials who are directly confronted by the predicaments caused by the climate change. However the risks are underestimated by those whose position is further removed from the realities faced by reindeer husbandry. Nevertheless one can surmise that the anthropogenic factor, responsible for some of the negative consequences of warming, also has the potential to correct some of the harm caused to reindeer husbandry through climate change. The further development of transportation and additional mechanisms for communication, an improvement in the network of slaughtering service centres, and the provision of veterinarian medicine can help reindeer herders better adapt to climate challenges.

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Chapter 5
Vulnerability of Community Infrastructure to Climate Change in Nunavut: A Case Study From Arctic Bay

James D. Ford, Trevor Bell, and Dominique St- Hilaire-Gravel

Abstract This paper uses a vulnerability approach to characterize infrastructural vulnerability to climate change, drawing upon a case study from the Inuit community of Arctic Bay. Interviews with community members and geomorphological observations indicate a number of exposure-sensitivities which currently affect the community and which have the potential to become more problematic with future climate change. These include landscape hazards such as coastal erosion, permafrost thaw, slope instability, and flooding, which have damaged built infrastructure and threaten to constrain future community development, and climatic risks including sea ice thickness and high winds which are affecting the usability and safety of semi-permanent trail networks. A number of adaptations are utilized to manage infrastructure risks including the construction of buildings on piles, the use of non-pipe based water and sewage distribution, the construction of shoreline protection, and the construction of drainage diversion and control channels. Risks of using trail networks are moderated by traditional knowledge of trail conditions. Climate change will increase exposure-sensitivity of trail networks and hard infrastructure, and population growth is likely to increase sensitivity to climatic risks: areas for new housing development, for example, may be constrained by ice-rich permafrost, slope instability and increased exposure to landscape hazards. A number of barriers to adaptation are likely to constrain future adaptability including financial constraints on strengthening and protecting infrastructure, lack of knowledge of climate change projections and likely impacts on the community, and an erosion of traditional knowledge through which the risks of using trail networks are managed.

Keywords Adaptation · Climate change · Infrastructure · Inuit · Vulnerability · Mixed methods

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5.1 Introduction

There is strong evidence that human induced climate change is occurring in the Canadian Arctic (ACIA 2005; Barber et al. 2008; Comiso et al. 2008; Graversen et al. 2008; IPCC 2007b; Min et al. 2008; Serreze et al. 2007). These changes are having implications for biophysical systems with evidence of accelerated thawing of permafrost and ground ice, reduced slope stability, and increased coastal erosion, which in turn are threatening the viability of some northern settlements, damaging important heritage sites, compromising municipal infrastructure and water supply, and affecting important hunting trail networks (Furgal and Prowse 2008; Larsen et al. 2008; Martin et al. 2007; Nickels et al. 2006). These risks directly challenge community viability affecting sense of place, historical attachment, and the quality of the physical fabric of a community, to the extent that human rights are being challenged (Crump 2008; Ford 2009a).

Modelling studies indicate that future climate change will be amplified and expressed most dramatically in Arctic regions (IPCC 2007b; Lenton et al. 2008; Serreze and Francis 2006). Lenton et al. (2008) illustrate that the Arctic is sensitive to even small changes in climatic conditions due to significant changes in climate already experienced and sensitivity of biophysical systems. Projected changes in climate will undoubtedly bring benefits for Canada's northern regions; more open water in the summer, for example, will increase opportunities for oil and gas development, mining, and improve transportation access (Huntington et al. 2007b; Nuttall 2008; Stewart et al. 2007). If the present day trends are a guide, however, the negative impacts of climate change will significantly outweigh the benefits (IPCC 2007a). Accelerated coastal erosion, permafrost thaw, sea level rise, and changing ice conditions will all affect community viability and livelihoods.

With the realization that we are committed to some degree of climate change and current experience of climate change in the Arctic, efforts to increase the ability of communities to manage impacts are increasingly being viewed as central to climate policy (Ford 2009a). To identify adaptation needs and inform the development of policies to reduce the negative impacts of climate change, it is crucial to identify and characterize vulnerability (Smit and Wandel 2006). While there is an emerging body of scholarship on climate change vulnerability in the Arctic, only a limited number of studies have assessed vulnerability of community infrastructure to climate change (Ford 2009b; Ford and Furgal 2009). In this chapter we draw upon ongoing interdisciplinary collaboration between the authors beginning in 2005 and continuing throughout the CAVIAR project, utilizing a community case study from Arctic Bay, Nunavut, to characterize the vulnerability of community infrastructure to climate change. This collaboration was established to develop a more in-depth and multifaceted view of vulnerability and its determinants using both social and physical science methodologies. We use the term 'community infrastructure' in its broadest sense to include both 'hard' infrastructure (e.g. houses, roads, heritage sites etc) and 'soft' infrastructure (e.g. semi-permanent hunting trails). The chapter begins by outlining the research approach and then describes the case study community. We then assess the nature of current and future vulnerability with regards to hard and soft infrastructure, finishing by placing the study in the larger context of vulnerability research in the Arctic.

5.2 A Vulnerability Based Approach

In this chapter we use the CAVIAR model described in the introductory chapter to characterize the vulnerability of community infrastructure to climate change. This model conceptualizes vulnerability as a function of exposure-sensitivity to climate-related risks and the adaptive capacity to deal with those risks. Exposure-sensitivity refers to susceptibility of a community to climatic conditions that represent risks, and is a joint property of both the characteristics of climatic conditions (e.g. magnitude, frequency, spatial dispersion, duration, speed of onset, and temporal spacing of climatic risks) and the nature of the community (i.e. location of community, resource use, timing of activities, etc). Adaptive capacity refers to the ability of individuals, households, communities, institutions, etc. to address, plan for, or adapt to these risks. In this conceptualization, vulnerability is viewed as being determined by economic, political, and climatic conditions and processes operating at multiple scales which affect exposure-sensitivity and adaptive capacity at a local level. The two stage analytical framework outlined in the introductory chapter is used to empirically apply the conceptual model to characterize vulnerability of community infrastructure to climate change and integrate social science and biophysical data. Analysis begins by identifying *current climate vulnerabilities* faced by communities, which directly feeds into an assessment of *vulnerability to future climate change*.

Assessment of *current vulnerability* is concerned with the present day, beginning by identifying exposure-sensitivity to climatic conditions, and characterizing the nature of exposure-sensitivities in terms of the physical nature of the risks (spatial distribution, magnitude, frequency, duration), local impacts, change over time, and determining factors. Characterization of current vulnerability finishes by identifying and characterizing adaptive strategies currently employed to manage climatic risks and the process and conditions which affect their success. Assessment starts by identifying adaptive strategies employed: it is noteworthy that such strategies might concern climatic conditions directly and/ or indirectly. Once adaptive strategies have been identified, assessment then examines their effectiveness.

To assess current vulnerability we conducted 60 semi-structured interviews with local Inuit community members and hamlet staff to identify and characterize climatic related conditions posing risks to infrastructure and strategies employed to manage those risks (see Ford et al. 2006 for more detail). Aerial photographs and satellite images (e.g. QuickBird ©DigitalGlobe) and mapping of terrain characteristics in and around the community were used to characterize the physical nature of infrastructure exposure-sensitivities. Both surficial sediment type and distribution were delineated, together with identification of past and current landscape instability in relation to community infrastructure. Field visits permitted ground-checking of remotely sensed data and characterization of landscape hazards.

Analysis of current vulnerability feeds directly into characterization of *vulnerability to future climate change*. Assessment of future vulnerability begins by assessing future exposure-sensitivity, examining how climate change will affect climatic conditions to which exposure-sensitivity already exists. Once the impacts of climate change have been specified, it is then necessary to evaluate how communities might interact with these changes to determine exposure-sensitivity. In this project we review the published literature for projections of what changing conditions might mean for biophysical systems in Arctic Bay and evaluate implications for the community. The vulnerability assessment is completed by evaluating the extent to which current adaptive strategies employed will enable future climate change impacts to be dealt with. We examined the strengths and weaknesses of existing plans to manage exposure-sensitivities and experience at managing change to provide insights of future adaptability. Future scenarios were also explored with local decision makers and potential community response options assessed.

5.3 Nunavut Case Study

5.3.1 Territory of Nunavut

The territory of Nunavut was created in 1999, carved out of the Northwest Territories by the Nunavut Land Claims Agreement (1993). Covering 1.9 million km^2 the territory has a population of 29,474, 84% of whom identify themselves as Inuit. The climate of Nunavut is characterized by very cold, long winters and short, cool summers, with sea ice an integral part of life. Depending on geographic location, the length of time at which the ocean is frozen varies from 7 months in the south to nearly year-long coverage in northern Nunavut. In many locations, the ice may exceed several meters in thickness, although distribution and thickness of sea ice are variable. The frozen ocean provides an important transportation link between communities, with few permanent paved roads in Inuit regions, and also acts as a barrier to boat transport. The ice also provides a platform for culturally and economically important harvesting activities. The majority of the land surface area of the four Inuit regions is continuous permafrost, which in places is several hundred meters thick.

The majority of Nunavummiut (Inuit inhabitants of Nunavut) live in small, remote, coastal communities, with economies composed of waged employment and subsistence harvesting. The waged economy is largely based on public administration and resource extraction, with tourism also important in some regions. Many Nunavummiut retain a close and intimate relationship with the environment and a strong knowledge base of their regional surroundings, with traditional foods derived from hunting having social and cultural importance (ACIA 2005; Kuhnlein and Receveur 2007; Young and Bjerregaard 2008). Social, economic, and demographic characteristics of Nunavut communities often mirror those in developing nations (Senécal and O'Sullivan 2006). Many communities are challenged by limited access to health services, low socio-economic status, high unemployment, crowded and poor-quality housing, concerns regarding basic services such as drinking water quality, and low educational achievement (AHDR 2004; Seguin 2008).

All except one of Nunavut's 26 communities are coastal, reflecting their close association with the sea and their reliance on marine resources and transportation. Buildings are designed to reduce their impact on the permafrost landscape through the use of piles, wooden blocks, space frames, or thermal siphons that limit the transfer of heat into the ground. Likewise, domestic water and sewage tanks are either raised above the ground or insulated in the ground to prevent permafrost thawing. Water delivery and sewage removal are primarily by tanker truck with some exceptions (e.g. parts of the capital city Iqaluit where water pipes are installed in insulated utilidors). Potable water sources include local ponds and rivers, whereas sewage lagoons are constructed on the land surface. Community roads are generally graded gravel with culverts installed to route surface drainage to local streams or the sea. Nunavut communities generally do not have harbor infrastructure, except for small craft where a natural or constructed breakwater provides some protection in the open-water season. Larger marine vessels that visit communities, including the annual sea-lift that replenishes bulk non-perishable goods and materials and cruise ships, rely on barges or smaller landing craft to access the community shoreline.

5.3.2 Arctic Bay

Arctic Bay is a small coastal Inuit hamlet (population: 690) located on north Baffin Island, Nunavut, approximately 700 km north of the Arctic Circle (Fig. 5.1). Its Inuit name is Ikpiarjuk, translated as the 'pocket' because of the steep hills that surround the settlement on three sides. The region forms part of the Lancaster Plateau which is characterized by a generally undulating surface that reaches 750 m elevation on the Borden Peninsula and steep, in places near-vertical cliffs that rise 300 m or more above the sea (e.g. St. Georges Society Cliffs to the southwest of the community). The area surrounding Arctic Bay is largely dominated by two bedrock types (Lemon and Blackadar, 1963). Black,

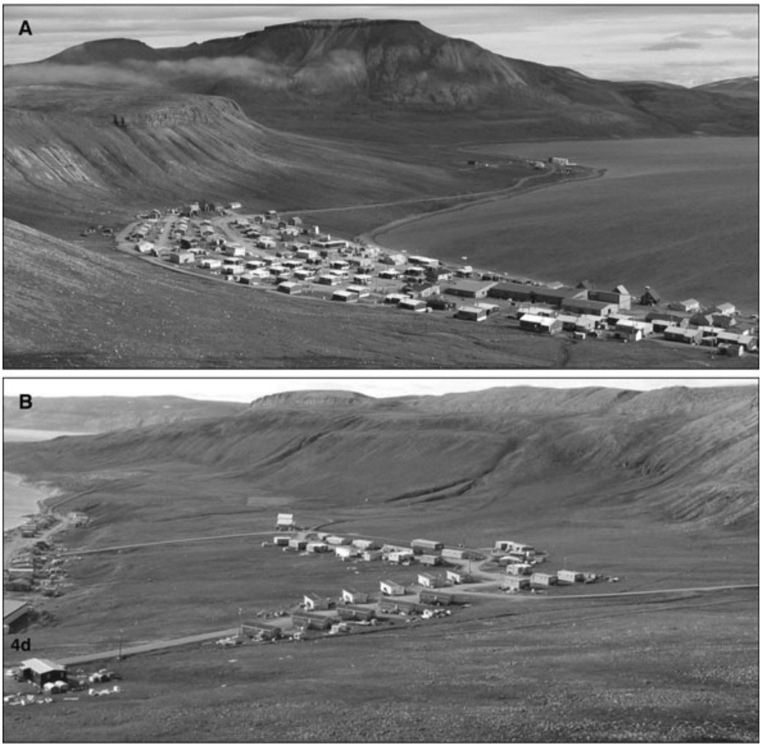

Fig. 5.1 Arctic Bay, Nunavut. (**a**) Steep slopes surround the community on three sides. The road to Nanisivik runs along the coast in the background. (**b**) New housing and commercial development extends to the west of the main community. Photos: Trevor Bell

fissile argillaceous (clay-rich) limestone and calcareous dolomite outcrop under and behind the community (Arctic Bay Formation), whereas a massive, grey dolomite caps the local cliffs (Society Cliffs Formation). The limestone and dolomite of the Arctic Bay Formation are relatively soft and weather readily, producing a dark colluvial deposit. The region had emerged from the ice cover of the last glaciation by 8,500 years ago and postglacial marine overlap occurred up to 50 m above present sea level (Dyke 2008). The main surficial sediments in Arctic Bay and vicinity are of glacial (till), marine (beach gravel and sand) and colluvial (slope deposits) origin.

The local Environment Canada climate station is located at Nanisivik airport on the plateau surface at 640 m elevation. Climate normals for the period 1971–2000 show that only the months of July and August have mean daily temperature above 0°C, while January and February have mean daily temperature of –30°C (Environment Canada, 2008). An average total rainfall of 50 mm falls between June and September, while 80% of annual snowfall

(173 cm) occurs between May and November. Wind data are limited but suggest that extreme wind events (maximum hourly speeds) originate from the southeast 75% of the time. It is uncertain how representative this high inland site is of local conditions in Arctic Bay, especially in summer when fog and low cloud cover may persist on the plateau and open water conditions exist off the community.

The hamlet is built on the shoreline of Arctic Bay, a largely sheltered inlet that opens southward into Adams Sound. It is connected to the former mining camp of Nanisivik (closed in 2002), the associated deep-water port facility on Strathcona Sound and the local airport by a 32-km-long gravel road. There is also road access to Victor Bay where fishing camps are maintained. The settlement has expanded rapidly since the 1960s, and the economy has shifted from being based largely on subsistence activities to a mixed economy where both the informal and formal economic sectors assume an important role. Harvesting of renewable resources is an important activity in Arctic Bay, contributing significantly to food supply. Marine mammals and fish – predominantly ringed seals, narwhal, and arctic char – form the mainstays of the wildlife harvest, which, except for a period of open water from mid-July to early October, is largely performed on sea-ice. Access to other communities and terrestrial caribou hunting grounds also requires travel on the sea-ice in winter and open water in summer.

The community infrastructure is composed of single and multiplex housing, several stores, a school, a satellite college campus, nursing station, ice rink, hotel, churches and hamlet and territorial government buildings. The sewage lagoon, garbage dump, primary drinking water supply and fuel tanks are located several kilometers to the east off the Nanisivik road. These services are delivered by truck. A breakwater was constructed in front of the community to provide protection for small boats. Recent expansion of the community, primarily in the form of housing, has taken place on open flat land to the southwest of the main hamlet. In 2007, the Canadian Government announced plans to develop the Nanisivik port site into a new docking and refueling facility for the Canadian Forces, in an effort to maintain a Canadian presence in Arctic waters during the navigable season. Currently a new airport is being constructed within several km of the community off the Nanisivik Road.

5.4 Current and Future Vulnerability of 'Soft' Infrastructure

'Soft' infrastructure concerns the semi-permanent trail networks widely used by Inuit in Arctic Bay, and common across the North, comprised of snow machine tracks on the sea ice and snow covered land commonly used between the end of October and early July, land based ATV tracks used from May until late September, and boating routes used throughout the summer open-water period. Theses semi-permanent trails are particularly important in Arctic Bay with an absence of permanent paved roads and location of hunting grounds on the ice and inland. They are also used for travel to other communities including Igloolik and Pond Inlet and enable inter-community trade in traditional foods.

5.4.1 Current Vulnerability

5.4.1.1 Exposure-Sensitivity: Changing Climatic Conditions

In Arctic Bay, Inuit are perceiving and experiencing changing climatic conditions (Table 5.1). These changes have amplified the magnitude and frequency of hazardous conditions that people have to deal with when using the semi-permanent trail network, which has safety implications. Changing climatic conditions are challenging Inuit knowledge and understanding of the environment, specifically the ability to evaluate risks of using trails. With the visual clues of weather and wind becoming more difficult to read, identifying precursors of hazardous travel conditions is increasingly difficult. Typically, before going out on the land, individuals will look at the clouds' height, form, and the direction of movement, and wind, as well as other environmental indicators, to attempt to forecast the weather in order to decide if it is safe to hunt or travel (Ford et al. 2006). Prediction is essential; the ability to anticipate and respond to dangers, opportunities, and changes, is important for safe travel. Strong winds, for example, can be dangerous while boating on exposed water in the summer and can cause the pack-ice to suddenly detach from the landfast ice in late spring. According to community members, the weather was fairly predicable over the past several generations. In recent years, however, there have been incidents where sudden and unexpected changes have stranded hunters on the land (Ford et al. 2006).

Table 5.1 Observed climatic changes in Arctic Bay (after Ford et al. 2006; Ford 2008)

Aspect of change	Reported change
Weather	• Increasing unpredictability – elders predictions never correct anymore • More extremes of temperature
Wind	• Changes to the direction, strength, and frequency of the wind – especially in summer • More unpredictable • Stronger wind • Change in the predominant wind direction is affecting the shape of snowdrifts
Sea ice	• Later freeze-up, earlier break-up • Less stable – breaks up suddenly • Thinner in places • Takes longer to form
Snow	• Less snow on the land
Rainfall	• More summer rainfall

The risks are particularly acute for those who travel to the floe-edge to hunt narwhal during sea ice break-up. In late spring 2000, for instance, 52 hunters were caught by surprise when a strong wind from the south detached the ice they were on from the landfast ice and pushed them down Admiralty Inlet (Ford et al. 2006). According to elders, these break-off events are happening with increased regularity.

Unpredictable weather is a problem for those who travel and hunt by boat during the summer open-water period. People have been caught out by unexpected strong winds in small boats and have had to return quickly to shore. Others have been forced to spend extra, unplanned nights on the land waiting for conditions to improve to allow safe travel. Community members also indicated changes in the condition of the ice, including later and longer ice freeze-up, earlier break-up, thinner ice, more snow on the ice, and new areas of open water. Snow covered thin ice presents a potential hazard on trails, particularly in fall when it hides thin ice, and hunters have noticed more snow on the ice recently. There have been numerous cases in recent years where trail users have gone through unusually thin ice and snow covered ice and lost their snowmobiles (Ford et al. 2008a). Similar changes in exposure-sensitivity have been noted elsewhere in Nunavut (Gearheard et al. 2006; Laidler et al. 2009; Riewe and Oakes 2006).

5.4.1.2 Exposure-Sensitivity: Changes in the Human System

Changing exposure-sensitivity to risks of using ice, open water, and land-based trails are occurring in the context of changes in human use of the environment. Thus increasing danger cannot be attributed to changing climatic conditions in isolation. Some of main documented changes have been technological in nature, including the use of, and dependence on, imported technology such as snowmobiles, motorized boats, and more recently GPS and VHF radios (Aporta and Higgs 2005; Bravo 2009). The adoption of these modern technologies has occurred in the context of decreasing time availability for hunting due to participation of hunters in the formal economic sector, distance of communities from hunting areas, and a reduction in land based skills, especially among younger generations (Wenzel 1991).

The adoption of new technology and equipment has had implications for harvesting safety. On the one hand, if used properly, they confer improvements in safety and reduced exposure to hazards of trail use (Bravo 2009; Ford et al. 2008a). VHF radios allow the community to be contacted in case of an emergency, personal location beacons have saved lives by enabling rescue teams to locate lost or injured hunters, GPS permits navigation in near zero visibility and makes navigation by boat easier, larger and faster boats offer more protection than kayaks when hunting in open water, and snowmobiles allow land to be reached rapidly if the ice disintegrates. Local search and rescue groups make use of this technology in emergency situations. Technology also enables resources elsewhere in Nunavut to be drawn upon in search and rescue operations, including helicopters, planes, and logistical support (see CBC 2005; George 2000). Technology, however, has also created new hazard exposures and exacerbated old ones (Ford et al. 2006). The replacement of dog teams with snowmobiles, beginning in the 1960s, for instance, has increased the dangers of travelling on ice: snowmobiles, unlike dog teams, cannot sense dangerous ice, they break down, run out of fuel, and can't travel over very thin ice. Snowmobile travel is particularly dangerous in fall when there is snow-covered thin ice.

Inuit risk assessment when making decisions regarding trail use has also changed in other ways; people are now more likely to travel in spite of poor weather conditions. This is partly due to the reduced time available to harvest and travel. Many hunters now balance full or part-time jobs with hunting activities. Time off from work, which is used for hunting trips, has to be booked weeks, if not months, in advance. Weather or safety concerns may, therefore, be superseded by consideration of time availability when harvesting decisions are made.

Increased risk taking behaviour is also linked to de-skilling and incomplete transmission of knowledge for safe hunting among younger generations (Bravo 2009). Many young Inuit do not have the knowledge to travel safely, including the ability to locate dangerous areas on the ice, identify precursors to hazardous conditions, or judge whether it is safe to go hunting. Many hunting accidents in Arctic Bay involve youth. This is reinforced by equipment such a snowmobiles and new technology which enables young Inuit to hunt and travel without the years of experience required to operate a dog team and navigate using traditional wayfaring methods (see Aporta and Higgs 2005; Bravo 2009; MacDonald 1998).

5.4.1.3 Adaptive Capacity

Table 5.2 shows how changes in 'soft' infrastructure related exposure-sensitivities are being managed by Inuit community members using several strategies, including risk management, risk avoidance, and risk sharing. Many of these adaptive strategies are being utilized throughout the Arctic (Berkes and Jolly 2002; Gearheard et al. 2006; Huntington et al. 2007a; Laidler et al. 2009; Nickels et al. 2006; Pearce et al. 2009a). Table 5.2 also highlights that these coping mechanisms are not without their costs and not all people have equal access to them. Technological adaptations, for instance, are only available to those who can afford them, and there is evidence that technological developments may increase inequalities within communities (Ford et al. 2006). The effectiveness of adaptation also varies. Some adaptation technologies such as GPS and VHF radios can increase exposure-sensitivity by encouraging risk-taking behaviour (Aporta and Higgs 2005; Ford et al. 2006).

The ability of Inuit in Arctic Bay to cope with changing exposure-sensitivity of using semi-permanent trails is indicative of their adaptive capacity. As documented by Ford et al. (2006, 2008a, b), adaptive capacity is facilitated by traditional knowledge and land base skills and resource use flexibility.

Table 5.2 Adaptive strategies employed to manage climate change related risks with regards Arctic Bay's semi-permanent trail network (modified from Ford et al. 2006b)

Climate change related risks	Adaptive strategies	Adaptation costs
Unpredictability of the weather, wind, ice	• Hunters are taking extra food, gas, and supplies in anticipation of potential dangers • Hunters are making sure that they travel with others when possible • Some hunters are being risk averse, avoiding travelling at certain times • New equipment taken along e.g. immersion suits, satellite phones	• Costs of purchasing extra supplies prohibitive • Avoiding travelling at certain times results in shortages of some traditional foods • New equipment is often expensive
Waves/stormy weather for summer boating	• Identification of safe areas prior to travel where shelter can be found • Waiting in the community for adequate conditions	• Waiting results in reduced harvests • Avoiding certain areas can result in increase gas costs and time needed
Snow covered thin ice	• Avoidance of snow covered areas • Extra care while travelling	• Avoiding certain areas can result in increase gas costs and time needed
Reduced accessibility to hunting areas	• Waiting in the community until hunting areas are accessible • Switch species and location • Sharing of country food	• Waiting results in reduced harvests and need to purchase more store food • Not all have the hunting skills to switch species

Traditional Inuit knowledge is important in facilitating adaptive capacity. From knowledge passed down the generations and from personal experience, hunters learn the inherent dangers of the Arctic environment, including how to evaluate risks; what preparations to make before hunting; and what to do in emergency situations. As a repository of accumulated experience and knowledge of changing conditions and successful adaptations, this knowledge is drawn upon to minimize the risks of using trails and maximize opportunities. It is a highly experiential form of knowledge, continually being updated and revised in light of observations, trial-and-error experience, and incorporation of non-traditional knowledge alongside the traditional (Berkes 1999; Ford et al. 2006; Stevenson 1997). Increasing unpredictability of biophysical conditions in recent years, for example, is now part of the collective social memory that frames individual practice and decision making (Ford et al. 2009). This ability to learn and combine new experiences with traditional knowledge confers significant adaptability.

Flexibility in seasonal hunting cycles facilitates adaptive capacity. Hunting is in many ways opportunistic; it has to be given the inherent variability of Arctic environments. While there are preferred seasons and locations to hunt, hunters will harvest what is available when it is available and where. In Arctic Bay, for instance, if the caribou hunt in August and September fails, other species, such as seal will be harvested. Substitution allows people to cope with variations in accessibility due to trail conditions, using trails that are available and safe for use.

5.4.2 Future Vulnerability

5.4.2.1 Future Exposure-Sensitivity

Drawing upon a review of literature on future climate change impacts, Table 5.3 summarizes how key exposure-sensitivities associated with trail use might change with climate change. The majority of projected changes in climatic conditions will have negative implications for trail networks, although a lengthening of the ice-free open-water season could improve boat access. Changes in human use of the environment will both moderate and exacerbate exposure-sensitivities associated with using ice, land and water travel routes.

Table 5.3 Drivers of future exposure-sensitivity in Arctic Bay (– = negative implication, + = positive implication)

Current exposure-sensitivity	Implications of climate change	Human drivers
Sea-ice: ice dynamics, break up and freeze up timing, thickness	• –: 2081–2100 mean ice thickness reduced by 50 cm, earlier break up and later freeze up (Dumas et al. 2006) • – : Increasingly dynamic sea ice (Derocheret al. 2004; ACIA 2005) • + : 2 months more open water by 2081–2100 (Dumas et al. 2006)	• – : erosion of land based skills among youth (Ford et al. 2008b) • –: improper use of new technology (Aporta and Higgs 2005) • –: inability to afford technological adaptations • + : increase Nunavut emphasis of land skills training (Ford et al. 2007)
Weather: predictability, extremes	• – : Changing wind directions, reduced predictability (Barber et al. 2008; Furgal and Prowse 2008) • + : fewer extreme cold days	• –: erosion of land based skills among youth (Ford et al. 2008b) • +: under investment in weather forecasting
Terrestrial environment: snow depth, mud	• + : permafrost thaw and water logging of land (Furgal and Prowse 2008)	

5.4.2.2 Future Adaptive Capacity

Barriers to adaptation are already evident in Arctic Bay. Financial costs in many instances limit access to coping mechanisms, coping mechanisms are not always effective, and they may entail unacceptable socio-cultural costs (Ford et al. 2008b). Characteristics of Inuit society that traditionally facilitated adaptive capacity have also been altered as a result of changing livelihoods during the last half of the twentieth century. An erosion of traditional Inuit knowledge – through which trail use risks are managed – for example, has been documented among younger generation Inuit in Arctic Bay (Ford et al. 2006), and throughout the Canadian Arctic (Bravo 2009; Condon 1998; Condon et al. 1995; Newton 1995; Pearce et al. 2009b). Consequently, certain skills necessary for safe and successful trail use have been lost, including the ability to identify precursors to hazardous trail conditions, how to dress appropriately, and what to take along on trips. This has increased the vulnerability of young hunters when they travel and hunt without experienced hunters. Future adaptive capacity will be dependent upon the extent to which financial constraints continue to restrict adaptation and the land based skills and knowledge of today's younger generations who will be the main users of trail networks in the future. Ford et al. (2007, 2008b) note some positive trends with the Government of Nunavut funding a number of cultural initiatives to preserve traditional skills and provide financial resources for adaptation, yet they also caution that success of these initiatives in increasing adaptive capacity will depend upon long term institutional support.

5.5 Current and Future Vulnerability of Hard Infrastructure

Hard infrastructure concerns elements of the built environment including roads, houses and other buildings, air strips, and port facilities. The location of Arctic Bay, occupying a narrow coastal fringe between the sea and upland slopes, presents challenges for the stability and security of hard infrastructure, and imposes constraints on future development.

5.5.1 Current Vulnerability

5.5.1.1 Exposure-Sensitivity: Landscape Conditions

Evidence of coastal erosion and retreat were identified from aerial photographs and ground surveys. At the western end of the community where local aggregate was used to level ground for a former airstrip, significant erosion has taken place (Fig. 5.2a). Rates of coastal retreat are unknown; however, the first buildings were constructed on the site in 1990 (M. Allurut personal communication 2009) and the consulting firm that prepared a bank stabilization plan estimated that 8 m of fill had been lost due to erosion in 2002 (Dillon Consulting Limited 2002). That represents more than 0.6 m of coastal retreat per year between 1990 and 2002. Prior to stabilization (see below) the footings of six homes were deemed at risk. Currently, the road to the cemetery is eroding and

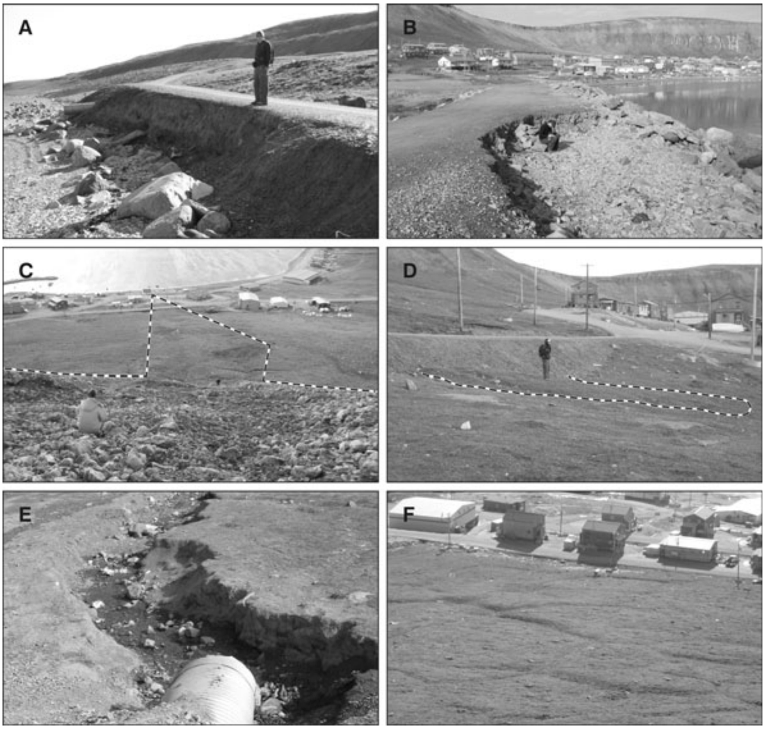

Fig. 5.2 Examples of landscape hazards in Arctic Bay. Coastal erosion has eroded local roads (**a**) and community breakwater (**b**). Slope instability has resulted in landsliding, slumping and debris flows, the largest of which predates the community (**c**) and extended downslope beyond where local infrastructure is now developed (**d**). Culverts contain and control surface drainage through the community but may result in local erosion (**e**) during snowmelt or extreme rainfall events. Ice wedge polygons indicate the presence of ground ice below the permafrost surface in parts of Arctic Bay and suggest that local housing, commercial and community infrastructure is built on sensitive terrain. If disturbed or subjected to ground warming, thaw subsidence will likely result. Photos: Trevor Bell

out-buildings associated with residential housing on the former airstrip are being undermined. These areas lie on either side of the stabilized coast.

Farther east, the seaward slope of the waterfront road in the community shows signs of active erosion, as does the work area for the local hamlet garage. An abandoned Parks Canada building along the waterfront has experienced significant damage to its foundation pad, despite attempts to protect it with large boulders (Fig. 5.3e). The community breakwater, which was constructed to provide shelter for local boats, experienced significant damage during a single recent storm event in 2006 when open-water conditions prevailed in the early Fall (Fig. 5.2b). Precisely surveyed coastal transects at intervals along the community shoreline provide a baseline against which to measure coastal change in future years.

Fig. 5.3 Examples of local adaptation to landscape hazards in Arctic Bay. Adjustable jack (**a**) and pile (**b**) foundations mitigate the impacts of permafrost thaw and ground subsidence or heaving on buildings. Coastal armouring, either through large government-funded stabilization projects (**c**) or local protective measures (**d**, **e**), attempts to reduce the impact of erosion on infrastructure and land use. In the cases of (**d**) and (**e**), measures were only temporary and erosion eventually undermined local infrastructure. Surface drainage is contained and routed through the community using open ditches (**f**) and culverts. Photos: Trevor Bell

Slump scars attest to previous mass movement on steep slopes above the community. Although these scars indicate the susceptibility of community slopes for failure, only one that extended downslope into the community has been documented and it predated local infrastructure development (Fig. 5.2c). Archival photographs from the Hudson's Bay Company and from Library and Archives Canada dating from as early as the 1920s record the presence of multiple slump scars on slopes backing the community. The toe of the most extensive slump terminates above the hamlet office but the run-out zone has recently been traversed by a community road (Fig. 5.2d). Recent failures have largely been in the form of active layer detachments high up above the community and limited in extent. All of the recent and historic slope failures appear to have developed in deposits derived largely from the Arctic Bay Formation, which produces fine-grained colluvium.

Rockfall on the vertical dolomite outcrops of the Society Cliffs Formation has resulted in a scattering of large boulders on the upper slopes above the community. One such boulder tumbled down the slope and impacted a house at the back of the community. It is uncertain whether the boulder originated on the cliff face and gained sufficient momentum to reach the lower slope or, as hamlet staff speculated, the boulder was dislodged by local human activity on the slope. Either way, there is potential for these boulders to reach the community and impact infrastructure.

The combination of sloping terrain and bedrock, frozen ground or a thin active layer means that snowmelt and storm runoff readily drains downslope across the ground surface. This surface drainage is then channeled through culverts under roadbeds or open ditches in the community. During low to moderate flows this water is efficiently drained around or under infrastructure to the sea; however, during peak flows culverts and open channels may have insufficient capacity to carry discharge and flooding results upslope. Damaged or partially blocked culverts and channels may further reduce drainage capacity, leading to flooding under moderate discharge conditions. As a result, drainage may overflow across roads and gravel pads of buildings, causing erosion. Furthermore, high discharge at culvert outlets may produce local erosion of stream channel beds (Fig. 5.2e). Over time, road foundations and building pads may be undermined, compromising infrastructure.

Permafrost is defined as a soil (or rock) which remains at zero or subzero temperatures ($\leq 0°C$) for at least 2 years. The presence of ground ice is common in permafrost areas. The amount of ice present is greatly influenced by sediment texture; coarse sand and gravel commonly contain less ground ice than fine sand and silt, which may contain more ice than the original porosity of the sediment (Williams and Smith 1989). Although to date there have been no assessments of the character and volume of ice-rich permafrost underlying the community of Arctic Bay, the presence of ice wedge polygons immediately behind the community suggests that some buildings may have been located on ice-rich terrain (Fig. 5.2f). Natural or inadvertent thawing of this ice-rich terrain has the potential to cause ground subsidence which may cause structural damage to buildings (e.g. Esch and Osterkamp 1990). Thermo-mechanical erosion by surface runoff along ice wedge troughs may capture drainage and channel it through the community, bypassing the storm sewer system, or causing subsurface piping of water flow, which may eventually lead to ground collapse, as observed on slopes adjacent to the community (cf. Fortier et al. 2007).

5.5.1.2 Adaptive Capacity

Both institutional and individual measures have been taken to reduce the vulnerability of community infrastructure in Arctic Bay to landscape hazards. Typical adaptation strategies for construction on permafrost are employed in the community. For instance, buildings are placed on piles drilled to bedrock or deep into the permafrost to avoid differential heaving of structures (Fig. 5.3a and b). Gravel pads are constructed beneath buildings to mitigate the effects of thermal conduction and permafrost thaw. Household water distribution and sewage collection is by truck or above-ground pipes (abandoned due to inefficiencies), rather than buried pipes.

In addition, local adaptation measures have been taken to reduce exposure sensitivities. In 2002, the Department of Community Government and Transportation, Government of Nunavut, constructed 160 m of shoreline protection, in the form of boulder armouring underlain by a type of filter fabric, to reduce the effects of coastal erosion along the shoreface of the abandoned airstrip at the western end of the community (Fig. 5.3c). This has reduced the vulnerability of local housing to coastal erosion, although it may have amplified erosion at either end of the protected shore zone. Individuals have also attempted to armour the coastal bluff in front of their properties, using available materials (e.g. wood and stones, old truck parts), although this appears to have had only limited effect (Fig. 5.3d). The placement of large boulders on the shoreface in front of vulnerable buildings has only temporarily halted coastal retreat, as illustrated by the abandoned Parks Canada building at the eastern end of the community (Fig. 5.3e).

The diversion and control of surface drainage is routinely accomplished by culvert placement at strategic locations in the community. The size and maintenance of these culverts, however, are issues that may compromise adaptation measures. For instance, undersized or blocked culverts may impede drainage at peak flows, or culvert placement may not adequately capture a dynamic drainage system upslope, a condition which has caused erosion problems already (Fig. 5.2e). Excavated drainage trenches attempt to reduce flooding on higher slopes but may exacerbate conditions farther downslope unless appropriate measures have been taken to increase discharge capacity (Fig. 5.3f).

5.5.2 Future Vulnerability

5.5.2.1 Future Exposure Sensitivities: Changing Landscape Instability

Future exposure sensitivity of hard infrastructure to landscape hazards in Arctic Bay will be largely dictated by the magnitude and frequency of geomorphic processes operating on community lands and the nature and extent of development. Coastal erosion in the community represents a delicate interplay between sea level, tidal phase, storm-generated wave action and sea ice cover. Projected rates of future sea-level change are uncertain due to inadequate knowledge of recent trends. Geological data on postglacial relative sea-level (RSL) change in the Canadian Arctic show strong east-west gradients from the Beaufort Sea to Baffin Bay. Conditions range from ongoing emergence in the central archipelago (up to 3 mm/year over the last millennium) to areas of submergence along the eastern fringe of Baffin Island and the Beaufort Sea region (e.g Andrews 1989). This is broadly consistent with the pattern of vertical isostatic adjustment in geophysical models, such as ICE-5G (Tarasov and Peltier 2004). Northwestern Baffin Island lies in the transition zone between emergence and submergence and recent field observations (e.g. prograded beach crest elevations rising seaward) to the north of Arctic Bay tentatively suggest submergence is underway (St. Hilaire et al. 2008). Even though absolute rates of sea level change are currently unavailable, it is anticipated that the zone of submergence will expand to communities such as Arctic Bay, which may have been previously unaffected by sea-level rise.

Much of the coastal erosion witnessed by residents of Arctic Bay has been attributed to late summer-early fall storms with strong southwesterly winds. The timing of these events coincided with open-water conditions. Recent local observations suggest that the duration of sea ice-free conditions have been lengthening (Table 5.1) and sea ice models predict later freeze-up of channels and bays (Dumas, et al. 2006). Combined with the observation that the number, intensity and duration of cyclones in the Arctic have increased during the second half of the twentieth century (Zhang et al. 2004), it is anticipated that conditions promoting coastal erosion will be more common in the future.

The occurrence of mass movements is a function of the inherent conditions of a slope (slope steepness, geology, surficial deposits, presence of permafrost) and climatic conditions (e.g. Ryder 1998). Climatic parameters that influence the sensitivity of a slope to sudden failure are the frequency and magnitude of exceptional events and the variability of temperature at various timescales, especially in areas of permafrost (Dyke 2000). Rapid snowmelt or intense summer rainfall events may saturate the active layer, decrease sediment cohesion and promote slumping and active layer detachments in susceptible materials (Sandersen et al. 1996). Observations of recent failures on slopes behind Arctic Bay suggest that there is an inherent sensitivity to slope failure, which may be amplified under projected climate conditions of increased summer air temperature and cyclonic precipitation (ACIA 2005). Community members have specifically associated large rainfall events with local landsliding (Community of Arctic Bay et al. 2005).

Thawing of ice-rich permafrost decreases the strength and increases the water content of the active layer, resulting in ground instability. Since the thermal regime of permafrost favours a greater accumulation of ice just below the active layer (Robitaille and Allard 1996), there is an enhanced risk for ground instability if the active layer progressively thickens under a warmer climate. On the steeply sloping terrain behind Arctic Bay, the deepening of the active layer as a result of warmer temperatures may potentially result in an increased frequency of slope failures. Furthermore, even in the absence of thaw, an increase in ground temperature would affect the strength and deformation properties of frozen ground (Williams and Smith 1989), thus enhancing much slower slope processes, such as gelifluction and creep, and decreasing the overall stability of slopes.

Thawing of ice-rich permafrost under projected increases in ground temperature will also affect the stability of level to low-sloping terrain within the community of Arctic Bay. The magnitude of ground subsidence will depend on the ice content of permafrost, whereas differential heave of foundation piles will be affected by the seasonal depth of freeze-thaw cycles. In either case, infrastructure may be at risk to increased disturbance (e.g. Couture et al. 2003).

The magnitude and frequency of surface runoff from snowmelt and rainfall events will be highly sensitive to climatic parameters such as spring snowpack thickness and thermal regime, summer warming intensity and the frequency, intensity and duration of summer precipitation. Although projections of local climate parameters from global circulation models are likely to be highly variable and unreliable, particularly for precipitation, if regional trends of increased cyclonic activity and open water conditions persist through the first half of the twenty-first century (ACIA 2005), then it is anticipated that surface drainage volumes may increase, producing more flashy discharge regimes and exposing community drainage infrastructure to increased stress.

5.5.2.2 Future Exposure Sensitivities: Community Expansion and Development

Population growth and a housing shortage have lead to a recent expansion of Arctic Bay to the southwest and rezoning of community hinterland to residential in preparation for new housing and community services development (Hamlet of Arctic Bay, By-law Number 108-2003). Building lots for over 50 houses, a new school and fire hall have been identified on rezoning plans. Given current exposure to landscape hazards within the community of Arctic Bay and its hinterland, it is likely that, in the absence of a risk assessment, new developments may inadvertently increase exposure-sensitivity to landscape instability. Although the proposed expansion appears to be back from the shoreline, other factors such as slope stability, thaw settlement, and surface drainage may constrain the location and extent of community land suitable for development or limit the type of planned land use activity. As an illustration, in 2008 site preparation for development of the land behind the hotel triggered an active layer detachment (C. Kines personal communication 2008), which destabilized the slope and threatened the security of adjacent buildings and road.

5.5.3 Future Adaptive Capacity

Instanes et al. (2005) suggest that in most cases engineering solutions are available to address the significant impacts that climate change will have on Arctic infrastructure (e.g. thermosyphon foundations for buildings; Holubec 2008), with economic rather than technological issues the greatest challenge to adapting. At the community scale, however, knowledge of local climate variability and change (e.g. air and ground temperatures, precipitation, permafrost), together with landscape response, over the next several decades is likely to limit adaptive capacity as much as economic factors. Engineering design solutions rely on detailed knowledge of ground conditions and seasonal behaviour (e.g. freeze thaw indices, active layer thickness) over the projected age of the structure (Instanes, et al. 2005) and for most Arctic communities this information is not yet available (Furgal and Prowse 2008). Future adaptive capacity, therefore, in the short term must rely on both sustained use of existing approaches to reduce the impacts of ground disturbance (e.g. pile foundations, surface insulation) and avoidance of sensitive terrain which may become unstable under changing climate and human activity. Identification and mapping of such terrain within and around communities and integration of this knowledge into local community planning and decision-making will help reduce community vulnerability to landscape hazards (e.g. Irvine et al. 2008). This process is currently underway in Arctic Bay in partnership with community members, local planners, government agencies and scientists.

5.6 Conclusion

Nunavut communities are generally coastal, low-lying, underlain by permafrost and subjected to strong seasonal contrasts in temperature, wind, precipitation, and sea ice conditions. Seasonal changes in the landscape and extreme weather events can create instability and hazards, including flooding, landslides, thaw subsidence, and coastal erosion. Arctic Bay, because of its geologic and geomorphic setting, has increased exposure-sensitivity to landscape hazards which adversely affect current community infrastructure. This chapter uses a vulnerability approach to integrate insights from the social and physical sciences to assess current and future infrastructural vulnerability to climate change. Changing climatic conditions – particularly altered sea ice dynamics and rain and wind regimes – have been noted by Inuit residents in Arctic Bay to be affecting safe travel on the semi-permanent trail networks that connect communities, hunting areas, and cultural sites, and landscape stability within the community, particularly coastal erosion and landslides. Projected changes in climate together with rapid expansion of Nunavut population and communities and changes in cultural and social dynamics suggest that there will be increased exposure sensitivity for both soft and hard infrastructure. For example, increasing danger of using sea ice routes is being exacerbated by an erosion of traditional land skills among younger generations which, if not addressed, will increase exposure-sensitivity and reduce adaptive capacity to future climate change. Similarly, there will be increased exposure to landscape hazards as coastal communities seek to expand their housing and commercial developments inadvertently on terrain that is sensitive to future climate change.

Inuit have demonstrated significant adaptability to climate impacts documented already in Nunavut, which indicates that while climate change will pose significant challenges, Inuit can adapt. From our analysis of infrastructure vulnerability to climate change in Arctic Bay, we can suggest the following:

- Although adaptation of northern infrastructure to climate change is largely dominated by engineering challenges of living on sensitive permafrost terrain, avoidance of other landscape hazards that may increase their intensity and magnitude with changing climate is strongly advised.
- Monitoring both intensity of exposure sensitivities and performance of adaptive responses will be a critical dimension of any community adaptation strategy.
- Climate scenarios that specifically focus on parameters that force exposure sensitivities will be particularly effective in anticipating rates and magnitude of those environmental changes that affect community infrastructure.
- Policy intervention to enable Inuit to afford to adapt and to develop programs to transfer important land skills to younger generations will be required.

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Chapter 6
'Translating' Vulnerability at the Community Level: Case Study From the Russian North

Anna Stammler-Gossmann

Abstract This chapter presents findings from anthropological research on Nenets community vulnerability to anthropogenic and environmental changes in North West Russia. Rapid changes in the environmental landscape in combination with ongoing societal changes pose a real threat to the livelihoods and semi nomadic way of life of reindeer herders. Variation in the freeze-thaw cycles of sea- and inland ice, alteration in the timing and intensity of weather events, and river bank erosion, influence the mobility and lifestyles on the tundra and in the villages. Numerous previous small- and large scale development projects have been visited upon this remote location such as the introduction of the cattle breeding among Nenets, as well as engineering attempts to develop road infrastructure, to retard river erosion, to ensure safe drinking water sources, to improve electricity supply for the village, and to introduce specific requirements to improve travel safety were not successful. In most cases the cause of ultimate project failure was not only insufficient consideration of local natural environmental conditions or limited funds, often the new projects or new technologies failed to take into account local perceptions. This chapter analyses how members of an Arctic society perceive, conceptualise and negotiate changes in their environment, focusing on cultural factors that shape human sensitivities and adaptive strategies. I argue that concrete measures that people take to respond to changes in their environment and possibilities of lowering vulnerability will depend as much on human values as on planning, engineering and policies.

Keywords Arctic Russia · Nenets autonomous district · Nelmin Nos · Reindeer pastoralism · Culture and climate change · Perception of environmental changes

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6.1 Introduction

According to geo-ecological characteristics the case study area of Malozemelskaia tundra in Nenets Autonomous Okrug (district, further NAO) belongs to a high vulnerability area (Korobov and Shumiliova 2008). The climate monitoring data in the NAO demonstrate an increase in the annual temperature average for the period of the end of 20th to the beginning of 21st centuries (Anufriev forthcoming). Russian experts estimate that the current trend towards warming on the territory of Russia by 2010–2015 will remain unchanged and lead to a rise in the mean annual surface air temperature by 0.6°C ± 0.2 compared to the year 2000 (Bedritsky 2005, 7). The biologists' analysis of the area reveals an extension of the tree line to the North and an especially visible expansion of boreal plants into the tundra, and shrubs growth by the river valleys of the North-European tundra (Anufriev forthcoming; Lavrinenko and Lavrinenko 2003, 2004).

The number of bird species in the coastal area of NAO has almost doubled in the last five decades according to a Russian biologist, who has studied ornithology in the region for more than a decade (Anufriev, forthcoming, personal communication). For example, on Kolguev Island in the Barents Sea (NAO) the general diversity of bird species has expanded to include both wide ranged and Siberian species (Fig. 6.1), but at the same time the depopulation of some Arctic bird species is observed (Figs. 6.2 and 6.3). Also the southern border of the reproductive area of the Arctic fox (*Alopex lagopus*) has moved to the North of the mainland tundra (Anufriev 2002, Figs. 6.4 and 6.5).

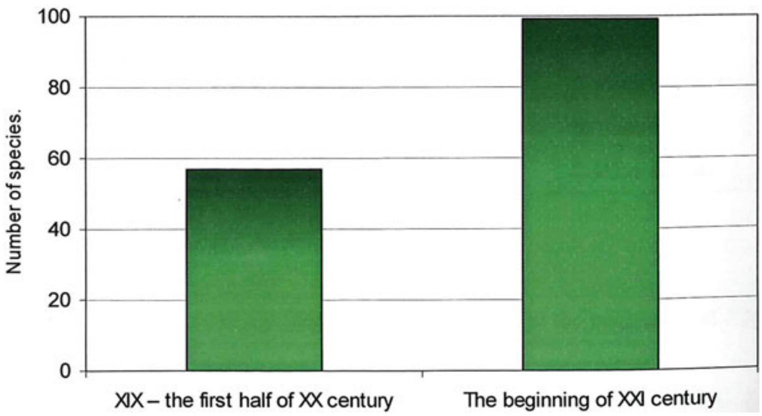

Fig. 6.1 The diversity of bird species on Kolguev Island between the 19th and beginning of 21st centuries *Source*: Anufriev (forthcoming)

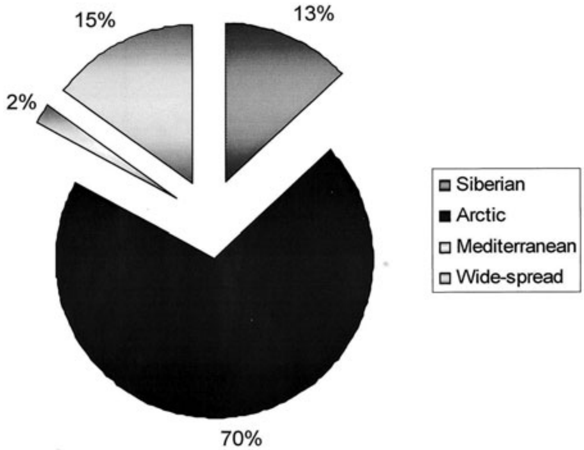

Fig. 6.2 Fauna-genetic complexes of the birds on Kolguev Island between the 19th and the first half of the 20th centuries. *Source*: Anufriev (forthcoming)

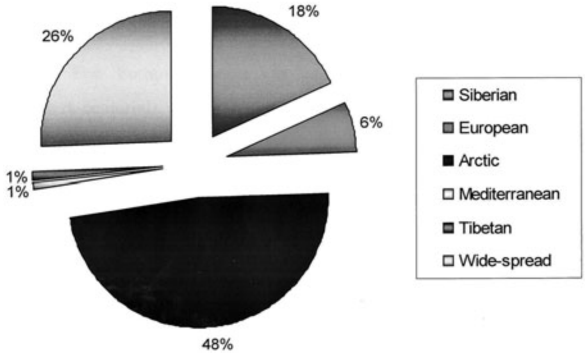

Fig. 6.3 Fauna-genetic complexes of the birds on Kolguev Island at the beginning of 21st century. *Source*: Anufriev (forthcoming)

Findings of previous anthropological research within the BALANCE[1] project, carried out in the NAO in 2003–2005, registered a few specific changes in the Malozemelskaia tundra as result of collaboration of scientists and Nenets reindeer herders. As Stammler states, the reindeer herders perceive significant spatial variation in climatic variables, for example claiming that snow refreezing events could be restricted to specific areas, thus providing scope for evading them (Rees et al. 2008, 211). Because reindeer movement is closely related to wind, detailed herder knowledge includes information on changes in the predictability of wind direction. In particular, periods of beneficial cold northern summer wind, which reduce mosquito harassment, are becoming shorter. Also noticeable is the extent of shrubs in Malozemelskaia

[1]BALANCE project (Global Change Vulnerabilities in the Barents Region: Linking Arctic Natural Resources, Climate Change and Economies) was supported by the Fifth Framework Programme of the European Commission (2002–2005)

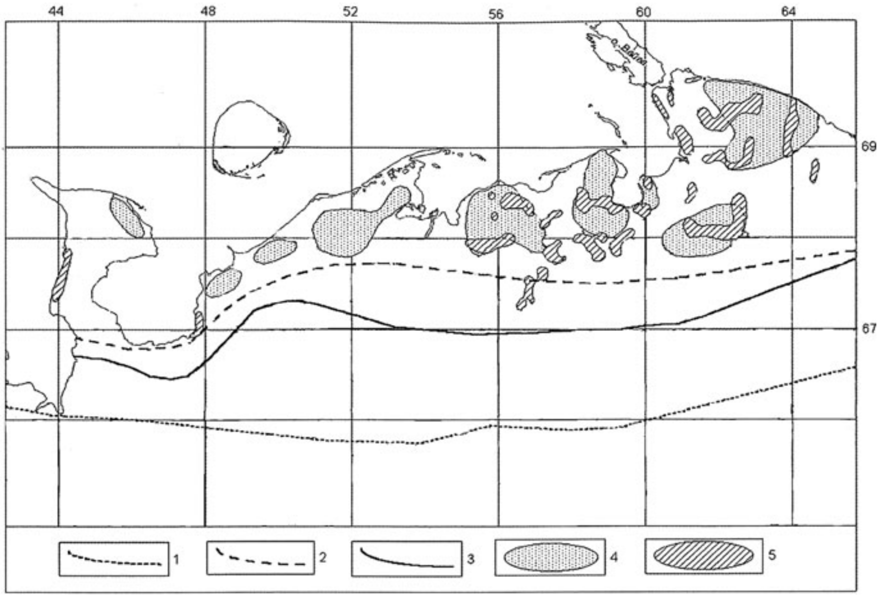

Fig. 6.4 Changes in the structure of the breeding area of the Arctic fox population of the East-European tundra in the 19th–21st centuries. *Source*: Anufriev 2002
The southern border of the breeding area:
1 – in the 19th-at the beginning of 20th centuries;
2 – in the middle of the 20th-at the beginning of 21st centuries;
3 – in the late 20th century;
The zones of the breeding den sites:
4 – in the middle of the 20th century;
5 – in the late 20th century.

tundra that have grown taller than the reindeer themselves. This was reported by reindeer herders to Stammler during the fieldwork in 2003 (Rees et al. 2008, 210–211).

The Pechora River is registered amongst the environmental 'hot spots' in the Russian Arctic (AMAP 2002) due to it recording amongst the highest levels of contamination in the region. The Archipelago of Novaia Zemlia in the Arctic Ocean is where Nenets nomads migrated to until the beginning of 1950s and was designated in 1954 a nuclear test site. Over its entire history as a test site, Novaya Zemlya hosted 224 nuclear detonations (Khalturin et al. 2005). In Nelmin Nos people found out about these activities in the beginning of 1990s (personal communication). Regional contamination is associated with the consequences of nuclear testing both in the atmosphere and under the sea (UNEP/GEF 2009, 15–16).

The NAO territory is a home to a population of 7,000 European Nenets and reindeer herding, as registered in 2007, constitutes the main occupation for

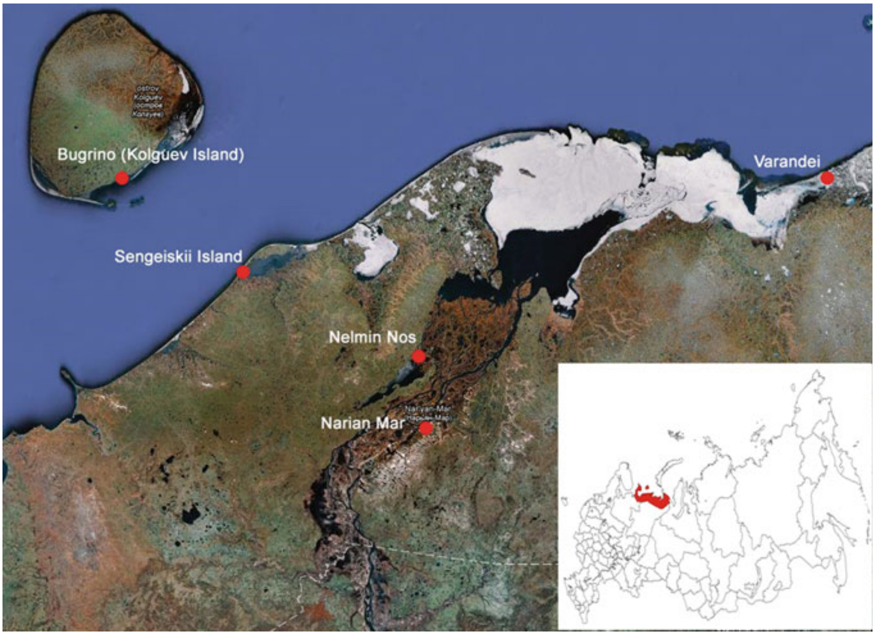

Fig. 6.5 Nenets Autonomous Okrug (District)

around 1,500 people (Administration of NAO, Decree N 165-p, 01.10.2008). A very high proportion of the whole district's territory (more than 70%) is used as reindeer pasture (CAFF 2000, 16; Stammler and Peskov 2008, 835). For nomadic and semi-nomadic reindeer herders of NAO who inhabit Arctic tundra west and north of the Ural Mountains, the coupled effect of anthropogenic pressure with natural processes influences mobility and lifestyle on the tundra and village. The coincidence of high risk area and indigenous population has a particular meaning for Nenets community. A threat to reindeer herding as an identity for Nenets people could constitute a threat to a central ethnic and cultural identity marker.

The chapter analyses the ways of perceiving, valuing, and corresponding habits and practices of northern residents who have been long-time residents of place that is subject to environmental and societal changes. Observing Nenets' engagement with changes that are large in magnitude and rapid in their onset, may contribute to understanding the role played by cultural values in successful Arctic adaptation. As Huntington pointed out, response strategies that do not reflect the values, priorities and needs of society will fail, either because they are not acted on or because they destroy the very thing they were supposed to help protect (Huntington 2002).

6.2 Vulnerability Approach: Specifics of Russian Case Study

Within the conceptual framework of the CAVIAR project, I consider vulnerability as a socially and culturally constructed phenomenon. This construction is influenced by institutional and economic dynamics as well as filtered through practices of human 'embeddedness' in the natural world and processes of interaction of individuals and groups within society. I assume that all environmental and societal changes happen within the frameworks of interpretation, valuation and choice by subjects who see themselves as actual or potential agents. Thus, the analysis of a community's 'agenda' for change includes the vision of residents as far as they choose to address key issues, options and opportunities during ongoing changes, expressed in a narrative format.

The social and cultural parameters of vulnerability and adaptation are not well defined, mainly due to difficulties in quantifying them. The role of culture in mediating nature has only recently become a topic of discussion (Crate and Nuttall 2009; Cruikshank 2001; Heyd 2007; Sherratt et al. 2005; Strauss and Orlov 2003). Most of the research done on the components of socially and culturally determined vulnerabilities and adaptation strategies of Arctic communities are based on case studies from North America (Berkes and Jolly 2001; Fox 2004; Krupnik and Jolly 2002, to name but a few). When it comes to detailed case studies of vulnerability and adaptation and of climate change issues in general, material from Russia is not sufficiently represented. Only a small number of detailed case studies undertaken under the umbrella of the climate change agenda represents material from Russia (Crate 2008; Forbes 2008; Helander and Mustonen 2004; Rees et al. 2008; Stammler 2008).

A specific challenge in assessing vulnerability for the Russian case studies is served by the fact that the whole climate change vocabulary is simply transferred from western vocabulary, which does not necessarily correspond with Russian understanding of these terms. The recently published English-Russian glossary of climate change does not include for example, a definition for 'resilience' (Kokorin et al. 2008). It is hard to find an appropriate equivalent for that in Russian. Instead of using another product of 'western' schools of thought, the term 'sustainable development', people in Russia feel much more familiar with an interpretation like 'stable development'. However, it is not only a problem of difficulties with translation or of the possible absence of the concept in people's own worldview, but also the question of compatibility of the concept to Russian cultural context. On a more substantial level, there are also different domestic versions of the origin of the paradigm or the same definitions and notions are applied differently (Ivanov et al. 1999; Oldfield and Shaw 2005; Tyugashev 1995).

In spite of national interests and setting up activities in the field, the climate change issue has not gained a high profile on the national political agenda. Issues related to climate change are shifted between different ministries and agencies with a low level of coordination. Many management actions, such as evaluation and diagnosis of ecological changes, determination of baselines, impact assessments, the development of adaptation targets are not existent or at best limited in applicability. The signals from federal to regional and local authorities are weak. This has implications on society although the issue has begun to receive broader media coverage.

The topic is not on the top of the agenda either for the municipal administration or for the native population of the northern regions. Russian research funding is concentrated on different topics to climate change, and related projects are mostly integrated into joint international activities in the field, if they are not focused exclusively on natural science. The absence of institutionalised indigenous elder groups and the integration of local knowledge into resource management, as well as weak collaboration of communities with scientists, contribute to climate change being perceived in general as less troublesome. Also the nature of available data is different. For example, no harvest data for the nature-based economy or in-kind income from household subsistence production and cash income data are collected. However, attaching a monetary value to the subsistence economy where monetary exchange is limited and calculation of data such as household income may be difficult. Related statistical information, especially on the community level, is in general difficult to access, if at all available.

6.3 Methods

The research area within Russian sites was selected to provide an optimal insight when applying place-based methods with a particular interest on three aspects:

(1) High-risk area undergoing direct climatic and social changes
(2) Area with patterns of subsistence economy closely related to natural resource use
(3) Area that epitomises the respective cultural identity for the whole ethnic group and the region.

In my work amongst reindeer herders and fishers I have used a combination of methods, including in-depth and extensive conversations, semi-structured interviews, oral history and during my stay in Nelmin Nos, participant observation. I have spent days in May and June 2008 in the community, participating in daily activities, hunting, visiting families, attending social events. Community research partners in NAO were reindeer herders, fishers, and their families, members of the municipal administration and the indigenous association Yasavey. Records of local observations were created and partially tested in discussions (conversation) with residents of the community and representatives of the indigenous association in the capital of NAO, Naryan Mar. The multi-method framework also included local archive and media research as well as collected statistical data.

Fieldwork was conducted during the transitional season of the year and made it possible to observe directly how people deal with the dynamic landscape in the spring/summer time, characterised by flooding in the regional capital Naryan Mar, limited access to hunting grounds and fresh water sources.

My accommodation in host families of reindeer herders made it possible to get important information about ongoing changes and dealing with these changes in every day life in the village and in the tundra camps, in hunting, fishing, and travelling activities.

On the other hand, conducting research during the spring season also meant that my mobility was limited, and certain places were inaccessible. Permission formalities and the unpredictability of weather inhibited going to another previously planned place – Varandei. Nevertheless, some people from Varandei were interviewed in Naryan Mar and Nel'min Nos, and I integrated data from these conversations into my research.

Explaining my research purposes during field work and keeping contact with the partners afterward has been an important task. The documentation and analysis, particularly of the changes observed by communities in their environment, photo materials have been prepared for a report to the community and are now in the progress of translation into Russian, including this paper. Lack of information addressing the phenomena of climate change and at the same time the big interest among community members to local changes, make this kind of availability a significant contribution to the outreach activities of CAVIAR.

6.4 Community

6.4.1 Nelmin Nos

Nelmin Nos is a Nenets reindeer herder and fisher community of approximately 1,000 people in eastern part of European Russian North. Residents of Nelmin Nos who permanently stay in the village, are in one way or another, related to the reindeer herding sector. Most residents grew up in the tundra migrating with their parents, members of kolkhoz reindeer husbandry, and have relatives involved in the reindeer herding or frequently visit families in the camps. It is located in Malozemelskaia tundra on the left bank of the Pechora River delta around 80 km from the Barents Sea coast (67.59° N, 52.55° E). The village is built in an ever-moving and frequently harmful natural environment of swampy tundra. As in other remote regions of the world the relationship between northern residents in NAO and their environment is influenced by the ways of 'mapping' the relationship between the central state and local communities.

Where and how the Nenets of Malozemelskaia tundra live, their way of reindeer herding and the infrastructure of settlements – all this is a result of state induced policies. Sedentarisation of tundra nomads that started in the 1930s was justified in the context of a paternalistic responsibility concept and development projects of the Soviet state. As distinct to the Nenets of West Siberia, often viewed as the 'most traditional' in the Russian North, European Nenets experienced stronger influence from the Russian and Soviet culture. The village of Nelmin Nos was founded as a fixed centre of Nenets nomadic herding enterprises in the area in 1937. The forced transition from a nomadic to a sedentary mode of life was largely completed in the 1970s, the beginning of 1980s in Nelmin Nos. Sedentarisation has totally changed the life of Nenets nomads and a created people with two cultures.

Reindeer herding became paid labour, and nomadic reindeer herding was transformed into part of Soviet centrally planned economy. Nowadays the Nenets of Nelmin Nos practice close reindeer herding in shifts of approximately 3 months and divide time equally between living in the tundra and villages. In the middle of the 1940s completely new economic activities such as cattle breeding were introduced and Nenets were forced to work in cow milking and hay preparation activities. The initiatives of Soviet cultural policy established a widespread system of boarding schools for indigenous children where they quickly lost their mother tongue and picked up Russian instead.

Reindeer herding is the main form of land use in Nelmin Nos and the main economic activity. The amount of reindeer in Nelmin Nos reported in available statistics varies greatly (Koinov 2006, 114; MODIL-NAO 2008). The general trend in herd size has been a drastic decrease in number since the fall of the Soviet Union. From this time the settlement economy has shifted from planned economy to subsistence activities. The transition to the market economy brought high unemployment among reindeer herders. Between 1990 and 2000, the number of indigenous people across the Russian North employed on northern livestock farms, as well as in hunting and fishing, fell by 37%. In these years of market reforms, the actual rate of unemployment in the indigenous settlements of the Russian North is, on average, not less than 40–50% of the economically active population (ACIA 2005, 679).

The institutional structure of reindeer husbandry in Russia, as taken from the beginning of the 1990s, exhibits very diverse and dynamic features (Stammler 2005a). In 2008 the reindeer herders of Nelmin Nos were organised in one quasi-state enterprise, the Agricultural Production Cooperative (*Selskokhoziaistvennyi Proizvodstvennyi Kooperative*, SPK) 'Vyucheiskii' and so-called 'clan-communities' (*obshchiny*) of small numbered indigenous people. [2] Many of those herders in NAO who have had a period of state employment at least on paper, became members of the SPK after the end of the Soviet collective farm, because regional subsidy programs have targeted mostly institutions rather than private herders. Also retired people of the village have had shares in the enterprise.

I visited the settlement at a time when the remainder of the SPK Vyucheiskii enterprise was in the stage of bankruptcy. The salaries had not been paid; the pastures had been sub-rented to private reindeer herders, and the SPK's reindeer were herded by these private herders. This situation forced people to slaughter reindeer thus leading to an increase of unemployment. Nonetheless, the SPK of Nelmin Nos as a state-related enterprise has managed to claim the heritage of the glorious Soviet kolkhoz farm that belonged to the most

[2]Nenets belong to officially recognised category of so called 'small numbered indigenous peoples of the North, Siberia and Far East'.

successful in NAO and reached its peak economic performance in the 1980s. Residents of Nelmin Nos widely recognise the SPK as successor of the kolkhoz, which has been always associated with stability and safe state support.

Recent regional programmes have been more supportive of private reindeer herding units. *Obshchiny* are 'clan communities' of individuals and families, which are registered as non-commercial organisations. They are eligible for state subsidies, but members of obshchiny are private individuals who do not get any salary. They have to feed themselves and their family from what they produce and exchange. Among all regional enterprises, the situation of reindeer herding in Nelmin Nos remains most difficult. In the last years no meat production was registered at all for the state enterprise. The herds are still small and meat production in Nelmin Nos is the lowest among all enterprises in NAO.

The sudden cancellation or reduction of all federal subsidies at the end of the Soviet Union has had a disastrous impact on the remote settlement. Radical cuts in the previously generous financial support of the state has resulted in a drastic reduction of herds, institutional reorganisation, a break-down of transportation system, increased unemployment, and a lack of basic services. All of this has consequences, which have still not been worked through. Given the considerable changes experienced by inhabitants of Nelmin Nos, the number of residents has remained surprisingly stable since the end of sedentarisation. The rate of out migration is low and there is a growing tendency for periodic return and circular migration. Some of the residents may explain this simply by 'being Nenets'; others emphasize that urban life is too stressful for them, and some refer to their roots.

It is the most mono-ethnic Nenets village in the whole district. European 'Nenetsness' would not be imaginable without 'most Nenets' village of Nelmin Nos. Reindeer herding is seen as crucial identity marker not only among Nenets herders themselves and their families but also for all Nenets residents in the region. As the only ethnic homogenous Nenets settlement in NAO, Nelmin Nos can be seen as a representative for the identity of the entire region, which is named after the group. In a region where Nenets constitute around 16.7% (2007) of the population, the situation in reindeer herding has practical relevance for the regional political arena.

6.4.2 Sengeyskii Island Case

The reason for choosing to conduct fieldwork in a remote settlement of the NAO in the Barents region was a story which I heard by chance about one brigade (work team) of reindeer herders from this area. Some years ago a large slab of sea-ice near the shore bearing around 1,000 reindeer had broken loose from land of the island Sengeyskii, pasture of the brigade, and floated north-east to Tapseda Peninsula. Setting aside this dramatic event, it comes as a surprise that the current migration patterns of the brigade demonstrate a very unusual seasonal cyclic movement. The windy coastal area is commonly used by reindeer herders as summer pasture where the herd can get relief from heat and insects as well as salt intake desired by reindeer. The seasonal patterns of migration between the northern coast in summer and the southern inland in winter are thought to be unchangeable as naturally dictated by vegetation growth periods and weather conditions (Habeck 2005; Stammler 2005a). In opposite to that, the brigade migrates in the last decade to the Barents coast in the winter time and moves to inland in summer.

The ice-floating accident and the distinctive land use patterns of the 'Neruta' brigade met directly my research focus on experiencing vulnerabilities and specific adaptation options within particular sociocultural settings. However, as fieldwork progressed, I realised that there was much more complexity and meaning to those happenings than I had originally detected. First, it was apparent that it was not easy to accommodate this remarkable event within a familiar standardised scientific chronology. Local knowledge is first and foremost detail-focused, and does not necessarily deal with absolute dating. The people knew exactly what time of day the accident happened, what they were doing at that time, how many reindeer were lost and why, who found the dead animals first, who cut the marked ears and brought them for identification of the animals to the village, as well as all possible facets of sea ice changes. At the same time different persons put the date of the event in a time range from 1997 to 2004.

Also, what reindeer herders of the brigade said about the shift in the land use patterns did not seem related, at least in serious manner, to coastal changes. Some of the herders may explain such radical changes in the seasonal migration as escaping from the increased danger of robbery in the tundra, when stored goods in the tundra may more easily be taken away with snowmobiles in the wintertime, as well the risk of reindeer poaching. Behind the decision to make this unusual migration were e.g. calculations of the small herd size and the absence of a need to bring animals for slaughtering to the regional capital. In reindeer herders' reasoning changes in migration routes were not predominantly associated with the effects of the changes of in sea ice conditions. However, their understanding of changes in the natural environment represents a combination of social and political factors, ecological knowledge, hard calculation of economic implications and the cultural importance of working in the tundra for reindeer herders and their families.

6.5 Current Vulnerability

6.5.1 Current Exposure-Sensitivities

6.5.1.1 Industrial Pollution

Several changes to environmental conditions in the Malozemelskaia tundra were pointed out by the community, and observed during the fieldwork. These included the disappearance in some years of summer sea ice and reduction of winter ice area, alteration in the timing and intensity of weather events, changes to fish and wildlife species composition and distribution, permafrost thaw, and river bank- and sea coast erosion and tundra shrubs growth. However, once the discussion is transferred to a community setting, the main indigenous concern, regarding changes in their environment, is related to the changes caused by human activity.

Fig. 6.6 Kumzhinskoe field: Anthropogenic garbage (Photo: V. Pershukov, CH-Oil & Gaz LLC, photo gallery)

Many of interviewed people in Nelmin Nos pointed to a nuclear explosion after an accident with the gas outburst on the Kumzhinskoe gas field in the delta of Pechora River in 1980 (AMAP NEFCO 2003) whereupon they were forced to go outside of the houses. A nuclear explosion was tried in order to isolate the leaking reservoir, but without any success. During the period from 1981–1987, four wells were drilled in order to penetrate the damaged well and plug it, according to the energy monitoring (SN Invest 2007). The gas outbreak was reported to be active again from 2001 (Semiashkina 2007). According to monitoring action in the area of field in 2005 the concentration of oil products in the sig (‘white fish’) increased 5 times in comparison with 2003 (Rosbalt 2005). The accident on Kumzha field has had a particular impact on the maturing area of sig and main migration routes of Pechora *semga* (*Salmo Salar*) (Semiashkina 2007).

There are not yet production fields in Malozemelskaia tundra, but several exploratory wells have been dug along the Nelmin Nos reindeer migration routes. The consequence of industrial development as a result of geological exploration has been faced by the community since 1970s. According to the

1983 local reports, the allocation of pastures for drilling activities and the alarming extent of damage to the best pastures by heavy vehicles and industrial waste were a of prime concern for herders (Nelmin Nos archive). Injury to reindeer and herders as a result of moving through polluted tundra still occur today (Fig. 6.6). According to Russian experts approximately 85% of persistent toxic substances reach the human body from local pollution sources. These include over 15 million barrels of industrial waste accumulated during the most intensive period of development of the Russian Arctic (Revich 2008, 3).

The consequences of past exploration activities, as community residents relate, not only generate disturbances in the tundra but also in the village. Visibly progressing riverbank erosion is associated with vegetation and riverside deterioration through the use of heavy vehicles by geological expeditions from 1970s–1980s. A few houses, which previously stood on the riverbank, have already been removed to another place (Figs. 6.7 and 6.8). Cultural distress is caused to the community by erosion as the graveyard is located close to the riverside. Under strong Russian influence sedentarised Nenets nomads were induced to bury their dead in the village. The oldest graves from 1950s have already been washed out and the closest to the river rand is dated with 1972 (Khanzerova 2008b; personal communication).

6.5.1.2 Fresh Water Stress

Surface water bodies, such as the Pechora River and nearby lakes, supply the drinking water in Nelmin Nos (Fig. 6.9). Ground water exploration surveys, previously conducted in Nelmin Nos, in order to find fresh water reserves have not been successful. Extracted ground water has proved to need treatment due to

Fig. 6.7 Pechora river bank in 1970s (Photo: A. Stammler-Gossmann, Nelmin Nos archive)

Fig. 6.8 Pechora River Bank erosion in 2008: Removed house (Photo: A. Stammler-Gossmann)

its salinity, as the governor of the region stated in the local newspaper (Bezumova and Mamaeva 2008). The poor quality of drinking water, relative to the quality standards in existing guidelines, constitutes one of the major problems for the whole Nenets district. Poor water quality is caused by a number of natural and anthropogenic factors, including climatic and geographical location, the bogginess of the territory, the influence of the sea in estuarine areas of the rivers, and also the impact of industrial and agricultural enterprises.

According to the AMAP-NEFCO report of 2003, potable water quality in NAO met sanitary guidelines in only one settlement (2% of the region's population), and has failed the standards at 19 settlements (86% of the population)

Fig. 6.9 Drinking water from Pechora River (Photo: A. Stammler-Gossmann)

Table 6.1 Trends in total wastewaters discharge in NAO in 1998 – 2002, million m^3 (AMAP NEFCO 2003, 60, Table 4.5)

Characteristic	Year 1998	2000	2001	2002
Waste waters discharge:	1.356	1.370	1.245	2.31
Normative clean (without treatment)	0.275	0.250	1.237	1.19
Polluted waste waters: Including:	1.081	1.120	0.873	1.11
Insufficiently treated	1.067	1.095	0.871	1.11
Without treatment	0.013	0.026	0.002	–

Table 6.2 The main contaminants discharged into the surface water bodies in NAO, tons (AMAP NEFCO 2003, 61, Table 4.6)

Contaminants	Year 2001	2002
Petroleum hydrocarbons	0.004	0.200
Suspended matter	16.0	134.5
P_{total}	3.00	2.439
Phenol	0.003	0.002
Detergents	1.0	4.707
Iron	1.0	0.794

(AMAP NEFCO 2003, 62).[3] Main contaminants discharged into the surface water bodies were registered as being of suspended matter, detergents, phosphates and petroleum hydrocarbons (Tables 6.1 and 6.2). Fresh water stress remains one of the main concerns on the regional agenda, and for the Nelmin Nos community, the situation is critical (Bezumova and Mamaeva 2008; Pravda Severa 2007; Revich 2008,16; UNEP/GEF 2009, 15). Measurements of fresh water made nearby settlement Andeg (around 18 km from Nelmin Nos) demonstrate poor quality of drinking water in the area (Table 6.3).

The absence of sewage and recycling facilities in the village leads to the additional pollution of surface water. The households waste is simply dumped

Table 6.3 Drinking water quality in some settlements of NAO (extracted: AMAP NEFCO 2003, 61, table)

Name of settlement	Water supply type	Parameters of water quality exceeding MAC
Naryan-Mar city	Ground	*Ground water*: Fe-6 MAC, turbidity-5.5 MAC; colour-3.5 MAC.
Oksino village	Ground and surface (Pechora river)	*Surface water*: colour-3.5 MAC, turbidity-3-5 MAC, Fe-4.5-17 MAC, BOD-3 MAC; *Ground water*: Fe-2-11 MAC, NH_4-1.5 MAC.
Andeg village	Surface (Pechora river)	*Surface water*: Fe-3 MAC, colour-2 MAC, turbidity-2.0-2.5 MAC, BOD-1.8 MAC.

[3] There is no information on water quality at the remaining 8 settlements (13% of the population).

into the boggy ground (sometimes in close proximity to the water intake). There exist no sanitary protection zones whatsoever. The community residents also pointed to another source of contamination in the Pechora River that can threaten water quality, particularly in the spring time. Ice jams are commonly broken up with explosives during the spring flood, as seen in the regional capital during fieldwork in 2008. For this purpose 700 kg of trotile was delivered to Narian Mar, according a regional newspaper (Sluzhba novostei 2008).

In the AMAP report 'Arctic pollution', the concentration of DDT (Dichlorodi phenyltrichl oroethanes) in freshwater biota has been recorded as 70 times higher in Nelmin Nos than in other observation sites in Canada and Norway (AMAP 2002, 16–17). Official medical statistics indicate that the incidence of bacterial dysentery in NAO in 2005–2006 was on the highest level among Russian Arctic regions (Revich 2008, 15). In these years the incidence of disease among adults and children in the NAO was particularly high and reached double the national average (Revich 2008, 11–12). Fresh water stress poses a real health risk to community residents and to their well-being. This risk is cumulative with other exposures like the high concentration of PCBs (polychlorinated biphenyls) in reindeer, hare, ptarmigan, and mosses (AMAP 2002, 15).

6.5.1.3 Changes in the Wildlife

Since the end of the 1990s, when state-subsidised delivery services were abolished after the Soviet period, the consumption of market food bought among northern residents, significantly decreased and a reorientation to more accessible local products has taken place. Particularly, in the transition seasons of spring and autumn, people of Nelmin Nos rely heavily on country food, as market food, as well as other goods, is almost completely unavailable at this time of year. There is no food or other supplies for quite a long period throughout the autumn and spring, as the regional capital cannot be reached by snowmobile or passenger tank, and the shipping season will not yet have begun. There is limited cash in the village as only a small number of residents are involved in the wage economy. Thus for this period residents of Nel'min Nos are largely dependent on local resources.

Hunting is a valued activity with social, cultural, and economic significance for the community. Goose is a main dietary component alongside reindeer meat and fish. Thus, it came as no surprise that any discussion of changes in natural processes first of all involved hunting. The spring of 2008 was 'confusing' for the geese, as one local fisherman related, concerning the late arrival of birds: 'They did not understand the weather. Usually geese come around 23rd of May, but only now on 10th of June they settled in their nests and we find eggs still inside of the geese' (personal communication). At the same time, the hunters acknowledge the 'course of the nature' and that a 'goose knows exactly when to lay an egg, however, they have to fly back in autumn and manage a long distance' (personal communication).

The professional fishermen of Nelmin Nos, who previously were members of the state fishing cooperative, cite shifts in the fish species inhabiting the area to the abolition of algae prevention measures in the lakes. As stated by fishermen, the algae bloom creates good conditions for 'grey fish' such as pikes (*Esox*). Local residents also link the decreased availability of valuable whitefish to the persistent consequences of the 1994 oil spill near Usinsk, in the neighbouring Komi Republic. After this unprecedented accident, as reported by community residents, fish had a 'penetrating smell and softer meat'.

Observed changes in birds, as well as in fish species composition are seen as a disturbance of the balance in the local food chain, such as the increasing displacement of the preferred bean goose (*Anser fabalis*) by the barnacle goose (*Branta leucopsis*), or the replacement of *sig* (*Coregonus lavaretus*) one type of white fish valuable in the Russian Arctic, by another (*Coregonus peled*). This disturbance is perceived first of all as a matter of taste and preference, as reindeer herder and fishermen of Nelmin Nos may do not like 'fishy' smell of barnacle goose or 'bony grey fish' (personal communication).

While many of the environmental impacts have been absorbed by the community through adapting to the variable seasonal and harvesting calendar, the changes in species composition and behaviour such as the sudden invasion of an alien bird species, can come at greater psychological than economic cost. The arrival of woodpeckers in coastal areas of treeless tundra is seen as a highly unusual and alarming event. This bird may be seen as a messenger of the arrival of death as it was interpreted in case when a person from Kolguev Island died one week after woodpecker was observed in the area (personal communication). This is just one example of the possible ways of identifying abrupt changes and illustrates how changes in the environment are associated with particular world-views, personal experiences and local history. In relation to hunting the people emphasize their ability to adjust to changes and demonstrate a lesser degree of acceptance for sudden occurrences in nature as woven into their cosmology.

6.5.1.4 Moving: 'Risk Versus Reward'

In Malozemelskaia tundra, movement is of crucial importance for efficient resource use. Reindeer herders migrate with their herds over areas of hundreds of kilometres. While reindeer husbandry, as Stammler states, is best done in locations remote from human activity, herders and their families must balance this against the benefits of access to facilities and services (Rees et al. 2008, 209; Stammler 2005a, 118). The village of Nelmin Nos is built on a swamp, there are no roads. The only ground transport line to the regional capital is the Pechora River. The village is totally dependent on this connection for everything from medical service, firewood supply to mobile phone top-up, because goods and services are not available locally. There is no slaughter house, no large-scale refrigerator, and no meat processing modules in Nelmin Nos all of which must take place in the regional capital. Reindeer slaughtering, meat processing and sale are thus dependent upon the freeze-up of Pechora River to enable travel.

Dealing with nuances of seasonal cycles of sea, river, and lake ice has always been a reality for the community. Specialised skills, such as recognising ice conditions, are still highly valued. The failure to follow the advice of experienced people can have dramatic consequences. Shortly before my arrival to the village, at the beginning of May 2008 there was an accident on the river with a passenger tank transporting people, salary and post from the regional capital by order of the municipality. The official end of the winter road driving season for heavy vehicles on the Pechora River had been April 15! The institutionally produced travel safety regulations are not always is seen as applicable to local practices and needs. As the residents said, 'the driver did not follow the safe route advised by the local expert', which contributed to the sinking of the loaded vehicle (personal communication).

Accident-related mortality rates in Russia are more than double the international average and among northern residents this figure doubles again. (Revich 2008, 13). Risk taking behaviour and recorded accidents on ice are related not least to the drastically reduced state service provision such as transportation, health care and goods delivery in the post-Soviet period. In some reported cases accidents happened as a result of unplanned travel between camp and village when foodstuffs, such as salt, were in short supply. The reduction of helicopter emergency call outs, to flights only in cases of so-called 'life-endangered situations', where e.g. tooth ache or bone fractures are not included, poses a real challenge for the community. According to the statistics of the Ministry of Health and Social Development of the Russian Federation, quoted by Revich, the incidents of serious illness such as pneumonia, in NAO in 2006 exceeded the national average, which is related to difficulties in achieving timely access to health care (Revich 2008, 12).

The adoption of mechanised transport in the 1970s such as snowmobiles, passenger tanks and motorized boats has enabled greater mobility of reindeer herders but at the same time has created new dependencies on energy-intake from non-local resources and maintenance of mechanical devices – a consequence that has been identified as always accompanying technological change in the North (Kemp 1971; Pelto 1987; Stammler 2009). The combination of lack of fuel delivery, repairing services and maintenance difficulties can particularly hinder safe travel. Residing outside the formal wage economy, and lacking stable income, the majority of reindeer herders in Nelmin Nos cannot afford large capital investments such as new motorized vehicles. Evident for view in the village are mainly old vehicles which despite the innovative skills of men, lack parts for repair and thus poses an additional travelling risk.

The combination of changes in the natural and social environment makes travelling more risky. However, often the need or desire for some service unavailable in the village, or to ensure a successful hunt or resolve personal matters may constitute the risk worth taking to Nelmin Nos residents. One reindeer herder did not receive a flight ticket, by mistake during the registration in the list of the helicopter's passengers at Narian Mar airport. The helicopter took only 13 persons (including myself) to the destination in Nelmin Nos, just a third of those who desperately wished to go home. The only means to reach the Nenets community at this time was this scheduled helicopter once a week. For the reindeer herder in question this was already the second missed flight. In the evening of the same day he arrived to the village, having taken the risk of going by motorized boat, in spite of dangerous ice chunks on the river and minus temperatures. The official boating season on Pechora started two weeks after his travel.

6.5.1.5 Weather and Reindeer Movement

Main disturbances in reindeer movement and grazing are related to sudden changes in weather patterns in the transitional periods, and the following icing-over of the pastures. Refreezing of pastures due to sudden temperature changes has been identified as a major problem in the Arctic reindeer herding (Rees et al. 2008; Stammler 2008). The bottom line of this argumentation is, as pointed by Stammler, that no matter what the vegetation of the pasture is, when it is inaccessible by refreezing events, it poses a lethal threat for reindeer (Stammler 2008, 85). Icing-over events in 1990s and in 2005–2006, happened in Malozemelskaia tundra, and are described by Nelmin Nos reindeer herders as a hardest time (personal communication).

When the winter is warmer, 'the lichen becomes dryer, and reindeer do not like it', was stated by reindeer herders. For the brigades that migrate to Sengeiskii Island in winter the conditions of the sea ice are closely connected to the schedule of annual reindeer herd migration. An older member of one brigade, who retired from making the migration 2 years ago, recalled that the emergence of sea ice, stable enough to support a crossing herd used to be in the early days in December. The head of the brigade, whose reindeer drifted on sea ice in February in 1997/1998, said that nowadays the solid ice, between mainland and island, is in place in January.

The hot summer of 2004, for example, is recorded as it brought disturbances for herders. These were due to the effect of mosquito harassment upon animals' weight loss, and the additional work incurred in taking care of restless reindeer. To protect animals from mosquitoes herders use smoke fire, burning plants' leaves and shrubs' branches and placing it around the herd which moves in spiral. Spiral movement produces warmth that keeps insects away from the animals that are inside of the cycle, but does not protect the animals that are on the outside. Herders report that the smoke often causes head aches for herders, (personal communication).

The growth trend of tundra shrubs, another indicator for Arctic warming, disturbs reindeer herders because it is easy to lose herds, and finding reindeer is more work-intensive. The herders may emphasise the rapidity of shrubs growth noticing that 'it became taller after my return from 2 years military service' (personal communication). Nowadays 'the shrubs can grow on the crossings and hinder the movement in the tundra', as one reindeer herder noted. At the same time, other reindeer herders may see these changes as positive in the shallow sea shore area, where the reindeer can run away, and ‘the bigger shrubs can stop the animals’ (personal communication). However, the women, who are responsible for preparing firewood in camps, perceive recent increase in shrubs height and abundance positively: ‘We can have more fire wood’ (personal communication). Such different local assessments of changes trace back to the fact that not all people sharing the same space and engaged in one type of economic activities may evaluate such changes in the same way.

6.5.2 Current Adaptive Strategies

6.5.2.1 ‘Cultural Frame’ of Adaptation

As with elsewhere in the Arctic, adaptation to both a dynamic landscape and societal change is hardly a new phenomenon for European Nenets. Facing numerous challenges the Nenets have devised a number of cultural practices or mechanisms to minimise the threat of environmental and economic stresses. Such mechanisms are built on the principle of maintaining a balance between the environment, practical and cultural values. For example, mobile technologies (snowmobiles, mobile telephones) have been included as cultural supplements to mobile pastoralism (see Stammler 2009). By contrast, tundra cattle breeding failed to find a foothold in the Nenets subsistence economy. Introduced by the Soviet development ideology, cattle breeding collapsed in Nelmin Nos as soon as pressure from the state ceased. The remaining five cows that I saw in Nelmin Nos were slaughtered one year after my fieldwork.

The relatively recent establishment of permanent, service-oriented settlements has not diminished the deeply rooted high economic and cultural value of the tundra. Moreover, for Nenets who are moving between the tundra camp and village, the village is not necessarily perceived as the main living place. Nelmin Nos still perpetuates an image of a kind of temporary arrangement where house maintenance is considered the least priority among the range of activities that people may invest in whilst staying in the village. Another outcome of the perception of temporariness is that food is consumed directly, or else kept in smaller amounts in the house. Residents do not have a practice of storing food, and the use of ice cubes for drinking water, common in other areas of the Russian North, is not so in Nelmin Nos.

Another factor that frames Nenets adaptive strategies is acknowledgment of ‘autonomy’ of the nature and ‘non-conquering’ attitude toward their environment. In his analysis on respect, Heyd adapts a category of ‘autonomy’ of natural phenomena and its self-organisation (Heyd 2005, 2007, 2008). Applied to the relation of human beings to their natural environment, respect may be conceived on the one hand in terms of granting those phenomena sufficient ‘elbow room’ (i.e. space and time) for their expression and on the other hand, in terms of taking care of ourselves in the effective way of certain natural phenomena (Heyd 2008, 104). Similarly to this understanding, Malozemelskaia tundra

Nenets demonstrate great respect for natural processes, perceiving themselves as part of a broadly defined environment that include human and non-human beings as well as natural phenomena.

This respect tends to be expressed by community residents in their acceptance of natural processes as given and not malleable by humans. 'The nature will take its course' is an expression that I heard also in northern communities in other parts of Russia. Reviewing the unusual Sengeiskii event, when the piece of land fast ice with reindeer on it sheered off the island, the people regard it rather as an exception that confirms the rule. Such departure from the normal course of nature is one of the abnormal atmospheric events that are expected to follow some recurring patterns. However, we have to note that respect to natural phenomena may also apply to relatively recent changes experienced by the community of Nelmin Nos.

6.5.2.2 'Internalisation' of the Risk

Working with definitions of 'risk-taking behaviour' in areas where the people live under constant threat of rapid changes, such as tundra, river delta, and coastal areas, requires particular attention to the 'cultural frame' of human behavioural patterns. This question has already arisen in regard to cases of return to areas devastated after natural disasters. This surprising behaviour has been documented in the coastal zones of Sumatra, Sri Lanka, and Thailand, where the 'tsunami refugees' returned to their home territory, rebuilding in the same places, and thus exposing themselves to the same risks as before the drastic tsunami events of 2004 (Berger 2007; Leroy 2006). As Berger expresses it, 'cultural adaptation' to a 'culture of disaster' and 'internalisation of the risk of future catastrophes' (Berger 2007, 20) is nonetheless an important factor, among social and economic considerations, that explain these behavioural patterns.

In the case of other village, Varandei in NAO, which disappeared officially in 1998 from the regional map, the former residents relayed their efforts to regain official status for the village. Natural hazards (the strong storms of the 1990s and coastal erosion) were declared the main reason for closing the village, and the subsequent relocation of its native (mostly Nenets) reindeer herders, fishers, and hunters to the regional capital Naryan-Mar. However, community representatives link this relocation not only with environmental changes, but also with the development of a big oil terminal and a transportation port in Varandei.

The relocated fishers and reindeer herders, in spite of financial compensation and apartment availability, have had significant difficulties adapting to conditions in an urban environment which is alien to them. This policy is clearly perceived by former residents as having failed (personal communication). Relocation is seen as a purely managerial approach, insufficient to address the realities of climatic changes. Currently, the number leaving Naryan-Mar, in a return migration, is growing in spite of residents' awareness of the possible harmful effects of natural events in the area such as the reported storm in 2005 (personal communication).

Records of Varandei residents, as well popular examples like Shishmaref in Alaska or 'tsunami refugees' of Sumatra demonstrate that local people's priorities and their individual evaluation of the impact of natural hazards may differ significantly from environmental, political or economic assessments of risk, and standard 'technical solution' approaches.

Balancing a decision based on an individual risk assessment is part of every day practice in Nelmin Nos. For semi- nomadic Nenets migration across the tundra, movement between village and camps, between Nelmin Nos and regional capital, and between camps in the tundra is familiar and forms a constitutive part of their understanding of their interaction with nature. Changes in the dynamic landscape of the tundra perceived by the residents in their autonomous flow are not only respected as was described above, but also 'internalised'. Risk as a component of these changes is 'internalised' too, embedded and incorporated into every day practice.

Travelling on the spring ice in the tundra, or during bad weather, may be associated with no more risk than driving a car in the centre of a big city. What an outsider may perceive as dangerous, local people may view as matter of priority in the context of risks and opportunities, reliance on the local expertise and personal needs. During my stay in Nelmin Nos nobody knew or was able to estimate when the next, and last helicopter flight for the season was due, or when the shipping season will open. Missing the flight back to Finland, or taking a risk and going by motor boat to the regional capital, were the options available to me.

The Nenets avoidance of risky situations and knowledge of ice serve them well in general. Whilst travelling on river ice they definitely rely more on local experts' ice knowledge, and locally produced forecasts, than on the institutionally produced knowledge. The use-value of non-locally introduced knowledge on safety requirements, in contrast to many other forms of scientific discourse, seemed to be quite low for the reindeer herders. The reaction to my reading of 'Regulations of safety in reindeer husbandry', found at my host family, was definitely critical. According to these regulations, the ice thickness on the river and lakes, when the herd is driven over the ice, has to be not less than 18 centimetres and 20 centimetres for the sea ice. For fully loaded tracked vehicles the limits are 31 and 37 respectively (Pravila 1990). As a reindeer herder commented following my reading aloud from the book, 'if you will follow these instructions, you can stay at home and do not go outside at all'. Knowledge of specific places and the individual practices of actors engaged in their immediate environments is the main guide for moving in the tundra, nevertheless accidents still occur.

6.5.3 Flexibility

Just as the background is ever-shifting, so the predominant Nenets mode, regarding reindeer herding adjustment strategies, is flexibility. In order to prevent the slaughter and reconstitution of viable herds, Nenets reindeer herders diversify their economic activities into fishing and hunting. Internal economic diversification is the preferred economic adaptation mechanism as moving to a higher income in urban centres, or taking commuter jobs in the oil and gas industry is not a realistic solution. For the most part, herders adjust or modify subsistence patterns in accordance with environmental change and fluctuation. Such adjustments include modifying the timing and location of harvest activities, and switching to the harvesting of different species. An algae bloom at a nearby fishing lake has resulted in the community fishing at other lakes instead. As reported by herders and fishers, less preferable species are abundant and are gradually being accepted as normal food in households.

Mobility can contribute to pasture sustainability and improvement, since mobile pastoralists can access alternative areas while waiting for degraded pastures to regenerate. The brigade 'Neruta' serves as an example for demonstrating such a flexible land use. As long as the brigade herd size is small, reindeer herders may use the limited grazing capacity of Sengeiskii Island more intensively (approx. 14 km long and 3 km wide). When the herd is bigger, the regeneration of island grazing land takes 5 years, says the head of the brigade (personal communication). Weather induced mobility can be exemplified with the decision of the brigade to move from the island to the mainland, during a sudden rainfall in winter in 1990s, in order to save the animals' from grazing on an ice-crust. Relying on the advantages of a mobile pastoral system is seen economically more efficient than introducing additional artificial feeding. The latter is not considered as an option in critical situations. It would be a heavy load on the family budget, involving delivery difficulties to the reindeer, and not at least artificial feeding is also considered to alter the taste of meat.

Some herders emphasize the importance of the reindeer's ability to adjust to environmental stresses. Moreover, they point to a gradual nature of environmental changes as an important mitigating factor for animal that e.g. 'may use to be satisfied with more dry lichen' (personal communication). A reindeer herder from another brigade of Nelmin Nos, which follows the same seasonal patterns of migration to the sea coast in winter, described possible responses of animal to the absence of near shore sea ice: 'In that year on Sengeiskii island when the reindeer drifted on ice, they went on near shore ice to get desired salt intake. When there is no near shore sea ice they will eat small grass saturated with salt. When the winter is mild and the snow soft, it is also easier for reindeer to dig' (personal communication).

The disappearance of coastal ice may be perceived positively in terms of easier access to drift wood. The northern Barents Sea coast supplies migrating herders with wood, which is an important source of fire in the forestless tundra. The mobile pastoral system also involves common pasture sharing systems in situations of risk which strengthens the resilience of herds. Herders mean that if changes are gradual, access to different resources is ensured. The high value of tundra land can always provide resources for successful herding.

The flexible approach toward herding is carried over to the dealing with institutional structural changes. Newly established clan communities have leased pasture land from the kolkhoz in exchange for taking care of kolkhoz animals. Due to bankruptcy the kolkhoz could not pay for private herding labour and thus this exchange has been less profitable for private reindeer herders. Nevertheless, in times of uncertainties in land use regulations, and when increase of herd's size is a main priority, this is seen as possible temporary solution.

Also the women in the village demonstrate an increased engagement in economic diversification activities, enabling them to supplement their husband's as reindeer herding livelihood. Part-time work in nursing may be combined with the production of fur parkas, fur boots and hats for private sale. Demand for locally produced tundra cloths is great and for some female pensioners it constitutes a supplementary income above that of the modest pension. During migration, women flexibly combine childrens' school time with life in the tundra. From the end of May to the beginning of September, during the school holiday, the family migrates together in the tundra. Outside of this period other female members of the extended family, often with older children, substitute for relatives in the tundra. Frequently the children may spend some time in the camps without parents but with their relatives.

While men's adaptation strategy is reliant on internal flexibility within one production sector, the women may be even more flexible in their engagements. Female adaptation includes occupational diversity and even the movement from one economic sector to another one. Some female residents have established small retail kiosks, and two of interviewed women took up full time commuter jobs in the oil terminal.

The community's social life is another example of the flexible adjustment to natural variability, and is subordinated to travelling activities and resource use. Flexible timing is embedded in all activities within the settlement, formal or informal arrangements, institutional work schedule, meetings and social events. A fixed schedule is not compatible with uncertainties related to the variability of hunting, fishing, slaughtering or berry picking seasons, or uncertainty regarding helicopter and ship arrival. Winter is the most intensive travelling time and all important formal and administrative matters, requiring travel to the regional centre, are scheduled for the winter time following the freezing up of the Pechora River.

Seasonality is also a key factor determining fresh water consumption in the village. Lack of state driven technical solution is compensated through changing the water sources. During the spring time the people avoid using Pechora water for drinking and prefer water in lakes or 'snezhitsa', which has melted and 'filtered' through grass under the snow crust. For household requirements rain water may be collected in tanks. Motorised vehicles may be used to reach water supplies in farther located lakes.

6.6 Future Vulnerability

6.6.1 Future Exposure-Sensitivities

6.6.1.1 Land Use

Projected increases in climatic variability may bring additional challenges for reindeer herding in Nelmin Nos in terms of land use and resource access. So far herd size has remained small and reindeer are not delivered to the regional capital for slaughter, but the current situation will change with an increase of number of animals. Conveying reindeer to slaughter facilities is reliant upon the freeze up of Pechora River that must be crossed on route. The slaughter timing is dependent on the freeze up of tundra and the river. Circumventing open lakes is time consuming and delays delivery of a herd which has already peaked in weight and condition, thus translating to direct financial loss. Reindeer herders remember that when, in the early days, they drove reindeer to Naryan Mar for slaughter, and the animals lost 10% of their weight on route.

Reindeer herders from Nelmin Nos may be threatened in the near future by the region's oil and gas industry. NAO is among Russia's fastest growing oil regions. A new project on the construction of liquefied natural gas (LNG) plant in NAO to commercialize the gas from Kumzhinskoe and Korovinskoe fields may create a new region of gas production in Russia. Whilst I was in Nelmin Nos there was a discussion concerning the potential construction of two pipelines running through Nelmin Nos from the Kumzhinskoe field. Should this plan be realised the competition over land use between industry and herder will pose the greatest threat to Nenets pastoralism.

Nenets pastoralists of Nelmin Nos draw on their own bad experiences of drilling activities in the 1970s and 1980s to justify fear of loss of pastures to industrialisation. Reindeer husbandry in the region has been assessed in previous studies to be highly vulnerable to competing land use, particularly industrial activities whose pipelines cut through migration routes and cause environmental pollution, such as industrial waste in the tundra (Stammler and Forbes 2006; Stammler and Peskov 2008; Tuisku 2002). None of the residents interviewed sees possible industrial activities as profitable for the area's development. At the same time it is perceived as unavoidable.

6.6.1.2 'Nenetsness'

Beyond its economic significance, reindeer herding is a crucial identity marker for 'Nenetsness'. It makes reindeer herders feel that they play an equal part in a broader community of beings in the tundra (Kharyuchi 2001; Stammler 2005b). In the current situation the total number of reindeer and herds' size are the lowest in the whole region. While the meat production statistics in NAO demonstrate an increasing trend since 2002 (MODIL-NAO), in recent years the reindeer herders of Nelmin Nos have slaughtered reindeer almost wholly for their own needs. From presenting good evidence of economic performance of the Soviet regime, the image of village has changed to a depiction of a 'survival zone' (Khanzerova 2008a; Taleeva 2006; Zhitnyuk 2006) or showcase of all manner of social and economic stresses (Vologzhaninov 2006).

The recent bankruptcy of the state enterprise of Nelmin Nos, where the majority of herders had been employed, caused not only radical shortage of income, but also weakening of the prestige and respect afforded to reindeer herders in their own community. Since sedentarisation state employment is seen as a main source of stable income and family well-being. The adoption of wage labour, with its image of stability, has made the herder's position as the family's main earner particularly vulnerable under the conditions of the market economy. In spite of official unemployment status reindeer herders may be heavily engaged in hunting and fishing activities, in support of their families. However, working outside of state economic structure is not considered prestigious enough, particularly by women. Similar perceptions are documented by the results of survey from the village Bugrino (Kolguev Island) in NAO at the beginning of the 2000s. In a situation of high unemployment, Nenets herders considered hunting as a most important economic activity, whereas women decided reindeer herding (Volkova 2003; Davydov et al. 2006, 42).

The increased level of impact and influence of changes associated with both climate change and anthropogenic impact may further constrain the ability of the Nenets to express their identity through reindeer herding. This in turn may weaken masculine identity, and the traditional concept of fatherhood. Future changes, perceived both negatively and feared, may have far wider implications when taking into consideration that Nelmin Nos is the 'most Nenets village' in NAO. This reality may have consequences for entire ethnic group of European Nenets.

The 'ecological' vocabulary of the community's members, as with the whole range of wind and snow descriptions, is still in use in Nenets language. It has a particular meaning for the European Nenets who speak almost only Russian. The projected increase of climatic variability may weaken this important element of cultural identity. Locally unpredictable environmental events can expose taken-for-granted local knowledge and create new risks for the Nenets society.

6.6.1.3 E-Waste

Human-nature interaction may be exposed with new non-familiar changes that can be observed in relation to alteration of consumption patterns in the village. New life styles associated with greater material comfort have led to rapid consumption of electronic goods in the last decade. The people in the tundra camps and in village used to not have so much waste at all; every thing was recycled in Nenets households. There was no plastic waste, no e-waste. The 'reuse and recycle' approach, based on the lack of goods provided during Soviet times had a positive yet unintended effect. Nowadays, because formal recycling efforts are not available, the newly introduced e-waste is discarded in an uncontrolled manner and poses new challenges to humans and nature.

Every newcomer in Nelmin Nos can note strange metal constructions with cables placed outside some houses. They are missiles leftover from Plisetsk space port in the neighbouring Arkhangelsk region, which people brought from the tundra for use in their households. According to a statement made by the head of the region on the regional administration website there are five sites where the leftovers have landed in NAO (Administration of NAO 2009). This waste can be 'recycled' in the village for fixing storages, boats or sledges. In August 2008 the regional newspaper described a case when left over missile materials were placed very close to the river, the main fresh water source in the village (Khanzerova 2008b).

6.6.2 Future Adaptive Strategies

Management initiatives at the state level, targeted at climate related impacts and the development of mitigation strategies, remain absent. Adoption of appropriative legislation will comprise part of future adaptive strategies. The legislative basis that governs the territories and traditional land use is not sufficiently developed. With the current dynamic rate of growth in oil and gas production in the region, the issue of the development of a legal framework for industrial activities as well as the interrelation between industry and Nenets pastoralists will play an important role on the regional political agenda.

The NAO Program 'Protection and support of small-numbered indigenous peoples of the North in NAO for 2009–2010', which was adopted in 2008, announced the development of a regional law on some kind of social impact assessment (*etnologicheskaia ekspertiza*) amongst its projects. In 2009 the regional administration adopted another document 'Decree on establishing Elders Council of indigenous people at the administration of NAO' (N-138-p, 22.07.2009)

The costs of introduction of new technologies to this remote place such as a water treatment plant, are very high. However, the question of a secure source of freshwater drinking water for Nelmin Nos is on the regional agenda as a priority project. The issue of preparation and the maintenance of winter road/ crossings over the Pechora River, to allow passage between the regional capital and the village is hampered not by a technical solution but a definition problem. Defining any infrastructure as a crossing requires maintenance by the private transport enterprises that use it. Alternatively defining it as a road means responsibility passes to the regional administration (personal communication).

In adaptation to changes the Nenets people act mostly outside of the state and other institutional organisations. Under these conditions the components that constitute current community adaptive capacities of community will remain the main resource for adapting to changes. With the establishment of private reindeer herders enterprises in Nelmin Nos there is a tendency for the growing value of the tundra camp. The realisation of some of the intended support activities planned by the regional administration towards tundra life may reinforce this trend and keep the tundra intact.

Informal convertible knowledge and social networks provide the basis for a flexible response to environmental and societal changes. The social network can go beyond the close bonding and could be extended to even more loosely connected and distant associates. For example, the activities of the dynamic team of the regional indigenous association 'Yasavey,' and its established position on the regional political scene may bring this institutionalised organisation into localised social networks and make it more effective in a the society exposed to the dual impact of climatic stresses and anthropogenic changes.

6.7 Summary

The daily practices of indigenous reindeer herding nomads in the coastal area of Malozemelskaia tundra involves a permanent process of negotiating their position in an ever-changing environment, This perspective is embedded in their society. 'Translating' vulnerability at the community level makes plain that local people's priorities, and their evaluation of the effect of changes in their environment, may differ from the viewpoint of environmental, political or economic assessments. Their main approach, 'adjusting' to changes in the nature and not 'conquering nature' does not necessarily fit to the external view of the natural environment, which should be transformed, regulated or legislated. From this point of view, community vulnerability to changes is not simply determined by the presence of some external stresses, but is dependent on the residents' ways of conceiving of changes and attitudes towards the natural world surrounding them.

Changes to the natural environment induced by human activities are seen by the community as the main disturbing factor, whereas changes due to the 'natural course of nature' may be accepted in the broader context of the autonomy and self-organisation of nature. Accordingly, northern residents may absorb anthropogenic changes less successfully than natural processes. While past experiences with industrialisation are beyond their ecological conceptualisation, changes, for example in the wildlife, are integrated into cultural value system.

Due to the strength of industrial forces the sense of respect toward landscape, that is familiar to the Nenets society, as well as the pattern of adjustment to changes in a responsible manner may fail and some residents may adopt the same irresponsible spoiling the tundra as has been done by industrial workers: 'We ourselves destroy our tundra driving randomly passenger tanks, even ignoring the roads left by geological expeditions'. In opposite, the changes in the wildlife composition or distribution reinforce development of different adjustable options in a more respectful way.

The people may feel less vulnerable to more familiar changes that are based on experience or historical memory. While the hazardous event on Sengeiskii Island has been perceived within this framework, as an event that should not be afforded any special significance, increased shrub growth is a focus of herders' attention, but not yet incorporated into the concept of respect for changes. At the same time herders may emphasise that gradual accommodation of and wary approach to changes may enhance their adaptive capacity.

The community's agenda for change shows the importance of the cultural frame for evaluating its vulnerability. The memories, values, practices and habits of the Nelmin Nos people guide their thoughts and agency. The community's prevailing measures are not only an example of local patterns given the range of possible responses but are also evidence of the importance of the cultural aspects in human sensitivities to changes. These culturally specific variables can both enable and constrain the adaptive capacity of a community. Concrete measures that people undertake to respond to natural and societal changes, and which have the potential to lower vulnerability, will depend as much on human values as on planning, engineering and policies.

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Chapter 7
'As Long as the Sun Shines, the Rivers Flow and Grass Grows': Vulnerability, Adaptation and Environmental Change in Deninu Kue Traditional Territory, Northwest Territories

Sonia Wesche and Derek R. Armitage

Abstract Drawing on several years of collaboration with the community of Fort Resolution, Northwest Territories, this chapter highlights the complex relationship between environmental change and community vulnerability. We draw attention to water as the medium that connects people to their environment and affects local livelihoods and community well-being, although our discussion of capacity-building reflects a broader engagement with multiple forms of change. We used a participatory approach that incorporated a range of iteratively developed methods, including a literature review, semi-structured interviews, a household questionnaire, focus groups, and participant observation. Qualitative scenarios offered a valuable tool to assess future vulnerability. Results indicate that current exposure-sensitivities are largely experienced by land users, and that adaptations to date have generally been reactive and undertaken on an individual basis. Climate change and resource development are the primary drivers of concern to residents, as they threaten to exacerbate existing trends and introduce new challenges. Priority adaptation options were identified in five sectors: environment and natural resources, economy, community management and development, infrastructure and services, and information and training. In Fort Resolution, vulnerability and adaptive capacity are determined not only by changes to water resources, but by key socio-cultural relationships, values and worldviews operating at individual and community scales. Building adaptive capacity for an uncertain future should focus on incorporating different knowledge systems, engaging actors and institutions, and adopting a multi-level systems view. A collective engagement of actors at multiple levels to address vulnerabilities, support adaptation, and share experiences and knowledge, will support improved well-being in northern communities.

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7.1 Introduction

> For the Chipewyan of Deninu Kue, the Great Slave Lake is like a heart and all the rivers, streams and channels are like veins that supply the heart with blood. If you contaminate the blood, everything begins to shut down, and soon your heart stops. This is what we see for the future of the Great Slave Lake with all the development north, south, east and west of it. – Deninu Kue First Nation (2007)

Across Canada's vast northern spaces, environmental and social change are sources of uncertainty and concern (Berkes et al. 2005; Ford and Smit 2004). Concern about 'change' is the focus of countless workshops, research studies and government reports seeking to document the implications for wildlife, human health, northern cultures and economic sustainability. In the Traditional Territory of Deninu Kue First Nation (DKFN), Northwest Territories (Canada), however, few topics garner as much concern as the relationship between people and water. For the Chipewyan Dene and Métis in Fort Resolution, water is life and a material and symbolic construct around which related forms and types of change often intersect.

Drawing on several years of collaboration with the community of Fort Resolution, our goal in this chapter is to highlight the complex relationship among environmental change, the resulting exposure-sensitivities, and the adaptation strategies that are emerging (as they must) in response to change. The scope and intensity of environmental and social change in DKFN Traditional Territory is significant, with threats to water resource quality and quantity among the most dramatic (Brock et al. in press; Prowse et al. 2006; Wolfe et al. 2008), and of great concern to community members (DKFN 2007). In addressing current and future vulnerability, we draw particular attention to water as the medium that connects people to their environment and affects vital aspects of local livelihoods and community well-being. However, our discussion of capacity-building for future adaptation reflects a broader engagement with multiple forms of social-ecological change and vulnerability.

In the DKFN Traditional Territory, like other northern contexts, the ability of residents to adapt to on-going and future changes is connected with the community's social structure, economy and broader governance arrangements (see Keskitalo and Kulyasova 2009; Natcher 2008). Relationships of trust among people, and their historical bonds and connections, have been strained over the past several decades. The result has been periods of significant conflict and uncertainty, as well as the polarization of groups (i.e., DKFN and the Fort Resolution Métis). Moreover, the 'lost generation' that emerged from a tragic period of forced residential schooling created a disconnect between children, their extended families and traditions. More recently, an emphasis on individual and family-based economic activity (e.g., from employment in offices, mines and other resource sectors), and a gradual shift away from collective action in the community, have further exacerbated vulnerability and engendered challenges for proactive adaptation. Evolving self-government processes and Treaty negotiations, in contrast, are creating new governance opportunities that may have a profound influence on the capacity of DKFN and the Fort Resolution Métis to adapt to change and influence the manner in which ecosystems and resources upon which they depend are utilized. These historical and current experiences are central in efforts to understand change, vulnerability and adaptation, and the strong connections between environment and society.

Here we examine the case of Fort Resolution using a vulnerability lens (see Chapter 1). First, we introduce the case study site, reflecting on the biophysical, social, political and institutional contexts. We then outline our approach and methodology, which was participatory and exploratory, and which used a range of qualitative methods. The chapter goes on to examine current and future vulnerability in the community, addressing both exposure-sensitivities and adaptive capacity. The subsequent discussion focuses on overarching strategies for building adaptive capacity to respond to an uncertain future.

7.2 DKFN Traditional Territory and the Slave River Delta Region, NWT

DKFN Traditional Territory is located along the southern shoreline of Great Slave Lake in the Northwest Territories (Fig. 7.1). Initially, this land area was informally demarcated based on historical land use. It is now more formally referred to as DKFN Traditional Territory, forming part of the larger Akaitcho Territory land claim. Despite the name of this land base, it refers as well to land used by the Métis (Aboriginal people of mixed First Nation and European ancestry who also have long held ties to the area). 'Akaitcho Territory' refers to the entire proposed land claim area, and encompasses the Traditional Territory of several First Nations around Great Slave Lake: Deninu Kue First Nation, Lutsel K'e First Nation, Yellowknives Dene First Nation (including the communities of both Dettah and Ndilo), Salt River First Nation, and Smith's Landing First Nation.[1]

Three river systems dominate the DKFN Traditional Territory – Little Buffalo River, the Slave River and Taltson River. Each of these river systems has a distinct geography and is a place of historical connection for different groups within the main community centre of Fort Resolution (population ~500). The actual settlement of Fort Resolution dates back to the 1780s and is located

[1] Salt River First Nation and Smith's Landing First Nation have already resolved their land claims through Treaty Settlement Agreements and are not involved in the current Treaty 8 negotiations.

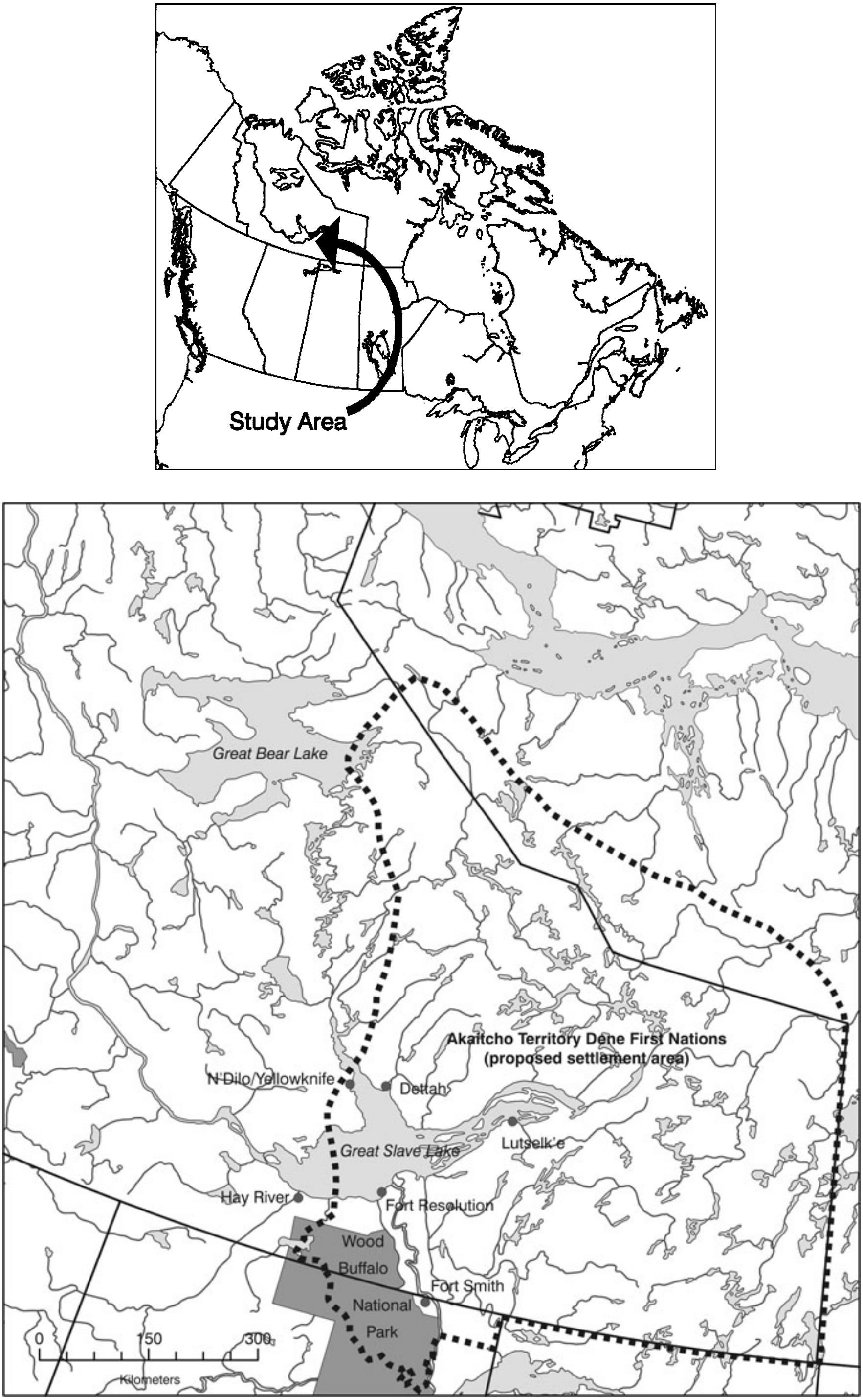

Fig. 7.1 (continued)

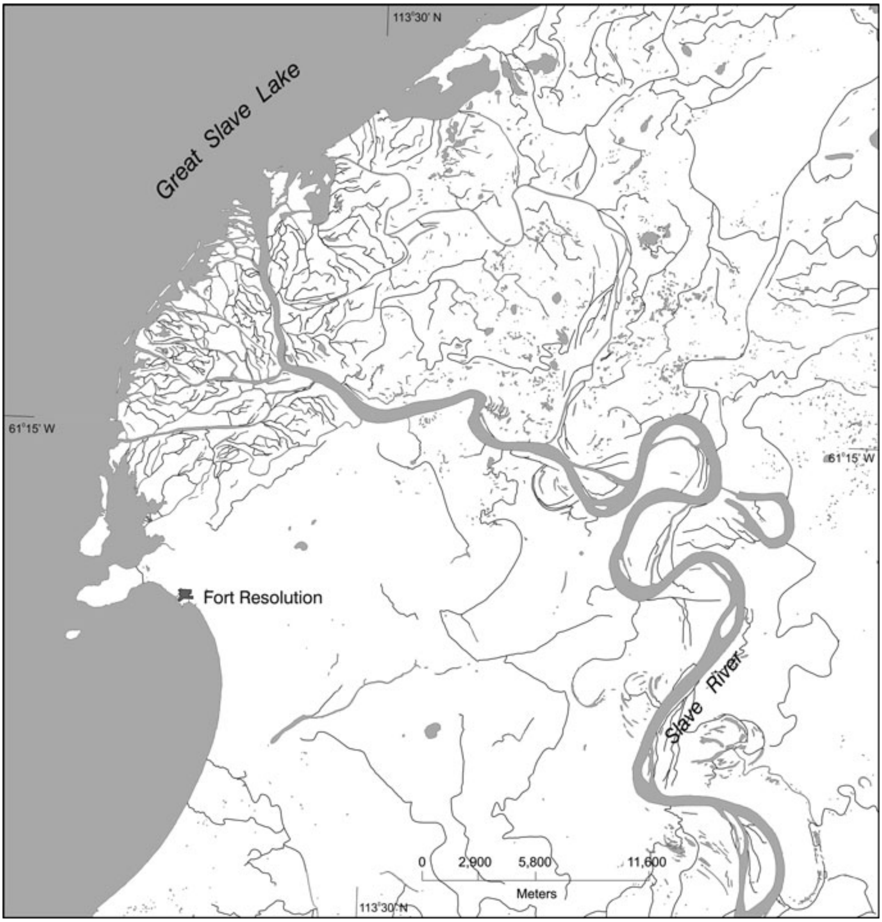

Fig. 7.1 (continued) (**a**) The case study area, (**b**) Akaitcho Treaty 8 Territory, (**c**) The Slave River Delta and community of Fort Resolution

ten kilometres west of the Slave River Delta (SRD). The SRD is the central geographic feature of the region. The delta is a highly productive ecosystem and supports a range of riparian plant communities and wildlife species, several of which are socio-economically and culturally valuable (Milburn et al. 1999). Key hydrological processes include seasonally fluctuating water flow and the deposition of nutrient-rich sediment during annual high water events that sustain extensive shoreline habitat and the overall vitality of this northern ecosystem (English et al. 1997). Like other large fresh-water deltas in the Mackenzie Basin, however, the Slave River Delta is highly sensitive to the changing climatic conditions experienced in the region (Wolfe et al. 2008), and the numerous resource and economic development activities associated with the land base and its waters (e.g., upstream water-taking for industry).

The delta's habitat diversity and wildlife resources are of central importance (historically and into the present day) to the livelihoods and socio-cultural integrity of Dene and Métis in Fort Resolution who use the area for hunting, trapping, fishing, transport, and recreation (Hoare 1995; Wesche 2009). In recent decades, alternative employment opportunities and local economic diversification have increased access to goods and services. Nevertheless, a strong sense of place exists within the community as a number of residents continue to participate in land-based occupations (e.g., trapping, hunting) that are dependent upon the delta and connected waterways (Wesche 2009). However, changes to the Slave River Delta specifically, and wider Akaitcho Territory more generally, have exposed the community to a range of vulnerabilities associated with travel access, food security and cultural identity. Such vulnerabilities are compounded by past and proposed resource development activities (e.g., mining, hydroelectric generation).

The political and institutional context in the region is also in transition. DKFN, in conjunction with three other First Nations, is involved in land claim negotiations for Akaitcho Territory (Treaty #8). The Métis of Fort Resolution are also in the process of seeking a separate contract agreement with the federal government to consolidate their Aboriginal rights (e.g., land access, hunting). The rapid environmental changes occurring within the Traditional Territory are compounded, therefore, by the evolving institutional and self-government arrangements, which may lead to co-jurisdiction over lands and resources.

7.3 Approach and Methods

Vulnerability is a function of both exposure-sensitivity and adaptive capacity (Adger and Kelly 1999; Smit et al. 2008). In this context, vulnerability represents the extent to which a particular group or community is susceptible to socio-economic, institutional and/or biophysical variables or conditions that affect (directly or indirectly) their well-being (Smit et al. 2008). Our approach to identifying exposure-sensitivities and adaptation opportunities in Fort Resolution was participatory and collaborative. This approach is consistent with broader calls for research in the North that is integrative, engages local groups and communities at early stages in the research process, draws on the knowledge and experiences of northerners, and facilitates capacity building (Graham and Fortier 2005; Wolfe et al. 2007). The approach is also consistent with application of the overall CAVIAR framework, which involves assessing the likelihood of changes in the conditions that are pertinent to the community, drawing on traditional knowledge and scientific predictions of change in natural and social systems, and characterizing the scope of and limits to adaptive capacity (Smit et al. 2008).

Identification and assessment of both current and future exposure-sensitivities and adaptive capacity in the DKFN Traditional Territory was based on a variety of methods, the results of which we have selectively drawn on for this analysis (see Wesche 2009). Methods evolved in iterative cycles with community input, building on previous results. They included: a document and literature review, semi-structured interviews with 33 land users and Elders, semi-structured interviews with 19 local and regional officials, a questionnaire administered to 104 heads of households, five focus groups using qualitative scenarios to understand exposure-sensitivities and adaptation options, and participant observation (Table 7.1). The development of qualitative scenarios offered a

Table 7.1 Summary of project methods

Method/data source	Timing	Participants	Content
Semi-structured interviews	• May–September 2005; December 2005; February 2006	• 33 land-users and Elders	• Land use, environmental conditions and observed changes (weather, water, ice, animals) • Existing exposure-sensitivities • Existing adaptation strategies
Semi-structured interviews	• March–May 2006	• 19 individuals involved in environmental governance at multiple levels	• Incorporation of climate change into planning and decision-making; major influences on policy-making • Cross-level linkages with other departments and governance organizations
Social dimensions questionnaire	• March–May 2006	• 104 heads of household in Fort Resolution	• 35 questions (individual information, environment and quality of life, social relationships and networks, trust and sharing, cooperation and collective action)
Scenario-based focus groups and interviews	• March–May 2006; November 2006	• 5 focus groups (20 participants) • 1 adaptation workshop (11 community leaders) • 3 interviews (3 community leaders)	• Qualitative scenarios of possible alternate futures, focusing on climate change and resource development as drivers (projected exposure-sensitivities, adaptation options and capacity-building)
Participant observation	• May–Sept 2005; December 2005; February 2006; March–May 2006; November 2006	• 15 field visits with local guides • Daily life with my 'adoptive' local family	• Knowledge of land use during different seasons • Environmental changes and impacts • Photographs

Source: adapted from Wesche 2009

particularly valuable tool to help make sense of the range of future socio-economic, institutional and biophysical conditions influencing community vulnerability. These scenarios and supporting narratives were constructed to reflect ‘possible futures’ in Fort Resolution and the Slave River Delta, based on potential future exposure-sensitivities as identified by community members. The scenarios were not predictive, but served instead to create dialogue about change and its many implications. Three scenarios were developed, each of which reflected different dimensions of change (with a focus on climate change and resource development) and the influences on key parameters of community life (e.g., hunting, health and wellness, economic opportunities, migration and demographics, etc.). Using these scenarios in the context of focus group discussions, participants were asked to: (a) reflect on the changes exhibited in the scenarios; (b) explore the exposure-sensitivities from an individual and community perspective, and (c) explore options to build adaptive capacity to address future exposure-sensitivities by reflecting on resource issues (e.g., human, financial), institutions and governance.

Fort Resolution residents often discussed environmental and socio-economic changes simultaneously, reflecting a general perspective of connectedness. With regards to the land user/Elder interviews, reported changes are largely based on personal observation tied to a defined area within the region, as different family groups traditionally connected to different river systems: Little Buffalo, Slave, Taltson. Observations of change from individuals are typically linked to the area where they have the longest association. However, sharing of knowledge, anecdotes, and experience among land users across geographical space occurs frequently.

7.4 Current Vulnerability

The current vulnerability of community members in Fort Resolution is determined by existing exposure-sensitivities and adaptive capacity. The region has been exposed to a number of biophysical, socio-cultural, economic and political stressors that have impacted local livelihoods. At the same time, residents have shown remarkable adaptability, considering the rapidity of change to date. Figure 7.2 provides a summary of the current and future vulnerabilities described below.

7.4.1 Existing Exposure-Sensitivities

7.4.1.1 Biophysical Exposure-Sensitivities

Through semi-structured interviews, study participants highlighted a diverse range of current exposure-sensitivities, with water emerging as a common reference point. Key biophysical concerns include reduced water levels, reduced

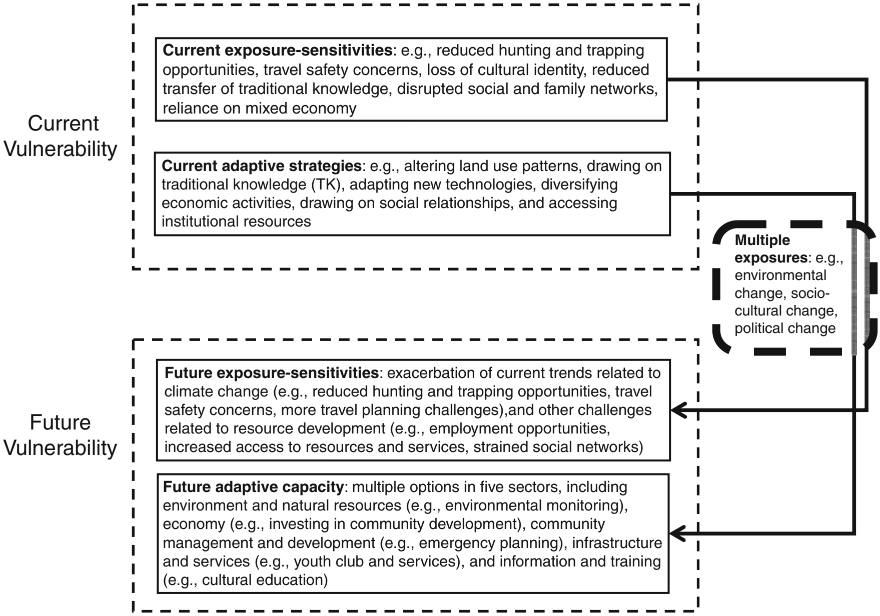

Fig. 7.2 Summary of current and future vulnerability in Fort Resolution

winter flooding, decreased ice quality and thickness, and reduced spring flooding. These changes are generally perceived to exceed 'natural variability', thus challenging the capacity of residents to adapt. While water-taking upstream is seen as a major source of exposure-sensitivities, warmer winters and less predictable weather patterns were also identified as priority concerns. Changes in water-related conditions have been identified by hunters and Elders to lead, in turn, to multiple livelihood impacts. These processes reduce overall hunting and trapping opportunities as small streams and tributaries in the delta become inaccessible by boat. Muskrat habitat is declining as a result of lower water levels and willow encroachment, a cycle initially exacerbated by a three-year period of water retention to fill the upstream Bennett Dam in the late 1960s/early 1970s. Unnatural and unpredictable beaver mortality is a consequence of winter water releases by upstream dams for hydroelectric power generation, which drown beavers in their lodges. In the winter and shoulder seasons, decreased ice quality and thickness is connected with reduced travel safety and compromises people's ability to plan travel consistently (see Fig. 7.3).

In Fort Resolution, the overall livelihood impacts associated with these issues are a concern. For example, the sediment build-up and diversion of water flow in the delta reduces accessibility for boat travel, as noted. In combination with the drying trend in inland marshes and ponds that encourages willow encroachment, habitat for muskrats and bison is compromised. Debris build-up along the riverbanks also limits moose access to the water. Both individually and in

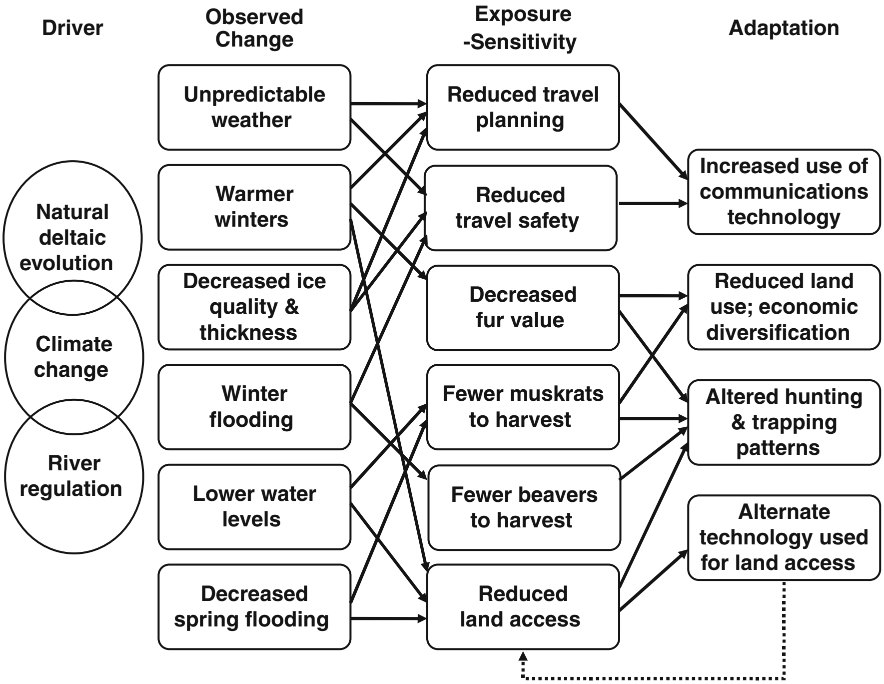

Fig. 7.3 Selected relationships linking observed environmental changes with current vulnerability, based on livelihood connections with water. *Source*: adapted from Wesche 2009

combination, all of these trends result in reduced hunting and trapping opportunities, which limits both income and traditional food harvests. As a consequence, many people feel that this (in combination with socio-cultural pressures such as modernization, alternate economic opportunities, income disparities, etc.) has challenged the transfer of traditional knowledge as past understandings and experiences do not always fit with more recent trends. Reduced food security and human health impacts were also identified as a result of these changes, as was the general loss of cultural identity, given the long association between people and the surrounding environment.

7.4.1.2 Socio-Cultural Exposure-Sensitivities

As critical as the biophysical changes are in terms of exposure-sensitivities, however, they interact with a range of uncertain social and political factors. One of the key issues confronting people in the region and the settlement of Fort Resolution, for example, is the nature of the community itself. Like many other northern societies, Fort Resolution has undergone rapid social, cultural and economic change. From its early strategic location on the river-based, north-south trade route and raison d'être as a fur trade centre, the community evolved from a modest assemblage of individuals to a commercial hub. As travel by road and airplane has become common, the settlement is no longer on the main transport route, resulting in limited opportunities for economic development. The current population has lived through much of this change, and has struggled to emerge from a particularly difficult period of social challenge in the 1970s and 1980s after the permanent road to the settlement was constructed and Pine Point lead and zinc mine opened nearby. This precipitated a range of new pressures and opportunities for livelihood expansion (e.g., mine work), while also increasing access to cheap goods, drugs and alcohol, and amplifying the influence of outsiders who came to work in the region.

Questionnaire results (see Wesche 2009), supplemented by descriptive data derived from multiple methods, highlight a series of socio-cultural and political issues that influence vulnerability. For example, contemporary socio-cultural change (e.g., increased wage employment, fewer multi-generational family living arrangements) has disrupted and at times eroded important bonds within and among family groups. Federal government interest in designating legal identity to individuals (for enumeration and remuneration) has exacerbated tensions resulting from the loss of social connectivity. Despite a long and shared history, for example, the Dene and Métis in Fort Resolution live under different sets of regulations and maintain parallel political councils, which complicates decision-making. The 'differences' ascribed to Dene and Métis have become the basis for different levels of social status in the community, as well as access to both local and external funding, training and other benefits. Yet, this distinction has not always been as prevalent, emerging largely in the late 1980s with efforts by DKFN to clarify their strategy for land claim negotiations with the federal government. Thus, the legal designation of 'aboriginality' by the federal government, and tacit acceptance of the negotiating parameters on the part of the Dene has framed how individual and group rights are considered. Participants indicated that such distinctions result in the unequal distribution of jobs, housing and other resources within the community, causing tension among residents and marginalizing certain groups. These disparities result in reduced economic, social and political engagement, and an overall lower quality of life.

There are other socio-political concerns. For instance, the generation gap that has emerged in large part due to residential schooling has in many documented instances caused a disconnect between children, their families and traditions. This has negatively impacted the well-being of the community and its residents. Many members of this current parental generation highlight the cycles of addiction and destructive behavior they have experienced, and the challenges they face in raising children. The shift away from land use activities and the introduction of formal education has also impacted the intergenerational transfer of knowledge about the land and people's connection to place. In the past, moreover, Elders were looked to for leadership and advice in community life, and revered for their role in knowledge storage and transmission through stories and oral histories. While Elders are still trusted and consulted, study participants often made the point that their advice is at times seen as outdated, leading inevitably to issues around identity and a sense of loss within the community (see Berkes et al. 2005). Participants also noted that the bonds between groups (inter- and intra-) have become less flexible and more exclusive than in the past when doors were always open, and livelihoods and material goods like meat from hunts were more readily shared.

The general shifts in social structure, finally, have influenced leadership in Fort Resolution. Elected leaders are the political face of the community, often spending significant amounts of time connecting with external officials and seeking outside resources. However, when local action is required, certain key community members quietly 'roll up their sleeves and do what needs to be done' (Wesche 2009). These individuals, who tend to be fairly consistent and small in number, provide essential social glue in the community. Often however, they are not in designated leadership positions, but rather engage in community-level work or in support roles for the elected leadership.

7.4.2 Current Adaptive Strategies and Capacity

Taken together, the biophysical, socio-cultural and political complexities outlined above create a complex vulnerability landscape. Residents of Fort Resolution outlined a series of adaptation strategies currently underway to address the exposure-sensitivities described above. Key strategies have been mainly undertaken to reduce the risk to land users, who are most concretely impacted by environmental change. Strategies include: altering land use patterns, drawing on traditional knowledge, adopting new technologies, diversifying economic activities, drawing on social relationships, and accessing institutional resources. In combination, these strategies reflect both objective determinants of adaptive capacity (e.g., resources, institutional arrangements) and more subjective determinants (e.g., perceptions of risk and change) (see Grothmann and Patt 2005; Klein et al. 2007).

7.4.2.1 Altering Land Use Patterns

Land users have shifted the way in which they use the land over time to adapt to the increased expense of travel, travel safety concerns, reduced access to harvesting areas due to environmental barriers, declining fur value, and alternative economic options. Common strategies include reducing the time spent on the land, concentrating hunting during seasonal high periods, delaying or altering travel routes, using alternate travel technologies (e.g. ATV for winter travel when snowpack is low), and changing targeted wildlife populations (e.g. harvesting from a different caribou herd near Yellowknife rather than from the herd that migrates through the east arm of Great Slave Lake). A positive, recent trend shows increased recreational land use for those with time and resources, providing a mechanism through which to strengthen cultural ties and identity through reconnection with the land.

7.4.2.2 Drawing on Traditional Knowledge

There are multiple ways to draw on available knowledge to better respond to variable environmental conditions. Land users draw heavily on their own knowledge of the land, paying more attention and taking added safety precautions when travelling. They also glean knowledge from family and friends, especially if travelling outside their area of expert knowledge. Local experientially-based culture camps are one method used to improve traditional knowledge transfer to youth, providing them with foundational survival skills on the land.

7.4.2.3 Adopting New Technologies

Technologies like the snowmobile and high speed power boats have greatly increased land user flexibility, making shorter and faster travel feasible, although the high associated costs are often prohibitive. Technology has improved travel planning and safety in multiple ways. As weather prediction has become more difficult, land users now rely on weather broadcasts (from radio, television and internet) to determine travel plans. Furthermore, many people carry Global Positioning System (GPS) units and satellite phones, or inform others of their travel plans to increase safety.

7.4.2.4 Economic Diversification

Opportunities in the wage economy combined with lower fur prices and government settlement policies have drawn trappers progressively away from the land during the past half century. Individuals, especially men, have become versatile in a range of labour activities, and adapted their mobility to take advantage of available opportunities, often working seasonally or on contract while continuing to trap during the off-season. Women have trended primarily towards work in local offices. Many have engaged in local training opportunities and office or mine work, while a few have developed local businesses, both formal (e.g. local convenience store, tourist operations) and informal (e.g. local catering, baked goods made to order), to generate income.

7.4.2.5 Drawing on Social Relationships

Strong social ties are extremely important in dealing with environmental change, especially in times of crisis. For example, when two community members failed to reach their destination across Great Slave Lake in 2006, a group of snowmobilers quickly assembled for the search. Land users are prone to helping each other out on the land to improve travel safety. Furthermore, the sharing of traditional foods is a custom that is still practiced, particularly within extended families.

7.4.2.6 Accessing Government Resources

In combination with opportunities in the wage sector, the ability to access family allowance, social assistance and pensions has shifted the mode of land use away from its former survival-based nature by introducing a formalized social safety net. This is a mixed blessing, offering resources during times of wildlife scarcity (which, in the past led to periodic famines), while at the same time failing to incentivize training and employment.

On another front, the Government of the Northwest Territories (GNWT) has implemented a complement of programs to support continuity within the territory's traditional economy. The Genuine Mackenzie Valley Fur Program promotes high quality, authentic NWT-harvested fur, while sub-programs (Guaranteed Advances, the Prime Fur Bonus Program and the Grubsteak Program) reduce individual risks to trappers. Funds from the GNWT Community Harvester Assistance Program are distributed to defray costs, and other GNWT programs (Take a Kid Trapping, Trapper Recognition and Trapper Workshops) promote and recognize trapper and general bush skills.

7.5 Future Vulnerability

The current exposure-sensitivities and adaptation options indicated above provide a basis for identifying likely or possible future vulnerability. Based on community input, we developed three scenarios of possible alternate futures that formed the basis of focus group discussions on future exposure-sensitivities and adaptation options.

7.5.1 Future Exposure-Sensitivities

Study participants established the two primary external drivers of concern as climate change and resource development, and we used these themes as a basis for three qualitative scenarios of possible alternate futures. Drawing on both traditional and scientific knowledge, narrative storylines and accompanying graphic images were developed, where exposure-sensitivities were identified by symbols (Fig. 7.4). The 'Small Town' scenario reflects business as usual, with moderate change in both climate and development. 'Shifting Seasons' draws on more extreme climate and impacts projections for the north, while 'Boom Town' illustrates significant resource development (e.g., a mine) in the region.

The climate change scenario was developed by extrapolating on past and current experiences with and local knowledge about change, combined with scientific projections. The broader Mackenzie River Basin system, within which the Slave River Delta is an important node, is experiencing significant

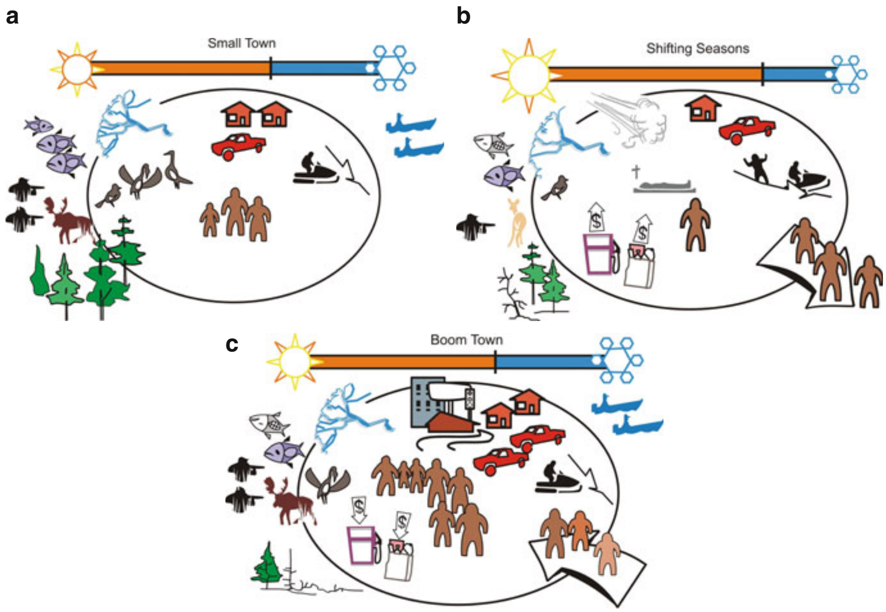

Fig. 7.4 Qualitative scenarios used to discuss future exposure-sensitivities and adaptation options. *Source*: Wesche 2009

change. Key trends and predicted changes in the region include mean temperature increases over the past century, with an expected temperature increase of four to seven degrees Celsius by 2100 and a trend in particular towards warmer winters (ACIA 2005). Paleohydrological and contemporary hydrological studies in the region provide further insight on these changes. For example, Wolfe et al. (2008) point out that shrinking headwater glaciers, decreasing high elevation snowmelt runoff, and declining river discharges at the hydrographic apex of North America (i.e., Canada's Rocky Mountains) will have uncertain implications for water allocation and downstream ecosystem function (see also Gibson et al. 2006; Schindler and Donahue 2006). Exposure-sensitivities under this scenario likely equate to an exacerbation of current trends (e.g., reduced travel safety, more travel planning challenges, reduced ability to harvest traditional foods, etc.).

While the resource development scenario is somewhat speculative, it draws on past experiences of local residents with Pine Point mine, and on the experiences of other northern boom towns. It also takes into account likely and possible developments in the region, including hydro-electric development, mining, oil and gas, logging, and tourism, some of which are already under consideration. As well, on-going industrial development pressure upstream from the DKFN Traditional Territory in northern British Columbia and Alberta (e.g., Athabasca Oil Sands) further exacerbates exposure-sensitivities (see Box 7.1) relating to water quality and quantity, ecosystem change and socio-economic impacts. Under this scenario, exposure-sensitivities will likely be more related to the social system. Resource extraction activity and infrastructure development may bring employment opportunities, but may also increase competition with outside workers. New resources may be available for community service development (e.g., food, accommodation, entertainment), and increased expendable income may allow more recreational land use. Local family groups and governance organizations (DKFN and the Fort Resolution Métis Council) may either be more or less motivated to work together for the common good.

Many overlapping concerns regarding exposure-sensitivities were expressed during the qualitative scenario discussions. For example, the integrity of the environmental system and quality of natural resources were universally at risk under climate change and resource development scenarios, with slight variations in perceived severity. This threatens to exacerbate existing harvesting and land use challenges. The potential effects on human health are also broadly concerning, especially those related to the deteriorating quality of water and traditional food. Another overlapping area of vulnerability is the negative impact on culture and traditional knowledge.

Box 7.1 Example of An Important Transboundary Exposure-Sensitivity

Water Use the Big Concern in Oilsands Developments, Native Leader Says

Edmonton Journal, Nov 8, 2006, FORT MCMURRAY

Water, not oil, is the big concern for many native people intervening at regulatory hearings for Imperial Oil's Kearl project, the environmental manager of the Deninu Kue First Nation said Tuesday.

'What you guys are discussing here is crazy talk,' Patrick Simon told a panel of representatives from the Alberta Energy and Utilities Board and the Canadian Environmental Assessment Agency.

Water is far more precious than oil, insisted Simon, who said a litre of bottled water costs about $2 while a litre of gasoline is below $1. He said it's unreasonable that water is being sacrificed so that energy companies can continue to develop the crude resources in northern Alberta. The Dene people, he said, are worried about the growing demand for water withdrawal from the Athabasca River, and question whether the water in the rivers around the oilsands development is safe for drinking.

Mark Little, oilsands development manager of Kearl, assured Simon that the project's impact on air, water and land are negligible. But Little also said that on average the project will draw more than one billion cubic metres of water from the Athabasca River for approximately 50 years.

Posted: March 22, 2007 on www.tarsandswatch.org [last accessed February 12, 2009]

7.5.2 Future Adaptive Capacity

In contemplating future alternate scenarios, climate change was perceived to cause mostly negative impacts on ecosystems and local livelihoods within DKFN Traditional Territory, whereas resource development was perceived to bring a distinct mixture of potentially more pronounced positive and negative impacts (e.g., threats to Aboriginal culture and way of life versus employment opportunities). At the same time, residents generally felt more able to adapt to climate-driven changes than those created by significant resource development. While strategies were linked to particular exposure-sensitivities, many overlapped, indicating that particular strategies are well-suited to concurrently address multiple aspects. Table 7.2 identifies the strategies (by sector) that were most commonly cited, and thus prioritized, by participants.

While there is some community support for resource development as an adaptation to lost opportunities on the land, participants in the study highlight a need for community planning, preparedness and risk mitigation. The level of local control over drivers of change also plays a role in shaping local perceptions. For instance, climate change is seen as an entirely external force that residents feel unable to influence, and they are thus resigned to its outcomes. In contrast, local residents have some degree of choice and control over if, when and how resource development projects are implemented in their Traditional Territory.

Table 7.2 Prioritized future adaptation options to address a range of future exposure-sensitivities, as identified by participants

Sector	Option
Environment and natural resources	• Modification of harvesting practices • Environmental monitoring program • Environmental health research
Economy	• Economic and livelihood diversification • Investment in community development
Community management and development	• Community planning • Emergency planning • Improve community consultation • Industry partnerships and agreements
Infrastructure and services	• Assessment of climate change impacts on community infrastructure • Infrastructure planning for population flux • Improved health infrastructure and services • Improved social service support and programs • Development of a youth club and programming
Information and training	• Environmental change awareness-building • Cultural education and development • Land use safety training • Employment training

Source: Wesche 2009

Some specific results of the qualitative scenarios exercise are worth noting in this regard. Individuals discussed how potential future changes could bring a combination of positive and negative impacts, thus requiring flexibility and openness to take advantage of new opportunities (e.g., employment, cultural renewal). Land use planning and management (e.g., a strategic plan outlining where, how and when development may take place, combined with systematic environmental monitoring) and cultural revival were deemed especially important in preparing for and responding to climate-induced changes. Political leadership, training and education were also highlighted as important elements of adaptation, although linked more explicitly to future economic development activities and livelihoods.

Coping and adapting to change demands an enabling institutional context (Agrawal 2008; Duerden 2004). In Fort Resolution, it is felt that locally-based institutions (e.g., DKFN council, Akaitcho Territory Government) and territorial government ministries (Environment and Natural Resources, Housing) provide important support and information to community members. Yet, there is also recognition that change must occur from within. This supports a focus on development at the local level, which is nested within a broader set of institutions that offer access to resources and expertise. Evolving governance structures (e.g., self-government and territory-based co-jurisdiction through land claim negotiations – see discussion below) which devolve control and resources to regional and local levels were identified by some as providing the scope for re-empowering actors within the community. Importantly, the underlying social structure based on kinship and shared history continues to offer a source of culturally-appropriate resources to support community members in times of need. As was witnessed on several occasions (e.g., with the sudden deaths of community members), the willingness of people in Fort Resolution to overcome family divisions and collaborate for the collective good does emerge in times of tragedy or crisis, and when the collective rights of the community are threatened. These social ties are often latent, but provide a foundation for social cohesion and cooperative action in response to change.

7.6 Building Capacity to Adapt to an Uncertain Future

In the DKFN Traditional Territory, the future is uncertain. Climate projections for the Mackenzie Basin point to rising temperature trends and declining precipitation and water levels (Environment Canada 2004; Rouse et al. 1997; Wolfe et al. 2008). These conditions are closely connected to changes in water flow from the feeder watersheds of the Peace and Athabasca rivers. Paleohydrological evidence suggests this should be a period of increased precipitation and water flow through the system, although in fact there has been an extended period of increasingly drier conditions (Wolfe et al. 2008). Uncertainty stemming from climate conditions is exacerbated as well by initiatives and plans for resource development, such as the proposed re-opening of the nearby Pine Point mine, and a proposal to place turbines on the Slave River between Fort Smith and Fort Resolution. Finally, changing governance systems which include Treaty negotiations and a move towards greater self-governance, along with shifting social conditions in the community, create additional sources of uncertainty.

A broad range of options to build future adaptive capacity can be identified that draw attention to governance issues and emphasize the multi-level dimensions of adaptation (Wesche and Armitage in press). Of central importance are the relationships among adaptive capacity and the features of social organization that facilitate collaboration and cooperation for mutual benefit, including local social networks, multiple forms of knowledge and equitable access to resources. Adaptive capacity at local scales reflects the wider socio-political and institutional context of the North, where the northern economic transition, government support programs, emerging land claims processes and governance models (e.g. co-jurisdiction) can have a profound influence on the ability of communities to proactively respond to change.

Based on the results of interviews and focus groups, we highlight here three key strategies that emerge from this context: (1) incorporating different knowledge systems; (2) clarifying the role of different actors and institutions in this transitional context; and (3) adopting a multi-level systems view. While the issues addressed here are most relevant to northern Canadian communities like Fort Resolution, they may also apply in whole or in part to other Aboriginal and/or remote community contexts.

7.6.1 Incorporating Different Knowledge Systems

A key lesson from experience with the vulnerability assessment process has been the importance of working from the bottom-up. Rather than starting a priori assigning vulnerabilities based on model projections, experience in Fort Resolution and the surrounding Traditional Territory highlights the value and importance of engaging knowledge holders to document key issues. The broad-based knowledge of active land users and Elders is also key to framing future adaptation options. Efforts to extract traditional and local knowledge to augment adaptation planning, however, will miss the point. To be sure, the knowledge of changing parameters of climate and its impacts on wildlife, water resources and livelihoods is powerful. Yet, it is the process of 'co-producing' knowledge (Davidson-Hunt and O'Flaherty 2007) within collaborative learning contexts that include stakeholders, researchers and others that is a critical feature of efforts to build future capacity to adapt to changes.

However, while there are many benefits to adopting a pluralist perspective on the incorporation of scientific and traditional knowledge, a number of important issues must be considered as was our experience in Fort Resolution. First, it is important for researchers to take a flexible, participatory approach. Yet, finding ways to overcome the challenge of matching study time scales with community expectations and time-frames is a difficult task. In our study we tried to maintain community interest via an iterative feedback process throughout the duration of the project. In terms of future adaptation, therefore, it is important to develop and maintain strong relationships with leaders in both political and other community-based organizations, and reflect upon community dynamics and other potential challenges that influence cooperation in adaptation planning (e.g., local conflict, fluidity in roles of community members – see Wesche 2009; Wolfe et al. 2007).

More specifically to knowledge co-production efforts, experience in Fort Resolution suggests that knowledge is not evenly spread within the community. Incorporating knowledge from a range of people provides greater probability of developing a more holistic understanding of change. Knowledge of individuals is determined by the intensity and consistency of his or her land use over time, the diversity of activities undertaken, and the geographic location of these activities. The knowledge of those who participated in this study has been tied in many instances to particular river systems (e.g., Little Buffalo, Slave, Taltson).

Knowledge of land users and Elders is not static. Rather, it changes and evolves due to influences such as religious conversion, residential schooling, western worldviews and knowledge, and environmental change. Thus the term 'traditional knowledge' in Fort Resolution may not have the same connotation to people of different generations within the community (e.g., Elders may attach more spiritual significance). Similarly, exposure to new ideas has influenced the way local residents interpret their environmental surroundings, thus the nature of knowledge takes on a hybridized form. The embeddedness of externally-produced knowledge makes it difficult (and counterproductive) to clearly distinguish between historical concepts of traditional knowledge and 'other' components. As such, encouraging the active use of such knowledge within Aboriginal communities as conditions change is helping to ensure that knowledge of the land evolves and continues to provide an important source of insight for adaptation. In the context of studies and planning for adaptation, a shift in mindset and approach is required, from one of documenting traditional knowledge to prevent or pre-empt its extinction, to one where it is recognized and valued as a source of knowledge that changes and evolves with the world around it. This points to the need for the fundamental involvement of local communities in decision-making about their lands, stemming from the grassroots level.

7.6.2 Engaging Actors and Institutions in a Transitional Context

In the DKFN Traditional Territory, efforts to build adaptive capacity for future change must take into account a series of institutional and actor-specific issues. First, the region is in a period of political transition (in addition to environmental change) associated with land claims and self-government negotiation processes. The claims processes and Treaty negotiations will likely secure greater local control over decision-making. This potentially has significant implications for future adaptation. Indeed, negotiations around land and self-government rights offer optimism for increased and improved involvement of local authorities and residents in management decisions regarding their territory and resources, and thus the potential for incorporating mechanisms for strengthening adaptive capacity and enhancing adaptation options. For DKFN, learning from the outcomes of other land claim processes has encouraged an adaptive management approach to multi-phased implementation. However, while changing governance arrangements provide a significant opportunity for transformation, it is uncertain whether the entrenched differences and relationships of power between the DKFN and federal/territorial governments will be changed in the short-term. Any new political structure will require local councils to be accountable and more participatory, and for all community members to feel that their interests are equally represented.

Second, certain determinants of adaptive capacity clearly relate to the community's operational context or the knowledge and skills, resources and technology, and institutional support that are available and accessible. However, underlying community characteristics including social networks and the level of equity among residents also play a significant role in shaping the capacity of individuals and households to adapt to future change, and in influencing whether or not existing adaptive capacity remains latent or becomes engaged. A range of community characteristics and affiliations were identified in Fort Resolution as important influences on the ability of individuals and households to adapt to change. These include legal identity (e.g., Dene, Métis, Other), family and location of origin, age, sex, education level, individual well-being, and economic and social status (Wesche 2009). Each individual in Fort Resolution has a unique combination of these characteristics and affiliations that, combined with personal capabilities, influences their adaptive capacity and the extent to which they would collaborate with others (see Box 7.2a, b for a comparison of adaptation options between a (fictional) Dene and Métis household).

Box 7.2 Comparison of Adaptation Options Between (Fictional) Dene and Métis Households, Based Largely on Differences in Legal Identity

(a) Dene Household

Household 1 consists of a family with middle-aged Dene parents and three school-aged children. The adult male is an avid land user with little formal education. The adult female has a full-time wage job at one of the local organizations. The female's steady wage allows the household to invest in a range of travel and harvesting equipment for different seasons (e.g. snowmobile, toboggan, truck, boat, boat trailer, ATV) which require capital inputs for purchase and continued maintenance. The male traps intensively throughout the winter in the Slave River Delta area, and hunts and fishes year-round. Financial flexibility and access to equipment allow him to participate in a range of harvesting events (e.g. group hunts by snowmobile for caribou (which can be sold to DKFN for distribution), intensive beaver and muskrat harvest by boat in spring, goose hunting by snowmobile or boat in spring, and moose hunting by truck or boat in fall). The household also has the flexibility to engage in other opportunities such as short-term contracts available through DKFN (e.g. guiding, research assistance, trail maintenance, and local forestry operations). These opportunities are also supported by strong family and friendship ties with members of the local government and other community organizations.

(b) Métis Household

Household 2 consists of a family with middle-aged Métis parents and three school-aged children. The adult male is an avid land user with little formal education. The adult female is a homemaker, who intermittently works in short-term contract jobs. The male owns the necessary gear for trapping (e.g. snowmobile, toboggan, traps), purchased with the aid of harvester support programs and earnings. He traps intensively throughout the winter, and is able to make a small profit. However, the household has limited resources to spend time on the land in other seasons. The household resorts to lower cost activities such as fishing in Resolution Bay or at Little Buffalo River, or hunting in areas accessible to the highway to provide food for the family. They are able to sustain a living in a small rental unit, but have few luxuries. The cash-strapped Métis Local is unable to provide substantive assistance, and there are limited opportunities for extra contracts since most funding and opportunities are generated through DKFN (e.g. contracts with incoming researchers or resource companies; government programs).

Source: Wesche 2009

Third, considering the role of actors and institutions for future adaptation requires careful consideration of scale issues and the interactions among actors across scales. While most of the focus of this analysis has been on Fort Resolution and the DKFN Traditional Territory, an enabling context created by linkages across scales is important for adaptation. However, this is not a straightforward matter. Local mistrust in higher levels of government, largely influenced by historical experience, reinforces the belief that it is important to take advantage and get what you can while it is on offer, rather than taking a longer term view. Since residents feel that in the past such relationships have generally been divisive, they may fail to recognize the potential opportunities for external organizations to provide support for the less tangible social aspects of capacity development required to support adaptation. If locals continue to be mistrusting in these relationships, they are unlikely to support measures where money and resources are used for activities that do not bring immediate benefits, constraining the feasibility of anticipatory adaptation planning. While there is significant political leverage when Aboriginal governments work together, community members indicate that efforts are often hindered by the perceived 'divide and conquer' approach taken by the Government of Canada and industry. This reinforces tensions between DKFN and the Fort Resolution Métis, as both groups are separately pursuing land claim and rights negotiations, despite the fact that individuals in the same family might be on opposing sides.

7.6.3 Adopting a Multi-Level Systems View

Fort Resolution, like many northern communities in Canada, is experiencing 'multiple exposures' from external and internal changes in socio-cultural, economic and biophysical conditions. In addition to economic development and climate change, northern Aboriginal communities must also address the legacy of cultural change catalyzed by the arrival of European settlers. Therefore, in most northern communities like Fort Resolution, the intersection of multiple exposures is complex. The ability of individuals and communities to cope with these exposures is mediated by access to economic resources, technology, levels of knowledge, information and skill sets, existing infrastructure, and the capacity and resilience of institutions and organizations. Framing these multiple exposures, moreover, are challenging socio-institutional relationships, values and worldviews operating at local to global scales (Armitage 2005), all of which shape the feasibility, effectiveness, cost and acceptability of adaptation options (Pelling and High 2005).

While all communities have some degree of coping and adaptive capacity, it is generally not specifically developed to deal with environmental change. In this case, the family bonds and knowledge of hunters, Elders and others in Fort Resolution engaged to overcome the negative consequences of the Pine Point mine, for example, are the same sets of social capital and memory required to deal with ecosystem changes and the implications for land use activities. Additionally, relationships among actors across different levels act as important social networks to draw on in times of need.

However, while it is important that strategies to build and apply adaptive capacity are focused at the local level, people in Fort Resolution have expressed a concern that these same foundations of adaptive capacity can be overwhelmed by external forces, particularly in the absence of a broader enabling institutional context. As indicated by participants in the scenario process, residents do recognize their shared future and limited ability to select the external influences that shape the community. Some suggest that climate change may bring residents together to face a common threat. Yet, this would likely not happen spontaneously until the community faces extreme conditions that threaten their livelihoods. However, residents may be brought together in other ways, such as through community visioning and community capacity-building programs.

Building the foundations for future adaptation, finally, will depend on how the emerging governance structure is able to foster collaboration and learning across multiple levels (Armitage et al. 2007). The limits of the DKFN Band Council to fully develop adaptive capacity are apparent. While many local level organizations beyond the Band Council appear intact and well-structured, the form does not always translate into functionality. In designing and developing new organizational structures through Treaty and Métis agreements, each responsible actor should recognize the need to create structures that support flexibility, social learning and adaptability (e.g., local governments that are open and participatory in nature, and that promote learning in cycles through periodic experimentation and evaluation).

7.7 Conclusions

> 'As long as the sun shines, the rivers flow and grass grows' – The understanding of rights with which the Fort Resolution Dene entered Treaty in 1900

In DKFN Traditional Territory, relationships among past and current environmental change, exposure-sensitivities and adaptations are cumulative and non-linear (e.g., Fig. 7.3). Perhaps now more than ever, the spirit with which the Chipewyan Dene from Akaitcho Territory entered into Treaty with Her Majesty the Queen in 1900 is under threat. Many overlapping areas of vulnerability are at play within the region as residents face social-ecological uncertainties beyond the range of historical experience. Changes to water resources, the delta and related environmental conditions are of particular concern and connect directly and indirectly to adaptation issues (e.g., travel, harvesting, economic diversification). Climate change is perceived to cause mostly negative impacts on water, lands and local livelihoods, whereas resource development, as noted, brings a distinct mixture of potentially more pronounced positive and negative changes. While many people in Fort Resolution feel more able to adapt to climate-driven changes than those created by significant resource development, general concern exists about adapting to any conditions that are beyond those experienced to date. There is, however, a significant overlap in the types of adaptation strategies proposed for both forms of possible future change, some of which could be readily implemented as 'no regrets' measures to reduce vulnerability under a range of conditions.

Within northern communities, consideration of adaptation options and vulnerability reduction has often been reactive and undertaken on an individual basis (e.g., hunter modifications of travel routes for safety, or modifications to timing and intensity of harvest). Yet, there is a growing recognition that a more proactive and collective approach is required. As experience in Fort Resolution illustrates, vulnerability and adaptive capacity are strongly determined not only by changes to environmental conditions (particularly water resources), but by key socio-cultural relationships, values and worldviews operating at individual and community scales. These relationships and values are without doubt under enormous pressure from exogenous forces, including climate and large-scale resource development. Contemporary socio-cultural change disrupts and erodes important bonds both within and among family groups.

As reflected in the spirit in which the Treaty of 1900 was entered, however, northern peoples and communities are building resilience in the context of change and negotiating a path forward. This spirit has also been illustrated more recently by the renewed efforts to deal with social injustices and lay claim to lands and culture. A collective engagement on behalf of local, regional and national actors to address vulnerabilities, support adaptation, and share experiences and knowledge, will serve to support those efforts.

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Chapter 8
Case Study Photographs

Fig. 2.1 Fish landing facility in Steine, Vestvågøy, Northern Norway in February. Photo: Halvor Dannevig/CICERO

Fig. 2.2 Sorting of stockfish (*vraking*) in Steine, Vestvågøy. The stockfish are sorted in a number of different categories on the basis of quality, size and several other criteria. Photo: Halvor Dannevig/CICERO

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Fig. 4.2 Reindeer herds in Yamalo-Nenets Autonomous Okrug, Northern Russia. Photo: Denis Laptander, owner of the herd

Fig. 4.3 Travelling with the herd in Yamalo-Nenets Autonomous Okrug, Northern Russia. Photo: Denis Laptander, owner of the herd

Fig. 4.4 Travelling with the herd in Yamalo-Nenets Autonomous Okrug, Northern Russia. Photo: Denis Laptander, owner of the herd

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Fig. 6.2 Nelmin Nos on the Riverbank erosion poses an immediate threat for any structures built too close to the river. A few houses, which previously stood on the riverbank, have already been moved and a part of the graveyard has been washed out. The Pechora River is also the only ground transport line that allows passage between the village and the outside 'world', and melt-freeze cycles crucially influence local inhabitants' livelihoods. Photo: Anna Stammler-Gossmann

Fig. 6.3 Passenger tank in Malozemelskaia tundra. Soviet style passenger tanks continue to be a major means of transport in the Russian Arctic in the absence of roads and railways in most places. For Nelmin Nos residents the need or desire for some services unavailable in the village, to ensure a successful hunt or personal business may determine the travel risk worth taking. Photo: Anna Stammler-Gossmann

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Fig. 7.3 Rocher River. A building slowly deteriorates in the abandoned settlement of Rocher River, NWT, on the south shore of Great Slave Lake. Most residents moved to nearby Fort Resolution and Fort Smith after the local school burned down (1958) and the Hudson Bay Fur Trade Post closed (1963). Photo: Sonia Wesche

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Fig. 13.1 Gathering Old Norwegian Sheep at Angsnes in Unjárga/Nesseby. This “traditional” breed is characterized by being small and light-footed. The animals take good care of their lambs, have a strong flocking instinct and thus seldom fall prey to predators. Through their versatile grazing pattern, the old Norwegian sheep utilize ‘everything’, including grass, heath, herbs, shrubs, tree bark, leaves and twigs. This gives the meat a mild but rich taste, reminiscent of game. Photo: Stine Rybråten/CICERO

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Fig. 13.4 Unjárga/Nesseby church from 1858. The church is located at the head of Varangerfjord, and racks for drying cod can be seen in the background. Photo: Grete K. Hovelsrud/CICERO

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Fig. 13.6 Ice fishing in spring is a valued activity in Unjárga/Nesseby, both as a food source and for recreation. Some of the residents now express concern for the possibility to maintaining this activity in the future, if the winter season will be reduced by less snow on the ground and an earlier snow and ice melt in spring. Photo: Stine Rybråten/CICERO

Chapter 9
The Ivalo River and its People: There Have Always Been Floods – What Is Different Now?

Monica Tennberg, Terhi Vuojala-Magga, and Minna Turunen

Abstract The Ivalo River and its annual variation have always been a part of the everyday life of the nearby town's inhabitants. This case study looks at the history of flooding and closely analyses the latest major flood of 2005. The development of the community, with particular respect to increase of infrastructure, has left the community more vulnerable to flooding than before. The case study discovers that the critical issue for adaptation to flood risk is communication within the community between local people, decision-makers and regional actors involved with flood protection. Adaptation to future flooding needs a multilevel and flexible strategy. The analysis integrates anthropological, political and natural science information.

Keywords Adaptive capacity · Exposure-sensitivity · Adaptive strategy · Vulnerability · Ivalo river · Finland · Lapland

9.1 Introduction

9.1.1 Flooding in the Ivalo River

In Finland, snowmelt related floods occur annually in spring time. Flooding is thus nothing new for the people living along the Ivalo River in the northernmost part of Finland during the spring time. In spring 2005, the snow-melt related flood in the Ivalo River reached the maximum discharge value of 1,045 m^3/s. It can be defined as a 'major' flood. 'A major' flood is a more severe flood than normal; a flood that exceeds the sizing and the risk level used in the flood protection of the given area (Karjalainen and Kämäräinen 2006; Suurtulvatyöryhmä 2003, 5). In the Finnish CAVIAR research project,

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the 2005 Ivalo River flood has been used as a case-study. This example of an extreme weather event can help us to study and define vulnerabilities in terms of exposure-sensitivities and adaptive capacity, and the different types of adaptive strategies needed for future flood protection in Northern Finland in the context of community system and its organization in an exceptional event.

9.1.2 Methodological Note

Three different disciplines are utilised in this chapter: anthropology, focusing on the locality, collective experience and knowledge systems: political science, concentrating on the structures of agency, knowledge and governance, and natural sciences, explaining the natural life of the river. In the following analysis these three disciplines are integrated with an aim at providing a community-based vulnerability assessment in Northern Finland.

Anthropological work in this study is based on interviews. The fieldwork in Ivalo town was conducted during June and August of 2007. Twenty-three interviews of the duration between half an hour to 2,5 hours were conducted. The informants were chosen according to their profession. The informants work in the departments of the municipality of Inari and represent different professions, roles and positions in decision-making processes and implementation. In addition to these thematic interviews researchers had informal discussions with the locals in a variety of everyday situations. The analysis and results were presented to the interviewees in a feedback meeting in June 2009.

The political science work focuses on the relationship between various actors and levels of government in tackling the threat of flooding. In this analysis, interviews, official documents and newspaper material were used. Articles from Lapin Kansa, the regional newspaper, were collected and analyzed to follow the discussions about flood protection after the 2005 flood until 2008. Some additional interviews (3) were conducted in the provincial capital Rovaniemi in the Regional Environmental Centre to discuss flood prevention and management from a regional perspective.

The natural sciences work of this study analyses the bio-geographical, hydrological and meteorological characteristics of the Ivalo River and its catchment area, which is fundamental for understanding the flood forming conditions of this river in general and particularly during the spring flood in 2005. The further analysis on the role of climatic change is based on statistics of temperature, precipitation and snow data during the past 35–50 years obtained from the Finnish Meteorological Institute (2009) and seasonal and annual discharge data for 1961–2009 obtained from Finnish Environment Institute (2009).

9.2 The Research Site

The 180 km long Ivalo River (Fig. 9.1) is one of the biggest rivers in Northern Finland. Its valley was located at such a height that it became an inlet of the Arctic Ocean upon the melting of the ice sheet during the last glaciation (Würm/Weichselian). Influx of meltwater led to the deposition of vast beds of sand, which have since been fashioned into a complex pattern of fluvial relief by the post-glacial action of the Ivalo River (Koutaniemi 1987). The bedrock of this area is composed of the West Inari schist zone in the west, forming part of Svecokarelides; and the Presvecokarelian granulite complex in the east

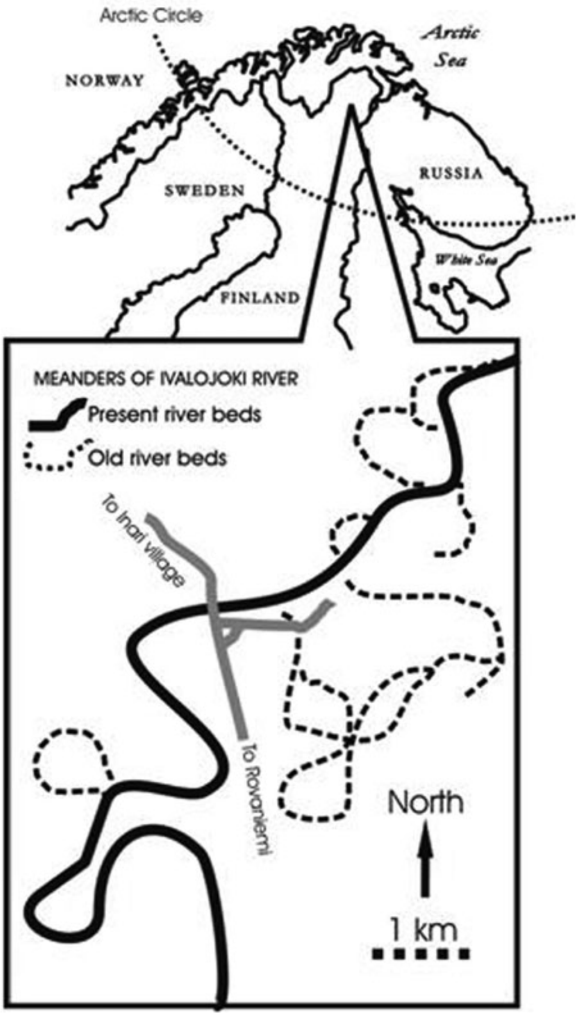

Fig. 9.1 Location of meandering Ivalo River in Northern Finland. The present river beds are marked with black lines and old river beds with dashed line

(Koutaniemi and Luoma-aho 1983). Structurally Ivalo River is a meandering river, which differs from most of the rivers in Finland. A prerequisite for formation of this type of river is a flat-bottom regular valley which is filled with even material. In a meandering river, the outside curve of a meander is deep due to erosion by higher stream velocities, and the inside curve is shallow often having sand banks due to sedimentation.

The Ivalo River flows through the Lemmenjoki National Park and Hammastunturi Wilderness Area into Lake Inari, and from there as a part of Paatsjoki river system to the Arctic Ocean. The area is characterized by boreal coniferous forests, subarctic mountain birch woodlands, mires and fells (Kalliola 1973; Oksanen and Virtanen 1995). In climatic terms, Ivalo River and its catchment area belong to a ‘cold, snowy, forest climate’ (Köppen climate type: Dfc). Due to the Gulf Stream, the climate in the area is relatively mild as compared to other regions at corresponding latitudes. The climate is characterized by high annual variability. The mean annual temperature, measured from 1970–2000, ranged from 0 to −2°C, with a mean temperature in July of 14°C, and January of −13°C. Yearly precipitation varies from 400 to 500 mm, and about half of this precipitation falls down as snow, which accumulates to a depth of 70-90 cm. The rivers and lakes freeze normally in October or November, and this ice cover lasts until the spring flood period in May – June (Finnish Meteorological Institute 2009). In the Ivalo River, spring floods normally start in the end of April, and the discharges are at their biggest during the latter half of May (Fig. 9.2) (Tulvavahinkotyöryhmä 2006).

The Ivalo River flows through Inari, which is the largest municipality in Finland. It covers an area of 17,321 km^2 with a population of only 6 861, resulting in a population density of 0.46 inhabitants per km^2. The town of Ivalo is located on both banks of Ivalo River in Inari municipality. The Inari Sámi were the first to inhabit the shores of the Ivalo river (Enbuske 2003, 157–58; Lehtola 1998, 18–24; Nahkiasoja 2003, 176–83). By the end of 1750s, the first Finnish settlers came to Inari. The Kyrö village became the centre for

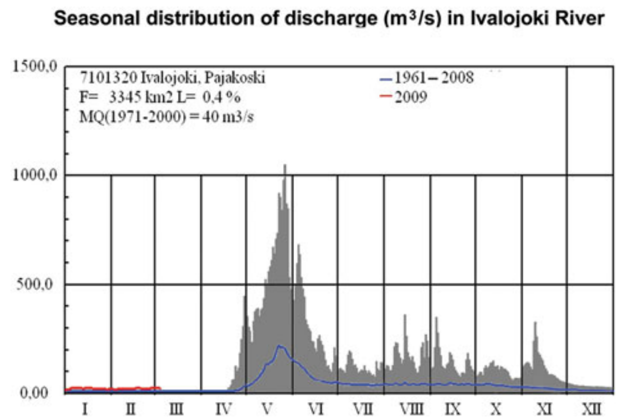

Fig. 9.2 Seasonal distribution of discharge (m^3/s) during 1961–2008 in Pajakoski, Ivalo River. The highest flood peak occurs typically during the later half of May. *Source*: Finnish Environment Institute 2009

the Finnish settlers as it was situated in the most fertile area of land flooded by the Ivalo River (Nahkiasoja 2003, 167–8). The town of Ivalo became an administrative centre of Inari in 1938. After the Second World War, Inari went through a long process of reconstruction (Lehtola 1996, 378). Northern regions in Finland became targets of active national development strategies. This led to the improvement of infrastructure in the community.

The Ivalo River has been known as a flooding river for a long time – 'a bad place for flooding' (Ollila et al. 2000). In Finland, flood protection is the shared responsibility of the municipality, Finnish environmental administration and rescue services. The municipal council takes care of the whole administration and thus is responsible for economy, construction and infrastructure, social services, healthcare, fire and rescue services as well as sports and culture. At the local level, the municipalities are responsible for land use planning, which is an important instrument for flood damage prevention.

9.3 The Case Study Results

9.3.1 Current Exposure-Sensitivity

Exposure-sensitivity reflects the likelihood of climatic conditions or natural hazards occurring in a particular place over time and also the situational characteristics of places and people which make them sensitive to the conditions of hazards (Chapter 1). In Northern Finland, flooding is usually related to snowmelt, ice jamming and torrential and prolonged rainfalls, with the most widespread floods taking place in spring during snow melt season. Formation of spring flood is greatly affected by the water content of snow and soil frost, speed of snow melt and the intensity of rainfalls during the snow melting period. (Tulvavahinkotyöryhmä 2006). Usually spring flooding is caused by the steel ice which forms easily ice dams. Steel ice ('teräsjää') is clear, hard and

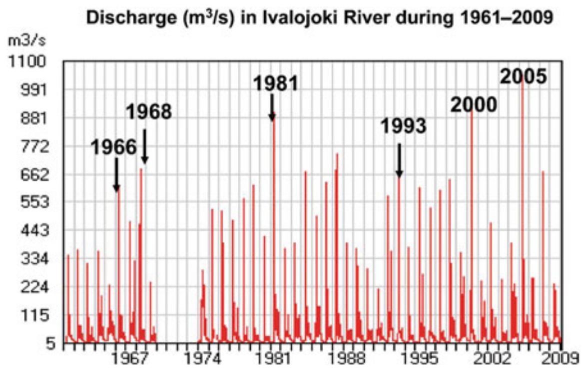

Fig. 9.3 Discharge (m^3/s) in Pajakoski, Ivalojoki River during 1961–2009. Pajakoski is located near to Ivalo town. *Source*: Finnish Environment Institute 2009

translucent ice with uniform structure and carrying capacity ca 50% higher than that of more porous and fragile 'kohvajää'.

Major floods have occurred in 1966, 1968, 1981, 1993, 2000 and 2005 (Fig. 9.3). Compared to the previous floods, the flood in 1981 and in 2000 were different. According to a local informant's recollections from 1981: 'The warm weather melted snow at a fast speed, which rushed to the river. There was good rain for a few hours, too. The large amount of water increased the flood peak, though there were no more ice dams' MTV3 2000.

By 1981, the Ivalo town had grown on the flooded side of the river, and therefore the damage was more serious than before. For individuals the flooding is obviously a concern regarding material damage to property, mainly to houses and cars. One of the interviewees pointed out: 'I owned my house, and I was afraid that it will soak the floors, we were saved, but many houses got wet' (Male 1). In 1981, material damages were considerable.

The flood in 1981 appeared after the ice dams had been destroyed. In 2000 the Ivalo river flooded again, attaining a record-breaking flow peak of 930 m^3/s. The 2005 flood was caused by a combination of special conditions: warm temperatures, high water content of snow and precipitation. It was not a typical spring flood as before because downstream ice had melted away days before. The spring flood in 2005 reached a dangerous level. The flood threatened the Näverniemi area in the centre of Ivalo town. Some roads were closed and a home for the elderly was evacuated by the rescue services and preparations were

Fig. 9.4 A major flood in the Ivalo River, Finnish Lapland on the 27th of May, 2005. Image drawn on a map is an interpretation of a near real time RADARSAT satellite image. Image area is 50km. (© FloodMAN EU-project EVG1-CT-2002-00085, background map © National land survey of Finland license nr. 7/MYY/05). Flooded regions are marked in grey

made for the evacuation of the local hospital. Fortunately there were no human injuries. The satellite image (Fig. 9.4) shows the extent of the Ivalo River flood in 2005 in the centre of Ivalo town.

A local informant recollects the events. She saw the news on the television about the flood. She (Female 1) tells: 'It seemed that our property could be flooded in Ivalo. I called my husband and said, lift all valuables to the table now, the rest does not matter. My husband stayed there to observe the situation. In the neighbouring house, people had already been evacuated, but our house is situated one meter higher, so the water reached did not flood in'. In 2005, 14 houses and 29 summer cottages were flooded. In all, the damages were estimated to be about 500,000 euros (Helsingin Sanomat 1.11.2005).

What made the flood surprising? The year 2005 was exceptionally warm. In Northern Finland, the water equivalence of the snow cover was over 80 kg/sqm, and at the same time ice thickness was below the average (Annual hydrological report 2005). In the report to the EU Commission (Aid no N136/2006) it was stated: 'in the Ivalo river basin the water content of snow was abnormally high and the snow melting period occurred later than normal and was coupled with heavy rainfall. These circumstances resulted in exceptionally heavy flooding, which peaked between 26 May, 2005 and 3 June, 2005. The peak flooding levels observed during this period occur once every 70 years on average' (Aid no N136/2006). Exposure-sensitivity in this case was formed by high water content in snow, fast snowmelt together with spring rain upstream.

9.3.2 *Future Exposure-Sensitivity*

The extent of flooding depends not only on the geomorphological characteristics of river with its catchment area and the land use patterns, but also on many hydrological and climatic factors. There are several reasons why Ivalo River is at risk of future flooding. Firstly, the steepness of the relief (by Finnish standards) (Koutaniemi and Luoma-aho 1983) means that spring flood reaches a much sharper peak than in other areas. Secondly, the low incidence of lakes (0,3%) in the Ivalo River catchment area means that there are not much capacity to absorb the melt water from the snow in the spring time. Thirdly, high accumulation of snow in this area combined with rapid melt together with sudden spring rainfalls may sometimes account for 2/3 of the total river discharge. Fourthly, during the last glaciations, massive fill deposits were left by the melt water from the glacier, making the river sensitive to even the smallest changes in river discharges. Since the river bed is constantly shifting its place, its banks are exposed to landslides, which are not only composed of sand, but also vegetation and big trees, which all contribute to the ice break ups and increase the probability of forming ice dams during the spring flooding. In addition, although the Ivalo River is in a natural state, regulation of the Paatsjoki river on the Russian side has an impact on the water level of Inari Lake and the end part of the Ivalo River, thus increasing the risk of river banks landslides (Karjalainen and Kämäräinen 2006).

In our case study, predicted climate changes may considerably alter the flooding characteristics of Ivalo River. The Fig. 9.3 does not directly indicate that frequency and/or magnitude of floods would have increased in Ivalo River, but the return period of flood (i.e., the time between the two latest floods – 2000 and 2005) with high discharge values (>900 m^3/s) has been somewhat shorter than earlier. Figure 9.5 shows that in the Ivalo catchment area, mean January temperatures (a) and annual precipitation (b) have increased during the past 40–50 years (Finnish Meteorological Institute 2009). The flood level of the river is dependent on a balance between increased evaporation derived from higher temperatures and increased river discharge caused by increased precipitation. Higher temperatures may lead, not only, to delayed formation of permanent snow and ice cover in the fall (c), but also to more advanced and sudden snow

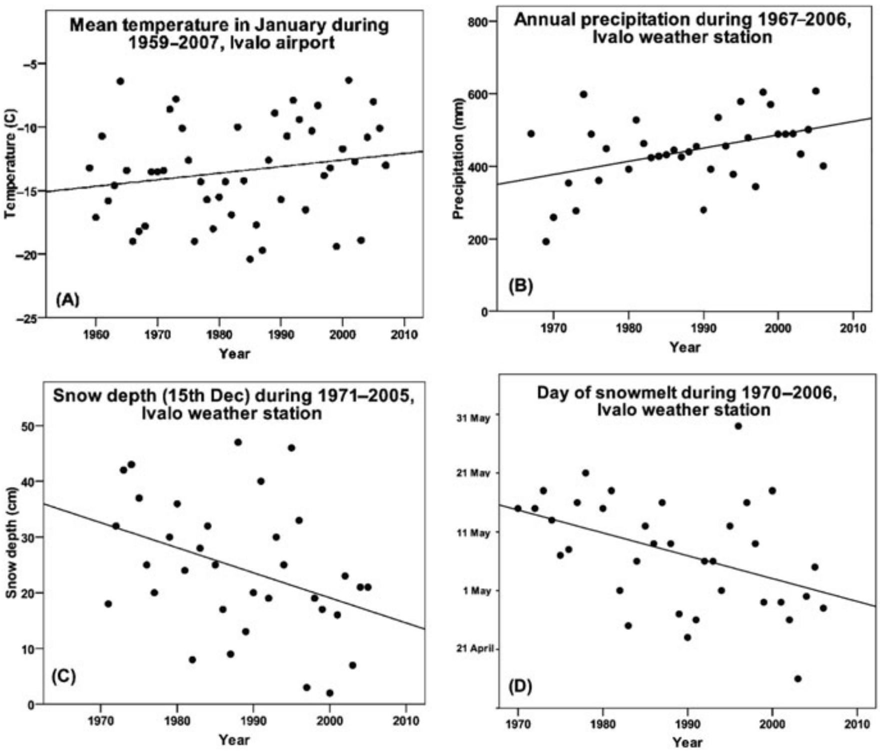

Fig. 9.5 Mean temperatures of January during 1959–2007 **(a),** annual precipitation during 1967–2006 **(b),** snow depth (15th December) during 1971–2005 **(c)** and the day of snow melt during 1970–2006 **(d)** in Ivalo, Finnish Lapland. *Source*: Finnish Meteorological Institute 2009

melt day in the spring (d), which may contribute significantly to the flood forming conditions.

In Northern Finland, the risk of floods is prevalent in circumstances in which there is a thick snow cover, late snowmelt and warm spring days with rainfalls and ice-dams (Suurtulvatyöryhmä 2003, 9; FINADAPT 2007, 18). Because of climate change it is estimated that the number of floods in every 20 and 100 years will rise by 10–20%, mainly due to increasing winter precipitation, in the next 20–100 years in Northern Finland (Tulvavahinkotyöryhmä 2006, 21, 48; Suurtulvatyöryhmä 2003, 9; FINADAPT 2007, 21). However, in the longer term, the level of flooding will decrease in Northern Finland (Tulvariskityöryhmä 2009, 51; FINADAPT 2007, 18). The scenarios indicate that flooding in Ivalo River will be similar in 2010–2039, and similar or slightly diminished in 2070–2099 when compared to reference periods 1971–2000 (Veijalainen et al. 2009a, b). In general, Northern Finland is considered to be an area with a potential for hazardous floods, but with low level of vulnerability because of sparse population (Schmidt-Thome 2005, 27).

9.3.3 Adaptive Capacity

Adaptive capacity is closely related to resilience, and reflects an individual's or community's ability to cope with, adjust to, or recover from an exposure-sensitivity. These processes are directly connected to community's planning or responding (see also Smit and Wandel 2006). In the Ivalo case, officially, the flood peak was recorded at the Pajakoski discharge measurement station somewhere after midnight, and early in the morning, on May 26th. The peak reached over 1,000 m^3/s (Karjalainen and Kämäräinen 2006). The Regional Environmental Centre reported the situation on the radio. There was a threat that the flood bank at the centre of the town Ivalo would not hold up should the flooding rise to meet the worst scenarios. However in that year, according to the Regional Environmental Centre, there was no such scenario threat, because there were no ice dams. With the flood current there was still 1 m left for water rise in the flood banks (Regional Environmental Centre 25.05.2005). Rescue organisations were made aware of the flood risk, but the locals were not aware of the situation because it was the middle of the night.

Eventually the flood came as a surprise early in the morning to the Ivalo inhabitants. Those who did not go to see the river, heard from the TV that people have to build the flood banks around their houses. The warning signs were already to be seen in Kuttura, a village around 80 km from Ivalo by the river, and 90 km by the road. These events are described in the dairy entry below (Vuojala-Magga 2010).

> 26 May, 2005. Early in the morning I went to see the river, water was just reaching the tops of banks. I went to see the old couple next door, they were still sleeping. I woke them up. Radio started to announce what to do. Mum phoned from Oulu (550 km

> away), and told me, that we should build up the banks around the houses, she saw this in TV. We all left for the main village to Maire, with Kaarina and Reija, just to see what is happening. The lorries were putting sand into the leaks of the bank by the bridge. Reija and me drove to the airport road, we were lucky to get back, road was just getting closed by water. People were following the situation, and in the radio they were told to get away from the dangerous bank areas...

When the highest peak of flood reached Kuttura village the previous evening of May 25th the only people who heard about it were the friends and relatives of Kuttura people. The alarming news spread through informal networks to Ivalo town. Kuttura people were correct, the early warning signs had already been seen a few days before. Until there were warnings in the national TV, it was rather difficult to comprehend the danger of the situation. People started getting together to hear the latest news in the centre of town, around the river banks, in Ivalo.

Two lessons can be taken from the 2005 flood. There was a strong prediction of flooding from Kuttura village few days earlier,which proved correct. The informal networks between some members within the local community were functioning. In the case of Ivalo flood, adaptive capacity is connected to delivery of information, communication and action. The actual flood information from the Regional Environmental Centre was accurate. The problem was in the proximity of the measuring station to Ivalo town. Once the high discharge peaks were measured, the flood had already reached Ivalo. In this sense the major flood came as a surprise for those who had not received unofficial information through informal networks. However, people gathered to the riverside and observed the changes in ice and water levels and exchanged their information about the flood situation in general.

The municipality decision makers had been aware of the situation: 'We were aware already a week before the flood /.../ though information failures had happened' (Male 2). There were criticisms regarding the communication and leadership. One of the officials commented: 'There should be a so called information bridge between the different officials /.../ there was once again obscurity about that who is allowed to act and who is not allowed to act. /.../ one shifts the responsibility to another – the environmental centre shifted the jurisdiction to the municipality and municipality shifted it back to environmental centre /../ the personal contacts are important' (Male 3).

The local decision-makers had to make fast decisions, too. Instead of the rescue organisation taking the lead, the head of the municipality with the administration took the charge of the rescue organisation. 'Our head of municipality came from Helsinki and he took the lead, he got the badge of merit from this' (Male 4). The head of the technical department organized the lorries to drive the sand to the leaking parts of the river banks. 'Each member of the administration worked with the small resources we had' (Male 5). Local administration was in contact with the border guards. Once the banks started to leak the boarder guards evacuated the old people from the Männikkö home for the elderly, nearby the river bank. ' /.../ we had 100 draftees whose holidays were postponed and they were ready to go, it was a rather big help' (Male 6).

In the Inari administration the native locals and young professionals from the south work together. Sometimes there are tensions between the two groups, because of a lack of trust due to different ways of communicating. There are still two ways of communicating; the traditional local face to face network and the modern professional negotiations. Briefly, this can be seen as a dissonance between two traditions, in which the former is based on the informal practical experience of personal intercourse and the latter could be defined rather formal, effective and professional. However, in the 2005 major flood, the traditional system of personal communication proved to be more successful than the modern technology dependent system.

In these kinds of crisis situations phone networks normally get overwhelmed, as was the case in Ivalo. Two fast decisions were made: first, the local radio received first hand information from the head of the municipality. Then, the local radio informed the community in real-time. Afterwards the radio commentator noted: 'There was this formal communicator, and the head of the fire and rescue services, head of the police, head of the border guards and finally we had our own agents, which gave us first hand information /.../ and from now on we are the formal part of crisis organization' (Male 7).

Also, lorry drivers, with the help of their radiophones (which operate on a different network to the phone lines), were able to communicate with each other whilst telephone lines were down. In this instance the drivers organised themselves independently to fill in the leaking breaks in the river banks. 'They were fully professionals, they had an open line in which they were shouting where the leaks were and the closest driver rushed to that place' (Male 8; see also Kurkela 2008, 9).

Finally, it was obvious that the local organization functioned as well as it was possible in these circumstances. Responsibility for action centred upon the local municipality administration. The head of the municipality took the lead with the help of the heads of different departments. The information between the local actors and media was functioning well, the only setback was the break down of telephone lines – so personal communication became essential. The local radio and the network system of local lorry drivers took over an active role in self-organization. What seems to be obvious in the process is that all the actors were native locals, the only exception being the head of the municipality, who was a professional from the South. The traditional communication system and the self-organized actors were in an important position during the break down of telephone lines. Also, the border guard was on full alert, so they could have assisted with further evacuation if needed. The response to the crisis situation was speedy. In our understanding, it was a result of a fast local decision-making and implementation in the community, despite the official rescue plans and responsibilities.

9.3.4 Current Adaptive Strategy

The Regional Environmental Centre provides information concerning flood management. As a result of the 2005 flood, a new measuring point for flood protection was established further down the river, by the hospital in Ivalo town. The Finnish Environment Institute's role is to conduct flood research, support regional authorities in flood prevention, supply tools for flood prevention and protection, and to conduct national hydrological monitoring and flood forecasting (Dubrovin et al. 2006).

The role of the state, however, is to financially support flood prevention and give compensation for flood damages. Lately, the financial responsibility for flood prevention has been shared between the state and the local municipalities. The state covers the expenses of building flood banks. The flood prevention and protection in Ivalo is based in technical solutions. Flood protection in Finland is based on a calculation that every 20 years there is a normal flood, every 100 years a major flood, and every 250 year a hazardous flood. The embankments have been constructed following these flood categories.

The municipality is responsible for maintaining the embankments for flood protection in Inari. Following the damage caused by the 1981 flood, local decision-makers resolved to build up protective banks in order to better secure Ivalo town. The banks were calculated to withstand a 50 year flood level. In addition, some single houses received their own flood banks. Subsequent to the flood of 2000 there has been a re-construction of the banks to ensure they could withstand a flood that is projected for 100 years. Altogether, 13 km of embankments were built on both sides of the river. Another technical solution is the use of ice saws. To reduce the likelihood of the formation of downstream ice dams, an ice saw machine, the first in Ivalo, was employed in late spring, after 1993 (Male 9).

9.3.5 Future Adaptive Strategy

Technical and informational solutions for flood protection are part of future adaptive strategies. These measures are planned taking into account the likelihood of major or hazardous floods in the future. Likelihood of certain size of flood can be expressed by a return period, which can be calculated by using statistical methods or runoff models (Dubrovin et al. 2006). However, the frequency of hazardous floods is difficult to predict: hazardous floods according to official assessment (Suurtulvatyöryhmä 2003; Tulvavahinkotyöryhmä 2006; Tulvariskityöryhmä 2009) could repeat themselves every 250 years.

In practice the floods do not occur regularly. They can follow each other year after year if conditions are unfavourable, according to local information. The future of flooding remains uncertain as one of the informants notes: 'The water will go somewhere and the people have interfered with the river and its normal flow, it can attack us by surprise, we will not know, but after the next big one we will know' (Male 4). However, the local informants have good 'flood memory'. Future scenarios accept that rivers, even without ice blockages, may cause a flood. The nature of spring floods could change as an outcome of climate change.

This suggests that there is a need to adapt to different kinds of changes and situations along the river and therefore, strategies should be made as flexible as possible. The improvement of adaptive strategy in response to increasing risk of flooding in the Ivalo river will require actions at various levels. Individually, the main flood threat is property damage. This entails that ultimately, the responsibility lies with the house owner and the house location. For most owners the best way to prepare for floods is to ensure they have adequate insurance. The existing insurance system is considered to be inadequate and therefore new insurance products should be developed by the insurance companies. (Lapin Kansa 28.5.05; 29.5.05; 3.6.05)

Locally, the role of the community decision-makers is central in future flood adaptation since the risk of flooding needs to be better incorporated into town and land use planning. There are number of technical measures that have been suggested as a solution to the flooding in the Ivalo River. These measures include raising the level of the embankments; the removal of the sand dunes in the river; building more flood banks; improving flood information and warning system; lowering the road; building a water reservoir in the upper stream and relocating the town. These different technical solutions to flood risk are known and debated locally. (Lapin Kansa 6.7.05; 4.1.06; 4.5.06; 24.5.07) There are sceptics about the adequacy of flood banks as a flood protection measure: 'I would have done the flood protection by using the delta area as a natural flood area /.../ the river is forced to flow in a narrow riverbed between to banks, so it is a very dangerous flood prevention' (Male 3). This view suggests a conclusion that because of the infrastructure, the community around the river is more vulnerable to flooding than before.

Also, the building of water reservoirs to help in flood prevention has been discussed as a regional measure (Lapin Kansa 10.3.06; 23.10.06). Regionally, the role of the regional environmental centre is important in providing flood maps, risk assessments and flood warnings. The European Union's Flood Directive (2007) requires member states to be better prepared for floods in the future. The directive requires the preparation of maps describing flood danger, damage assessments, and flood protection plans by 2015. Such preparations have been now started in Finland, including for the river Ivalo (Alaraudanjoki 2008; Halonen 2007; Karjalainen and Kämäräinen 2006).

Nationally, the state funds constructions such as dams and embankments, which are needed for flood prevention. The state also gives compensation for flood damages (Ollila et al. 2000; Suurtulvatyöryhmä 2003; Tulvavahinkotyöryhmä 2009). The compensation system needs to be adapted to the new conditions and national legislation needs to take better account of these new threats. Finland conforms to the EU regulations and the role of the municipalities in implementing those regulations is central (Lapin Kansa 20.9.06). The EU emphasis is on local risk evaluation and management. As part to it, there is also a need to increase the awareness of local inhabitants of flood risks and risk behaviour (Alaraudanjoki 2008; Peltonen et al. 2006; Tulvavahinkotyöryhmä 2009). The flood in 2005 taught the Ivalo inhabitants and the community that the river may flood for many different reasons. ‘Flood memory’, local knowledge about the river and its behaviour includes also recognition of different flood threats and capacity to deal with them.

9.4 Discussion and Conclusions

For inhabitans of the Ivalo town, the river is not only a river or running water in a simple sense, it is water in many variations – it has different formations of ice and snow, movements of flow and currents and highs. Even today the river is observed daily, especially during the times of weather changes such as autumns, springs and summer times by local habitants. The 2005 Ivalo river flood is a collectively experienced and debated topic in the discussion of climate change in Ivalo – as a ‘condition that is important to the community’ (Smit and Wandel 2006, 285).

According to the CAVIAR framework (Chapter 1) community is treated as a collection of individuals and families sharing a geographic space in the form of a town or village with its associated institutions. This interpretation of community includes all those who physically share the space for all or part of the year, regardless of diverse communities of interests, occupation, livelihoods, activity, locations and existence or lack of kinship ties. In our case, the role of the flood banks in flood protection and their maintenance is a lively discussed topic. There is no single voice for a community and it is not expected that all people within a community will have similar vulnerabilities. In the Ivalo case, the modern infrastructure has made the community and its people vulnerable to flooding.

In terms of exposure-sensitivity, the ice in the river does not behave like before.

No more does the ice ‘take-off’ in the spring times like before: ‘(Spring Ice) has run away, it has gone in secret, it has just melted in its position. /.../ It just melts bit by bit secretly’ (Male 4). Despite the local observations of changing environmental conditions, the local informants do not necessarily connect climate change and the changes in the river ice and its behaviour. They had noticed the diminishing and disappearing of steel-ice/black-ice and steel-snow (spring snow with extremely hard cover in the mornings).

Exposure-sensitivity is increased because of changing environmental conditions – traditional floods, related to ice-dams, still threaten the community, but also floods connected to precipitation, high water levels in snow together with fast warming are considered to be a new threat. The CAVIAR study (Chapter 1) focuses on the overall well-being or sustainability of communities and their susceptibility or vulnerability to changing conditions. The question of how the community is exposed and sensitive to climate conditions will define its vulnerability.

The question of communication is critical in thinking of adaptive capacity and strategy in Ivalo. Those local inhabitants with subsistence livelihoods have no time to organize or devise future strategies to avoid hazards. Instead of planning for the future, they adjust their daily life and activities with moderate changes, just as they have done before. This indicates that locals have immaterial skills of adapting to various changes, as long as it is not affecting their material prosperity. They have a good adaptive capacity but not adaptive strategies for planning their future. These people can hold their nerve in a crisis situation. Beside this they have a capacity for joint action without a foreseen practice because they mastered skills of coping with one another. Local people and their capacity to adapt in crises situations is a multifaceted issue. It depends on the capability of the local people to network and use their capacities to act together, and with the administration, in an unexpected circumstances.

In terms of adaptive strategy, from the perspective of local administration flexible strategies of adaptation are emphasised. Above all, administrators are not merely responsible for the welfare of the whole community, but they are also responsible for the execution of regional and national adaptation plans and strategies. Many of these professionals do not have such an access and time to adjust themselves to conditions where the locals live and act. This leads to the dilemma of two different systems of informative and practical action, which were evident in the Ivalo flood case in 2005, and the 'dilemma' avoided by letting the administration and locals organise in their own way. These two approaches appear to be important enabling the different knowledge systems held by the inhabitants of Ivalo to be connected together.

Interviews

Female 1. worker; Male 1. official; Male 2. official; Male 3. official; Male 4. official; Male 5. official; Male 6. official; Male 7. head of the local radio; Male 8. official; Male 9. technician

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6.7.05 Ivalojoki valjastettava.

4.1.06 Näverniemi mukaan Ivalon tulvasuojeluun.

10.3.06 Lapin liitto esittää tulvaveden ohjaamista tekojärviin tai suolle.

4.5.06 Ivalojoen tulvasta ennakoidaan kesyä

23.10.06 Vuotos vaihtoehdoksi tulvasuojeluun.

24.5.07 Ivalo suunnittelee suurtulvasuojelua.

20.9.08 Tulvariskien torjumisen valmistelussa ei saa viivytellä.

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Chapter 10
Climate Change and Institutional Capacity in an 'Arctic Gateway' City: A CAVIAR Case Study of Whitehorse

Ralph Matthews and Robin Sydneysmith

Abstract Throughout the north, the majority of residents live in sub-Arctic administrative centres south of the Arctic Circle. These 'Arctic Gateways' are critical administrative and service centres through which pass most goods and services to and from the Arctic. Although not Arctic communities in the strict sense, they still must deal with issues of environmental change such as melting permafrost, and threats from flooding and forest fires. While doing so, they also must cope with expanding economic development, tourism, and growing demands for services throughout the Arctic region. Findings are presented from a CAVIAR case study of adaption and vulnerability of one such 'Arctic Gateway' carried out in partnership with the staff and Council of the City of Whitehorse, Yukon Territory. The study is based on extensive, in-depth interviews with elected officials and senior and operational staff of the City of Whitehorse, as well as with representatives of the Yukon Territory Government (YTG), First Nations, inter-governmental bodies, and NGOs responsible for administrative and resource management throughout southern Yukon. We explore key decision processes, institutional linkages and relationships within the civic government structure of the City of Whitehorse as well as with other jurisdictions and levels of government, including two First Nations upon whose traditional territory the City is situated. We find that existing adaptive strategies regarding climate change reside frequently in the processes of decision-making, planning and organizational culture as they are applied in the context of other changes facing the City and Yukon Territory. Thus, we explore the processes by which policies, decisions and adaptive responses take shape in both routine and uncommon or surprise situations around key areas of civic concern related to infrastructure, public health and safety, land-use planning, emergency preparedness and the environment. The case study is linked to the City's ongoing Integrated Community Sustainability Planning process which

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provides the temporal basis for exploration of future changes and exposure-sensitivities as defined by various governance institutions. The focus on the application of governance as process and context provides a glimpse of the potential (institutional) capacity of Whitehorse to manage and cope with complex social-ecological changes taking place in the north now and in the future.

Keywords Whitehorse · Institutions · Governance · Gateway cities · Sustainability

10.1 Introduction: CAVIAR and Institutional Capacity

Invariably, images of the Arctic invoke the natural environment. The first peoples to live and succeed in northern regions did so by developing cultures and livelihoods closely linked with the patterns of nature and guided by the rhythm of ecological processes. The contemporary social landscape of the North is, however, predominantly urban. That is, most people living in northern regions of Canada and Alaska, as well as northern Europe, reside in small to medium sized cities and towns. These urban centres are the ‘gateways’ to the North for southern sojourners interested in resource extraction and tourism. Simultaneously they are ‘gateways’ to the south through which needed goods and services most frequently pass. What we find is that for the City of Whitehorse the most critical exposure-sensitivities arise from its relative isolation and dependence on the flow of fuel, goods and services from the south. The primary adaptive strategy under these conditions is to manage, and where possible reduce, this dependence through actions framed locally as sustainability.

Most Northern research on adaptation and vulnerability, especially in Canada, is concerned with smaller communities with populations of a few hundred inhabitants and focused at the household level on the processes by which people secure their livelihoods. In contrast, our study in partnership with the City of Whitehorse is a deliberate effort to look at a larger community and to examine current and future exposure-sensitivities, adaptive strategies and adaptive capacities in a heterogeneous urban setting. The application of the CAVIAR framework in this context shifts the focus from household livelihood strategies to processes of governance. First, while many Whitehorse residents have a strong affinity for the ‘wilderness’ and the image (if not the reality) of ‘living in a frontier town’ where at least some portion of household livelihood may be obtained from the land, most City folk work for a pay-cheque and buy the majority of their food at the supermarket. Second, the conditions of city life that are susceptible to disturbance are closely tied to the delivery of services, the maintenance of infrastructure and the viability of the local economy. Key exposure-sensitivities, therefore, lie in the delivery, safety and maintenance of services that range from garbage collection, sewage, water and the fire department to transportation, urban planning, and servicing the built environment. The stressors to which these exposure-sensitivities relate are a melee of social, economic, and environmental factors. The threat of climate change seems not to be imminent to City managers and yet increasingly potential impacts are being considered in a variety of planning contexts. Third, adaptive capacity in the urban environment resides largely with the elected officials and professional staff responsible for managing and maintaining civic services and functions. These are the persons who are charged with the task of ensuring that the challenges of exposure-sensitivities are met and overcome, whether that involves maintenance and emergency preparedness of City infrastructure or finding ways to manage their dependence on imported goods and fuel. On their shoulders rests the decisions that remain primarily at a household level in most smaller communities.

Our study of Whitehorse is thus a study of the decision processes, governance structures, and pathways of action taken by local planners, service managers and administrators to maintain civic functions and deal with changing conditions. Exposure-sensitivity, adaptive strategies and adaptive capacity in Whitehorse is very closely linked to the organizational and governance functions of the civic bureaucracy including both elected government and civic administration. Thus, by focusing on governance institutions at the civic and territorial level and on the social interactive processes that occur within them we find that adaptive capacity in the urban context flows primarily from what we call 'institutional capacity'. Institutions are a vital part of society's response and management of the diverse and varied effects of environmental change, especially as it interacts with and compounds other social and economic stressors (Adger 2003; Agrawal 2008; Berkes 2003; O'Riordan and Jordan 1999). Institutions, specifically governance institutions, are a vital component of adaptive capacity at the local level but also in coordinating and facilitating adaptations across scales (Vincent 2007; Young et al., 2008). Institutions provide pathways for local communities to access external resources from higher levels of governance and enable the distribution and implementation of such resources and services to constituents (Agrawal 2008). In other words institutions enable adaptation.

To facilitate our focus on institutions and on institutional capacity in particular, in this case study we investigate the elements of the CAVIAR framework (current and future exposure-sensitivities, adaptive strategies and adaptive capacity) in the City of Whitehorse through the lens of *new institutional analysis* (NIA) (cf. Hall and Taylor 1996; Portes 2006). On the one hand we ask what are the institutional dimensions of key exposure-sensitivities and on the other, and perhaps most importantly, in what ways do the institutions of Whitehorse enhance or retard the City's capacity to respond to and manage change. In so doing we concentrate on governance institutions within the City administration itself as well as in terms of its relationship(s) and interactions with other levels of government, First Nations and elements of the non-government and business sectors. In the process we hope to address how institutional capacity may be created through organizational structure and the interactive processes of governance (Yukon Bureau of Statistics 2010).

10.2 New Institutional Analysis (NIA)

During the final quarter of the 20th Century the accumulating evidence of global environmental change and recognition of increasing needs to both mitigate and manage the effects of human action on the biophysical world led to the emergence of the now almost ubiquitous concept of sustainability. The Brundtland Commission, in an oft quoted passage declared that, 'The real world of interlocked economic and ecological systems will not change; the policies and *institutions* concerned must' (WCED 1987, 9 emphasis added). This focus on institutions as the essential element of sustainability was partly responsible for a resurgence of theoretical and empirical work on institutions in the context of governance and management of global environmental change (ACIA 2005; Brinton and Nee 1998; IPCC 2007; O'Riordan and Jordan 1999; Portes 2006; Roland 2004). *New institutionalism* or *new institutional analysis* (NIA) first emerged in the 1960 and 1970s at a time when most explanations of the processes of social change and organization were dominated either by a focus on social structure or as the result of individual choice and action (Hall and Taylor 1996; Hotimsky et al. 2006). In this context, most analysis of institutions treated them as little more than a set of cultural norms that, in developing societies, served largely to constrain needed changes. That is, institutions were often regarded as little more than anarchistic holdovers of earlier cultural forms (Hall and Taylor 1996).

In contrast, through the last two decades of the twentieth century, there was a growing emphasis in economics, political science, history and sociology to see institutions from a more active, and inherently positive, perspective (Hall and Taylor 1996; Hotimsky et al. 2006). From this 'new' institutional perspective, institutions were seen as linking social organization and human action in important ways. In this context, a sharp distinction was made between organizations and institutions, emphasizing that institutions were largely the cultural and normative context in which behaviour within organizations was formed and both formally and informally regulated. Individual actions within organizations could be examined as inhibited or facilitated by the institutionally proscribed and/or expected norms of organizations. That is, institutions were seen not only as *resulting from* behaviour, but also as *shapers of* behaviour (Hallett and Ventresca 2006; Portes 2006). Behaviour in organizations could now be examined in terms of whether the institutional normative relations allowed actors to be flexible in response to new challenges, or constrained them to face new situations in largely prescribed ways that allowed little flexibility and social innovation. By the end of the millennium new institutionalist perspectives were increasingly influential in diverse fields concerned with social-ecological interactions, from explaining the human causes of global environmental change, to providing viable options for resolving the seemingly intractable challenges of managing the commons, and identifying options for societal response (Dietz et al. 2003; Hotimsky et al. 2006; Ostrom

2005; Young et al. 2008). In 2009 institutional scholarship received international recognition with the award of the Nobel Prize for economics to Elinor Ostrom for a body of work with many links to new institutionalist thinking and perspectives.

While it would be a mistake to think of new institutional analysis as a unified body of theory (Hall and Taylor 1996) the linkages between the strands of historical, rational choice and sociological institutionalism compliment more than they contradict each other (Brinton and Nee 1998; Hall and Taylor 1996; North 1990; O'Riordan and Jordan 1999). That said, our investigation of governance institutions in Whitehorse aligns primarily with sociological institutionalism, a reflection of our preference for a broad definition of institutions and a focus on the interplay between institutions, culture and individual behaviour (Brinton and Nee 2001; Hall and Taylor 1996).

Institutions include the accepted practices and procedures which facilitate and legitimate action, frequently described as, 'the rules of the game' which provide common ground for enacting (North 1990). They provide a symbolic blueprint for organization including sets of written and informal rules which govern relationships between individuals and groups (Portes 2006) which hold society together and enable it to adapt (Adger 2003; O'Riordan and Jordan 1999). Clearly institutions are not static rather, like other elements of society and culture, they are subject to dynamic processes including the influence of individual and collective action over time (Hallett and Ventresca 2006). We assume that adaptive capacity is realized through (Adger 2003), grounded in and constrained by (Berkes 2003) governance institutions and therefore, that in the context of changing conditions institutional flexibility is a desirable feature. Flexible institutions enable the modification of environmental governance in order to minimize situations of risk to economic livelihood and human well being (Hotimsky et al. 2006), and in this respect enhance adaptive capacity. New institutional analysis provides a conceptual approach to examine both the processes and structures of governance institutions within the City of Whitehorse and within other social institutions with which the City interacts including the Yukon Territorial Government (YTG), local First Nations and Non-governmental organizations (NGO's).

In order to elucidate the concept of institutional capacity in the City of Whitehorse and relate this to the overarching framework of the CAVIAR project we focus on the features and attributes of specific institutional forms and how these might facilitate or block effective responses to change or risks. We begin in the following section with a sketch, or institutional mapping, of the origins and current characteristics of key bureaucracies, and agencies which provide the organizational home for relevant governance institutions. Subsequent sections are organized around the core elements of the CAVIAR framework and we conclude with a discussion in which we attempt to synthesize the challenges and issues of governance in Whitehorse in the context of changing social, economic and environmental conditions.

A Brief Note About the Whitehorse Case Study Research Design and Method

We have attempted to operationalize the concepts presented in this paper through a series of meetings, interviews and conversations we have held with a wide range of individuals from both within and outside of the civil service of the City of Whitehorse and the Yukon Territorial Government. The core interviews were completed with elected and un-elected civic officials from various departments and levels of responsibility within the public administration of the City. Several interviews were also conducted with members of the Territorial government with responsibilities ranging from resource management and environment to water, emergency preparedness, infrastructure, community and economic development. Additional interviews were carried out with representatives from the non-government and private sectors. These interviews were guided by a schedule of questions designed to explore (i) workplace role, relations and organizational culture, (ii) decision making processes in both routine and non-routine contexts-including consideration of both formal and informal rules, protocols and practices which lie behind decisions and (iii) issues of capacity in relation to both current and anticipated challenges related to socio-economic and environmental change.

In addition to formal interviews we have had informal meetings with federal government representatives, former employees of the City and YTG and representatives of two aboriginal communities within whose traditional territory and treaty lands the City falls. These informal meetings provided background knowledge and understanding and helped us to identify themes and frame questions for the interview schedule. Additional context, background and clarification of institutional structure, rules and protocols was gleaned from a review of numerous supporting documents made available to us by respondents including various government reports, planning and policy documents, environmental and economic reports. Finally, we also participated in two City led planning processes including a large Integrated Community Sustainability Planning conference and a smaller expert workshop to develop community based climate change scenarios designed to feed into a broader community climate adaptation planning process.

10.3 The City of Whitehorse: Community and Governance

The City of Whitehorse is situated in the southern portion of Yukon Territory along the banks of the Yukon River a short distance downstream (north) of the former White Horse rapids from which the City took its name.[1] The City straddles the traditional territory of the Kwanlin Dün, the ‘people

[1] These once iconic rapids now lie behind the Whitehorse Dam, beneath the still waters of Schwatka Lake. To the north the City is bounded by Lake Laberge made famous in the poetry of Robert Service.

of the rapids' and the Ta'an Kwäch'än, 'people of the flat lake place'. In its early colonial history the City functioned primarily as a service centre, especially during the Klondike Gold Rush of the late 1890s when it was a major staging ground and replenishment destination for miners bound for the gold fields around Dawson City. Whitehorse became the capital of Yukon in 1953 (Fig. 10.1).

Today the City of approximately 26,000 residents is home to three-quarters of all Yukoners. In many respects Whitehorse sits uncomfortably between being urban but not like cities in the south and being northern but unlike the rest of the 'real' Yukon. The residents of Whitehorse are both dependent on and accustomed to many of the urban attributes and services typically associated with cities in the south. A very large portion of the workforce is employed in the public sector which provides a level of income and security befitting a 'middle-class', professional city, although Whitehorse residents might bridle at the

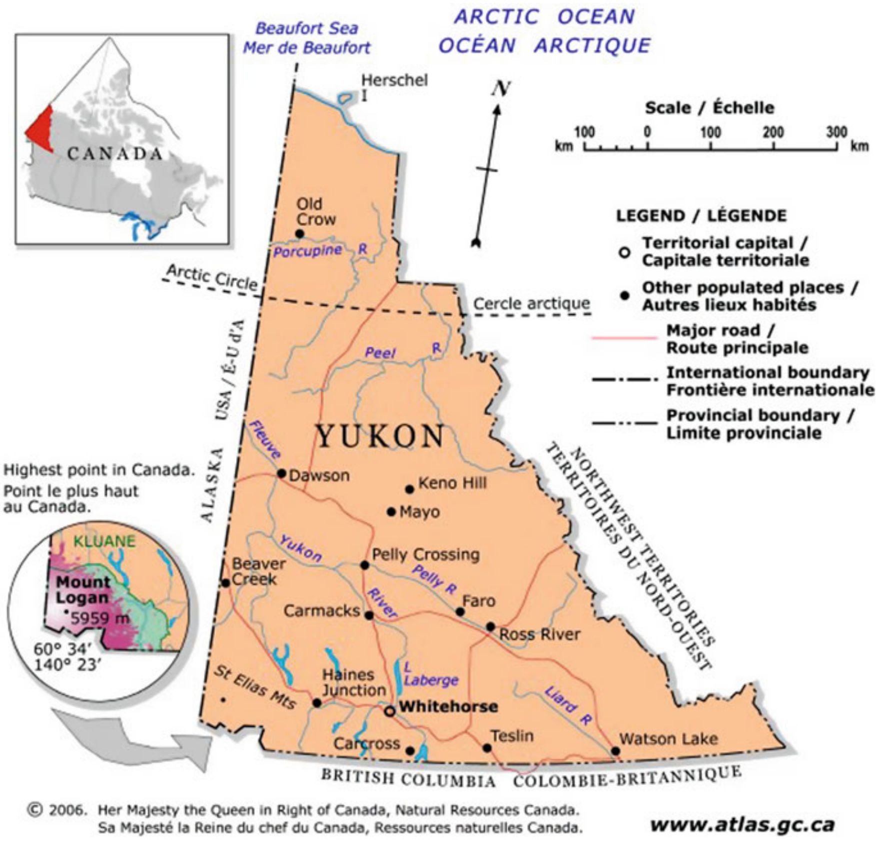

Fig. 10.1 Yukon Territory showing location of City of Whitehorse. *Source*: Atlas of Canada 2006. Accessed online, April 27, 2010. URL: http://atlas.nrcan.gc.ca/site/english/maps/reference/prorinceterriteries/yukonterritory/referencemap image view

'yuppy' connotations of such a label.[2] There is a vibrant arts community and non-government sector, hip coffee houses dot the down town core while big box stores and familiar corporate logos underline the City's gateway function between north and south. Demographically the City is young although in line with demographic trends across the country the median age is increasing over time. Relative to other cities in Canada there is a high rate of turn-over in the population especially among young and middle aged professionals, although several interviewees suggested that this might be changing.

With a land base of roughly 415 km^2 Whitehorse is, per capita the largest city in Canada. This expansive urban land base has precipitated development of exceptionally large lots, often with sizable tracts of wooded area in between. These so-called 'country residential' subdivisions help define Whitehorse as a 'wilderness city', where the spirit of the frontier, a mentality of independence and living close to nature, merges with values and expectations of urban life. Lately there is an increasing desire, especially on the part of City planners, to pursue 'infill' development of some of the large tracts of green space in between subdivisions. This movement toward denser urban planning stands in stark contrast to the almost iconic status of 'country residential' lots and exemplifies the tension between apparently contradictory pro-environmental cultures in Whitehorse (Fig. 10.2).

The City is incorporated under the municipal Act of Yukon Territory and has a typical governance structure comprised of an elected mayor and council and a professional administration. It is organized into two functional areas, Administrative Services and Operations, each headed by a director reporting to a senior bureaucrat: the City Manager. The administration side manages City's finances, human resources and some community service functions such as bylaw enforcement. Operations handles the physical functions of the City including engineering, planning, maintenance, parks and recreation, and the fire department. Recently senior staff have been looking at reorganizing the City by (re)creating a third director's position to help manage the City's increasing size and complexity.

An investigation of the institutional capacity of Whitehorse would be incomplete without an understanding of institutional structures and processes at the Territorial level. Interaction and relations between the City and the Territory are intensified by the presence of 11 of the Territory's 19 electoral ridings overlapping or falling within the City limits. Eleven MLA's (Member Legislative Assembly) in representing their constituents have direct personal and political interest in the affairs of the City. The Legislative Assembly is situated in Whitehorse and the Territorial government is also a major property owner of City lands. Interests and objectives between City and Territory are clearly intertwined and influence how civic governance institutions change and develop over time. The institutional environment has been

[2] At the time of writing employment statistics for the City were not available, however, a monthly report produced by the Yukon Bureau of Statistics for the Territory as a whole provides a useful proxy. Public sector employment in the Territory is substantial and over the past fifteen years has been increasing from 37% of total employed to almost 42% of the labour force in 2009 (Yukon Bureau of Statistics 2009).

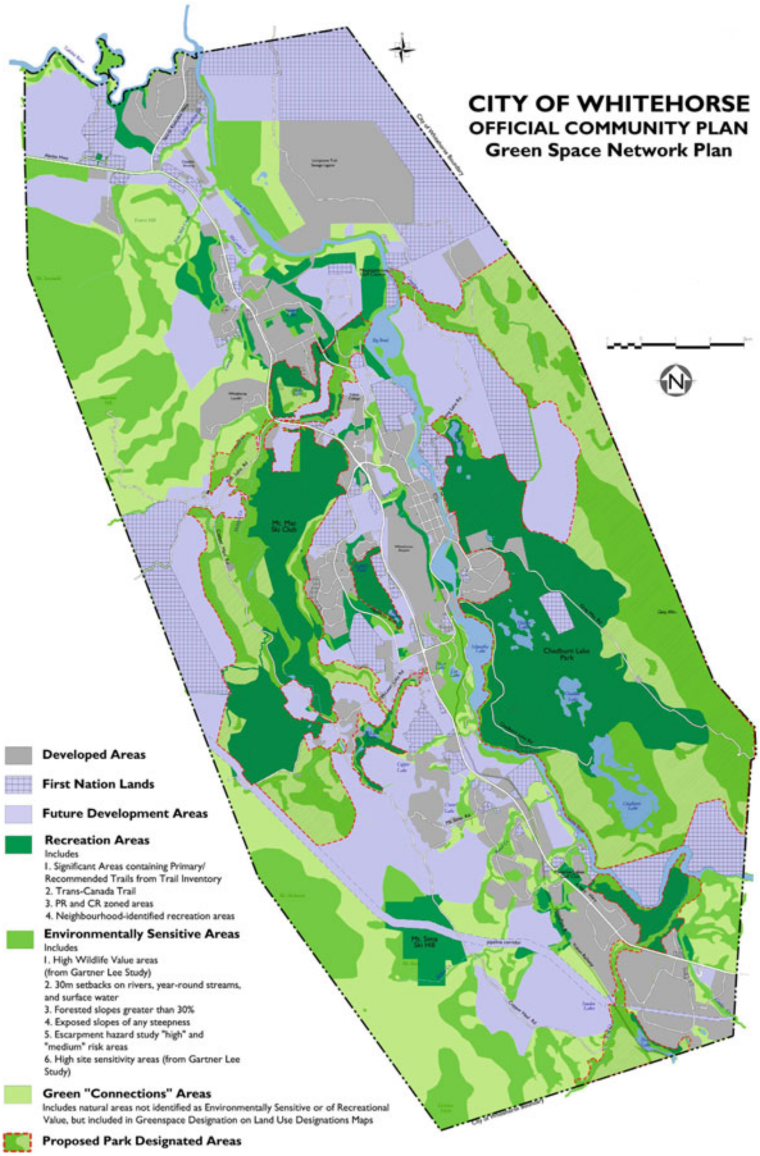

Fig. 10.2 City of Whitehorse. *Source*: City of Whitehorse Official Community Plan 2002. Accessed online, April 27, 2010. URL: http://ww3.whitehorse.ca/Planning/OCP/2007%20OCP%20web.pdf

especially fluid in recent decades due to the transformation of Territorial governance through the process of devolution. This formal shifting of responsibility for governance of Yukon from the federal to a nascent Territorial government is a key feature of contemporary institutional fluidity and change.

Up until the 1970s Yukon was governed by a Commissioner appointed by the Department of Indian and Northern Affairs (DIAND). Over time the local political and economic elite in Yukon grew weary of the quasi-colonial relationship with the appointed Commissioner and the remote federal interests he represented. By the late 1970s the political and institutional basis for a devolution of power was in place and subsequently initiated by and Act of Parliament of the Joe Clark government in 1979 (MacDonald 2008). Throughout the 1980 and 1990s extensive negotiation centred on the transfer of federal responsibilities, especially with respect to natural resource management and revenue sharing. These were formalized through a number of agreements and amendments to the Yukon Act which have led gradually to the emergence of new governance institutions and capacity in the Territory.

During this same period, Yukon First Nations were actively and increasingly engaged in negotiating self-government and settling outstanding land claims (MacDonald 2008). In 1993 the Umbrella Final Agreement (UFA) was signed between the main representative of Yukon First Nations (the Council of Yukon First Nations, CYSN) and the federal and territorial governments. The UFA sets out the framework for individual First Nations to negotiate final land claims settlement agreements. In 1998 the first formal agreement on resource revenue sharing, the Yukon Oil and Gas Accord (YOGA) came in to effect and later that year the Devolution Protocol Accord was instituted. The latter, signed between Yukon First Nations, YTG and the federal government provided the formal process for the transfer of control over natural resources, public lands, and water. These powers were solidified through amendment of the Yukon Act (2002) which established several key pieces of legislation including the Yukon Environmental Assessment Act (Government of Canada 2002; MacDonald 2008).

The process of devolution continues to unfold in the Yukon, as individuals and organizations attempt to understand and implement new powers and responsibilities. Despite its large population in comparison to other Yukon communities and distinctly different relationship with the Territorial government, Whitehorse is governed by the same legislation, the Yukon Municipal Act. As will be seen below this creates both opportunities and barriers for the City in how it manages its own affairs, how it operates within the broader context of the territory, and how it copes with and responds to change.

10.4 Exposure-Sensitivities in a Subarctic Urban Context: Past, Present, Future

The exposure-sensitivities of a subarctic city such as Whitehorse are often the outcome of a combination of biophysical and human conditions. In this case study of Whitehorse the focus on governance institutions provides a window into how the City experiences exposure-sensitivities, especially from the perspective of those in various positions of responsibility for City lands, resources, infrastructure and services. The vulnerabilities that arise from, or are linked to, the impacts of climate change are best understood in the context of a more fundamental set of conditions that shape the City’s vulnerability to change and stress. Two of these fundamental conditions are linked to the City’s relatively remote geographic location while a third relates to Yukon’s economic history.

From the perspective of City managers and others the City’s location is *the* key underlying attribute of how vulnerability is understood and responded to. First, the City is dependent on imported commodities and energy which are vital to support the way of life of the citizenry and the many functions and services delivered by the City. This exposure-sensitivity stems directly from the relative isolation of Whitehorse from the south of Canada. Major distribution centres such as Vancouver, British Columbia and Calgary, Alberta are well over 2,000 kilometres away along what for large stretches are only two lane highways. Other than air transport the only alternative link to the south is westward along the Alaska Highway through the coastal town of Skagway.[3] The dependence of contemporary goods movement on truck transportation means that Whitehorse is exposed and sensitive to disruption of road transport links to the south, but also to closures along the major east-west linkages between Vancouver and Calgary/Edmonton. Disruptions as far away as Rogers Pass in British Columbia have been felt in only a few short days in Whitehorse as supplies of certain goods, especially perishables that arrive almost daily, dwindle rapidly. Some officials in Whitehorse note that the existence of the port in Skagway reduces somewhat the City’s vulnerability to such interruptions. A potentially greater threat is the exposure of Whitehorse to fuel shortages during the winter months in particular when Yukon River levels are too low to enable the Whitehorse hydro power facility to produce enough electricity to meet City requirements. The City depends on large diesel generators to provide supplementary and emergency power supplies to augment the dam. Currently the territorial government which operates the dam only has the capacity to keep enough fuel on hand to keep the generators running for a few days in the event of a complete failure of the dam.

The second exposure-sensitivity arising from the City’s remoteness is the increased expense associated with any good or service brought in from the South. City and YTG officials argue that the additional cost burden is significant and influences the decision-making calculus in both the public and private sectors. For example, the ‘cost’ of being dependent upon southern imports is a key feature of discussions of long term, community sustainability planning. City managers see strong linkages between dependence on imported energy, the

[3] The historic jump off point for thousands of miners bound for the Yukon during the Klondike gold rush of the 1890s. Skagway now boasts a deep-water port built to accommodate large cruise ships drawn by the rich cultural and natural history of the area.

vulnerability this creates in terms of both cost and security of supply and adaptive strategies that feature conservation and efficiency measures.

A third condition that shapes the City's vulnerability to change and stress is Yukon's economic history which has been punctuated by the boom and bust cycles of resource development. As recently as the 1990s, Yukon has experienced abrupt declines in population, usually as a result of mine closures. Whilst these closures obviously have their most profound effect on the particular mining town in question, there are numerous direct and indirect impacts on Whitehorse where many support services and mining related subcontractor businesses and suppliers are located. The most recent period of growth that Whitehorse has experienced in the last decade has given some residents reason for quiet optimism that the era of extreme boom and bust may be behind. Although a careful analysis of whether or not this might be the case is beyond the scope of the current case study our interviews suggest three primary reasons behind this sentiment. First, such optimism is based on the perception that devolution has brought with it an expansion and potential stabilization of civil service jobs. The transfer of jurisdictions from DIAND to YTG saw many former federal employees keep their jobs, even their job titles and offices. Many reporting structures remained in place and, at least to begin with, changed only in name. Previously federal public sector jobs were susceptible to high rates of turn-over as people sought different career advancement opportunities within the federal civil service. Although with the transfer of most of these federal jobs to the Territorial government employee movement is now less likely to take people out of the Territory the loss of skilled people remains a challenge for the City. Governance institutions, as noted above, are more than the organizational structures and regulatory frameworks which hold up the bureaucracy and keep the public sector operating. Institutional memory resides primarily in the minds of individual actors. As such, City leaders are acutely aware of the vulnerability that is created when a key person is drawn away by an opportunity in the south. The second reason that some Whitehorse residents believe that economic cycles in the territory are likely to be less severe in the future is linked to the diversification of the Territory's economic base, principally in connection to the expansion of the tourism industry. Third, it has been widely speculated that a warmer Arctic may offer a host of economic development opportunities most notably in resource extraction and marine transportation (ACIA 2005). Milder conditions are conducive to a longer and more manageable mineral exploration season and according to some may be at least partially responsible for the recent upswing in resource development activity. More exploration is assumed to lead to more mine development and a net positive benefit for jobs and the economy in Yukon. In fact some interviewees claimed that one potential challenge to which Whitehorse will be exposed is to manage increased growth and development in the future, not only from increased mining activity but also potentially from expansion in forestry and agriculture opportunities or in the event that Whitehorse becomes a desirable destination for climate refugees from other parts of the globe.

Other exposure-sensitivities in and around the City of Whitehorse that are or may be linked to the impacts of climate change include City infrastructure and maintenance procedures, water supply, quality and management, and emergency or disaster risk and response (Lipovsky and Huscroft 2007). Many of the specific direct and indirect climate impacts of potential concern have been summarized recently in large assessment reports such as the Arctic Climate Impact Assessment (ACIA 2005) and the Northern chapter of the federal report, ‘From Impacts to Adaptation: Canada in a Changing Climate’ (Furgal and Prowse 2008). The City has also recently commissioned a summary report of past trends and projected changes in the hydro-climatology of the Whitehorse region (Werner and Murdock 2008) which takes a more focused look at specific climate effects on the City and its immediate environs. According to these studies, several parts of the city are at some risk of flooding from heavy precipitation, or from the formation of ice dams on the Yukon River during winter warm spells. This has occurred recently, although no clear connection with climate change has been confirmed. Conversely warming continues to cause shrinking of the glaciers and ice fields that feed the headwaters of the Yukon River which may ultimately effect hydroelectric potential for the city and possibly diminish energy security in the future (Church and Clague 2009; Janowicz 1994). ‘Rural residential’ areas both within and immediately adjacent to the city are often not on city water system and will be vulnerable to impacts on domestic water supply from various factors including climate change. The built environment, especially critical infrastructure such as roads and the Whitehorse International Airport are at risk of higher repair and maintenance costs from the damage and wear that arises from more frequent freeze-thaw cycles that accompany milder winters. City maintenance managers also report increased costs associated with removal of heavier, wetter snow and greater road salt usage.

The large tracts of urban and semi-urban forest land within and immediately adjacent to Whitehorse City limits means heightened exposure and sensitivity to the risk of forest fire and other vegetation and ecosystem impacts such as changing wildlife patterns, invasive species and pest outbreaks. Wild fire risk in particular is a public health and safety issue as well as a threat to property, infrastructure and recreation opportunities. The fire season in the Whitehorse region is expected to increase on the order of five to eight weeks according to some climate models (Werner and Murdock 2008). Pest outbreaks greatly increase the availability of fuel such as has occurred with the current outbreak of spruce bark beetle which has affected tens of thousands of hectares of spruce forest to the west of Whitehorse in the area of Haines Junction and the traditional territory of the Champagne Aishihik First Nation (Ogden and Innes 2008). Finally, the orientation of the City along the Yukon River valley and in relation to prevailing winds and weather patterns further heightens the City’s exposure to wild fires.

The context of exposure-sensitivities in the City is dominated by the unique urban culture of Whitehorse which combines elements of southern, urban lifestyle expectations with the desire to live close to nature in what we refer to as a gentrified wilderness setting. The context for understanding exposures-sensitivities that face Whitehorse, according to many of the respondents in this case study, are the risks and vulnerabilities related to isolation and the heightened tension this creates between the need for self sufficiency, the high cost of fuel and both the heavy dependence on and high (urban, cultural) expectations of availability of commodities and services which emanate from the south. There are numerous exposure-sensitivities that will challenge future leaders and citizens of the City of Whitehorse. Many of these challenges relate to the City's unique and prominent role in the Territory at large (e.g. urbanization pressures, managing development and sustainability expectations among an informed and active populace, managing potential economic boom and associated environmental stewardship demands and expectations associated with anticipated resurgence of the mining industry), others relate to environmental changes related to projected changes in climate and relate principally to infrastructure safety and maintenance, water and water management, landscape hazards, energy and increasing costs. No matter the nature or scale of specific types of exposure-sensitivities that the City will face there is sure to be a variety of them and in turn, this will elicit an equal if not greater variety of responses.

10.5 Sustainability as a Context for Adaptive Strategies and Capacity

Under the broad and inclusive definition of exposure-sensitivities taken in the CAVIAR approach adaptive strategies are part of the established practice of local government, adapting and responding to change is simply part of good governance. In this study it is important to start with the understanding that the City of Whitehorse has always been engaged in the ongoing task of developing and implementing adaptive strategies, that is, managing and responding to natural hazards, economic cycles, social and environmental change. Adaptive strategies have taken place in the past, are actively engaged in the present and will take place in the future. While it is difficult to point to specific instances and be able to say with certainty that a particular action was an adaptive response to an impact of climate change it is possible to see examples of adaptive strategies in various actions and plans. In most cases such strategies are embedded in broader responses to what are frequently multidimensional problems. For example, the exposure-sensitivity of Whitehorse to wild fire discussed above will likely increase with climate change and in some respects is already heightened in those parts of the southern Yukon affected by the spruce bark beetle (Ogden and Innes 2008). 'FireSmart' practices which already exist and are encouraged by government officials, involve such measures as clearing vegetation from building perimeters and limiting the buildup of brush, deadfall and other sources of fuel on both private and public property. Certainly these steps would reduce fire risk but 'fire-smarting' is expensive and the responsibility of the property owner so tends to be carried out on an ad hoc basis. On City property the practice is carried out only as needed and must be balanced off against other priorities. The Forestry Department of the Yukon Government, with a much larger forest land-base to manage, understandably has a more comprehensive approach and responsibility for forest management, including fire management. There has also been a long-standing interest primarily in the southern region of the Territory, to develop a forest industry. Although the small size of trees and long distance to markets have generally limited the viability of this idea. Recently however, the volume of dead and dying timber affected by the bark beetle has added an extra incentive to manage fuel build up in sensitive areas, for example near to parks or housing subdivisions. Although currently there does not appear to be much in the way of formal emergency preparation or other adaptive strategies to contend with the increased threat of forest fire officials in both the City and Territorial governments report excellent communication lines and informal cooperation and coordination procedures.

Transportation infrastructure is similarly an area of ongoing planning, engineering, maintenance and budgetary concern for the City. At the moment the strategies for dealing with increased snow removal and road salting needs are made at the operational level, using existing resources. Snow removal and road clearing for example, can raise a number of issues that challenge the capacity of the City to adapt. Heavier snowfall means more frequent road clearing and increased build up of snow banks along roads, especially in front of driveways. It also means higher costs. Whitehorse has not typically received a large accumulation of snow in winter meaning that roads could be ploughed and snow left along the sides to melt in the spring. Citizens have been expected to clear the banks of snow from their own driveways; however, this becomes more difficult or impossible for some property owners under heavy snowfall. If too much snow accumulates along the sides of city streets it must be collected and trucked away at considerable expense. Environmental regulations prohibit dumping snow in rivers or water ways so storage is also an issue. A seemingly mundane issue quickly compounds to put a strain on physical and financial resources available to infrastructure maintenance.

In discussions with various managers, planners and administrators climate change was not generally identified as an immediate threat or risk for which there could be specific planning. There is awareness of the issue and many within both the City and Territorial government expressed interest in and a need to learn more about what sorts of climate change impacts might be relevant to their particular area of responsibility. The more substantive finding from this research, however, is that the response to both general vulnerabilities and to specific climate change impacts are more closely identified with reduction in fossil fuel dependency and general sustainability preparedness. In the urban context of Whitehorse adaptation and mitigation are not considered discreet categories of response to climate change. Rather, interviewees consistently conflated adaptive strategies and mitigation under the banner of sustainable development. One of the principal goals of sustainability for City managers is to reduce the level of dependence on fossil fuels, whether for vehicles, power generation or heat which is imported from the south at considerable cost. In this sense, sustainability has economic security and environmental benefits, both of which are, at least implicitly, adaptive strategies to the most notable exposure-sensitivity identified in the preceding section, that is, isolation and dependence on imported fuel and other goods and services. Adaptive strategies in the context of exposure-sensitivities and related risks are centred primarily on ensuring strategic preparedness in the face of sudden shortage and reducing fuel costs. When asked for specific examples of climate change responses interviewees referred to steps taken to ensure that all existing and new buildings and equipment were fuel efficient and 'as sustainable as possible'. These were described as 'the right thing to do for the environment' but also as adaptive strategies to contain costs and address vulnerabilities from climate change and remoteness. Similarly, an ongoing project to replace existing traffic lights with energy efficient light emitting diode technology (LEDs) is a strategy to save energy and money, seen on one level as a mitigative measure (i.e. energy demand) and on another as an adaptive strategy to reduce operation and maintenance costs for the City.

City Administrators are generally confident that they have sufficient human, social and economic resources to manage most of the anticipated impacts of climate change, at least in the short term. Current adaptations are primarily spontaneous and unplanned although the administration and citizens of Whitehorse are proactive about sustainability and already focused on climate change issues. The City has embarked on a comprehensive planning process to create a sustainable development strategy that includes greenhouse gas emissions reductions and some climate change risk management. The latter is also being considered in a community adaptation planning process which seeks to engage local stakeholders, including citizens, community organizations and local government to develop community-based, qualitative scenarios of the future under different conditions of socio-economic and environmental change, including identification of key climate change risks and adaptive strategies. Institutional adaptive strategies and capacity therefore, are a combination of institutional structure and interactive processes that facilitate response. These include a culture of awareness, a recognition that something is (or could be) affected and are characterized by the social processes that allow response. Principal among these is the strong desire to be sustainable which has emanated from the confluence of changing social values and political leadership and opportunity afforded by funding available through federal gas tax money to carry out sustainability planning. In the context of sustainability, mitigation of climate change by reducing dependence on fossil fuels through efficiency, conservation and alternative sources of energy is seen as the most pressing and viable response. This also ends up being the key adaptive strategy to the vulnerabilities that arise from the City's dependence on imported goods, services and fuel. In other words, because of its isolation and fossil fuel dependency, a focus on mitigation reduces costs related to fuel consumption, which results effectively in a strategy to address both general vulnerability and climate change vulnerability.

Another key adaptive strategy example – what local planners identify as sustainability in practice – is the City's approach to urban planning, in particular its emphasis on strategic increases in density and location considered by staff and elected officials to be not only sustainable, but 'mitigative, strategic, cost-effective and adaptive'. For some time now the City planning department has been a strong advocate of so called 'infill development' where new subdivisions are planned deliberately to fall within green spaces between existing developments. This makes sense from the City's perspective on a number of levels as 'densification' is regarded as a key strategy to reduce costs around the installation, delivery and upkeep of City infrastructure and services. As such it is a current adaptive strategy that will also enhance the future adaptive capacity of the City.

The City's forward thinking and proactive approach to development is an outcome of recent transformations in the civic institutions of governance which have come about as a result of two relatively recent developments in how the City approaches its mandate. First, over the past 10-15 years leadership within the City administration has sought to rework bureaucratic processes and procedures, in part to control rising costs at a time when the City's population was in decline.[4] Driven by senior civic bureaucrats the organizational structure and culture of the City was transformed through the introduction of a more strategic, planning-based and policy-driven model of decision-making. Formerly City affairs were governed in a more ad hoc manner with numerous and largely unaccountable citizen committees and a limited long term planning horizon. The changes that were brought in formalized the separation of elected and non-elected officials and helped to rationalize many dimensions of civic governance in Whitehorse. Although, there was some initial resistance within the populace to the loss of a more personalized form of governance where social capital and relationships had more influence on local decision making (Matthews 2003), interviewees both within and outside the City administration saw this 'professionalization' of civic structures and processes as a positive development and maturation of governance institutions which changed the culture of the way things were done. The catalyst for institutional change in this case was leadership, but institutional processes seem to have changed quite readily, perhaps in part due to the highly fluid institutional and governance environment of Yukon and Whitehorse that has existed during the ongoing period of devolution.

A second, and more recent transformative development is the opening up of many planning and decision-making processes through a rapid and dramatic increase in community outreach and consultation in numerous types of planning and decision-making forums. The City has a vocal and active citizenry, which has now been afforded opportunities and formalized processes for input into numerous planning decisions through the use of 'charrettes', focus groups and workshops. For example the administration and operation of the City is

[4] In the wake of the closure of the Faro mine in 1997 (Yukon Bureau of Statistics 2009).

increasingly guided by the City's Official Community Plan (OCP) which is currently undergoing its second five-year review with extensive public input. The City has also undertaken an Integrated Community Sustainability Plan (ICSP) process that went through several stages of public involvement including a three day 'charrette' which engaged almost 200 people including City officials, residents and a variety of stakeholders and experts with a in an interactive three day visioning and planning exercise to help inform the development of the City's Strategic Sustainability Plan. While these processes are still subject to criticism from citizens for either not being accessible enough or for tending to attract and therefore represent the views of special interests, the same people or groups, according to many interviewees the process is sufficiently open and inclusive that non-participation is considered a matter of choice and not exclusion.

In both cases the formal and the informal 'rules of engagement' have changed. Planning and decision-making processes are more structured, some would argue more bureaucratic, but at the same time more democratic and less prone to corruption. Management and staff see the City's public service as competent, professional and forward looking. The City employees that we interviewed were almost universally confident and optimistic about the capabilities and proficiencies of themselves, their departments and the City administration as a whole. In other words, the view of most City officials and managers is that Whitehorse has a high degree of adaptive capacity and as a result is well positioned to cope with and manage specific vulnerabilities.

These processes of institutional change, which are more often theorized than observed, have taken place in Whitehorse as a result of both intended and unintended decisions and interactions. Whatever the suite of future challenges and risks that face the City of Whitehorse, it is clear from interviews and participation in several public events that the capacity to respond and effectively manage these challenges is considered by residents and leadership alike to be quite strong. Many of the assumed attributes or 'determinants' of adaptive capacity appear to be in place: financial, human, technological and social capital resources. Furthermore, the structures and processes that define current governance institutions in the City appear flexible and able to adapt to change. Institutional flexibility is increasingly identified as a critical attribute of adaptive capacity (Hotimsky et al. 2006), especially in the context of anticipated social, ecological and economic changes expected under long-term climate change. This study also illustrates the importance of transformational responses such as the explicit pursuit of achieving sustainability as both a feature and a goal of institutional capacity. Whether or not sustainability is too vague as a policy or planning goal it facilitates an explicit conversation about climate change adaptation and mitigation and allows for their formal inclusion into long range planning. Given that planning, especially in an urban development and management context is a vital step toward developing future adaptive capacity, the emphasis on sustainability as a development goal is strongly linked to the development of adaptive capacity. In Whitehorse there appears to be widespread support for and commitment to sustainability within the civic bureaucracy and among large segments of the population, regardless of the impetus for the pursuit of sustainability. Yet the complex cultural values about wilderness combined with the complex governance relationships among the four levels of government (City, Territorial, First Nation, and Federal) suggest potential challenges that will be the focus of the final section of this chapter.

10.6 Conclusion: The Challenge of Governance in a Gentrified Wilderness

It is not lost on many residents of Whitehorse that the local economy and the livelihoods and lifestyles it supports originate with government. Indeed many residents and employees of the City recognize that the current commitment to sustainability planning and practice in the City depends heavily on the infusion of funds from Federal Gas Tax money made available for that purpose. There are few illusions that many proactive initiatives, especially those concerned with sustainability would be far less ambitious with out 'extra' resources (i.e. beyond what could be generated by the local tax base). But the fundamental place of governance in the cultural and institutional fabric of the City goes beyond funding for programmes and special projects. The process of devolution and the directives and jurisdictions laid out in the Umbrella Final Agreement have transformed the institutional landscape of the Territory in general and the City of Whitehorse in particular. During this process of devolving federal powers and responsibilities to the Territorial government and the people of Yukon and the parallel process of First Nations' self government, the public service has (perhaps inevitably) expanded. Whereas once most federal employees in Whitehorse operated in a professional backwater, thousands of kilometres from 'head office', as YTG employees they are now at the centre of policy and decision-making. Furthermore, the number of well-paid, government jobs in the City has supported the emergence of a large, professional middle class, which plays a prominent role in shaping local debate, an increasing feature of which is the gentrification of wilderness or natural space within City limits and the emerging culture of sustainability.

Whether in conversation, meetings or formal interviews residents of Whitehorse consistently describe their community as a unique place to live, where the spirit of the frontier, a mentality of independence and living close to nature, merges with values and expectations of urban life, dubbed here the 'wilderness city'. Most residents of Whitehorse value the wilderness character of their City which is both surrounded by nature and permeated by large tracts of green space within City limits: the city in nature and nature in the city. Whitehorse's large land base has traditionally allowed for exceptionally large lots, often with sizable tracts of wooded area in between. These so-called 'country residential' lots, iconic features of the gentrified wilderness, exemplify the tension between different pro-environmental cultures in Whitehorse. On the one hand the City is committed, both philosophically and strategically to sustainability as a planning and development goal. From their point of view, therefore, residential 'infill' or densification is a key strategy of both cost-efficient and environmentally sustainable planning as noted in the previous section. Nevertheless, while residents increasingly demand more sustainable and cost-effective urban management, there are many who strongly (and paradoxically) oppose increasing housing density in their neighbourhoods. Many interviewees spoke eloquently of the need for sustainability to both mitigate the causes of climate change and enhance the adaptive capacity of their city at the same time that they defended the ideal of the wilderness city experience. The internal values tension between the culture of living in (or at least close to) nature, and the desire to have a low impact on nature plays out in the conflict between the stated goals of the City's 'Strategic Sustainability Plan' that emphasizes the need for more compact and 'efficient' urban development and lifestyles and the desire of citizens to live in and maintain the perceived values and characteristics of the wilderness city. From the perspective of City administrators exposure-sensitivities and adaptive capacity in the future will hinge very much on how this tension is resolved. The governance institutions of the City appear well positioned in terms of structure and set to handle the challenges but it is the relationship with other levels of governance that will pose challenges.

This challenge of governance in a wilderness city, where the ideal of a gentrified wilderness is in tension with the goals of urban sustainability, is embedded in a complex political landscape in which institutional goals overlap and the residents of Whitehorse are potentially 'over' governed. Whitehorse administrators argue that their responses regarding the environment have changed, not so much because of changes in the environment as because of changing social understandings of how people <u>should</u> treat the environment. As noted, sustainability is both a social and a strategic goal. Governance institutions at the territorial level reflect a similar transition whereby the environment is increasingly acknowledged as not only something that people want to take care of but as something that needs protecting. At the same time, however, strong political and economic imperatives influence how governance institutions at the territorial level implement such environmental values. The territorial government, especially the current administration, is strongly oriented to natural resource development as an important dimension of securing the Territory's economic future. The reach of the City's institutions is limited and its aspirations for sustainability must take place within and take account of the philosophical and strategic orientation of the Territory.

To the many people in the City and Territorial governments and others we met with and interviewed in this study the impacts of climate change seem neither self-evident nor imminent. Nevertheless, the prospect of climate change adds to the uncertainty of the future for Whitehorse as it does for most communities in the north. The CAVIAR approach highlights the fact that community vulnerability and adaptation to climate change is best understood as a social and environmental problem that may be, indeed often is, embedded in a melee of other problems. For larger centres, for gateway cities such as Whitehorse, people in government whose responsibility it is to manage the planning and implementation of governance upon which community life and civil society is based, are at the forefront of navigating what challenges the future holds. The process of devolution has challenged the people of Whitehorse, and Yukon more generally, to embrace change. Similarly, governance institutions have exhibited sufficient flexibility in the face of relatively large changes in both the political and economic landscape in recent decades. The greater vulnerability for Whitehorse in the future lies well outside city limits and indeed well beyond Territorial boundaries. Whether or not the institutional capacity of the City is flexible enough to cope with an uncertain future and the more extreme predictions for a changing climate remains to be seen. For the near term, the City's proactive approach to planning and focus on sustainability as a strategy for self-reliance, energy efficiency and cost control is both practical and adaptive.

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Chapter 11
Climate Change Vulnerability and Food Security in Qeqertarsuaq, Greenland

Christina Goldhar and James D. Ford

Abstract This chapter presents results from an exploratory study of food system vulnerability in the municipality of Qeqertarsuaq, Greenland, characterizing the exposure-sensitivities and adaptive capacity of the food system to stressors associated with climate and climate change in the context of changing livelihoods. The ability of community members to access culturally relevant foods of sufficient quantity and quality is discussed within the context of social, economic, political and environmental change in Greenland. The Qeqertarsuaq food system was found to be particularly sensitive to climate variability and change through the dependence of many residents on subsistence livelihoods and the isolated location of the community, leading to often unpredictable store food shipments. Recent warming has been linked to a reduction in sea ice extent with noticeable changes in the availability of harp seals, and the migration of eider duck populations. The effects of these exposures on food system vulnerability in Qeqertarsuaq are mediated by the role of food sharing and trading in the community, hunter support programs, knowledge gained through the experience of previous climate variability, and the presence of a diverse food system including both traditional and store food sectors- all factors that strengthen adaptive capacity.

Keywords Greenland · Food security · Inuit food systems · Inuit Livelihoods · Climate change

11.1 Introduction

The last decade has witnessed a proliferation of research examining how the climate of Greenland is changing, drawing upon over 130 years of observational data and considerable ice core records. This research highlights the

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highly variable nature of Greenland's climate, which is strongly influenced by the North Atlantic Oscillation (NAO) and volcanic activity (Box 2002; Chylek et al. 2006; Hurrell 1995). This variability has allowed researchers to examine climate sensitivities in biophysical systems (Hamilton et al. 2003; Humlum 1998; Kristensen et al. 2006; Wieland 2004), which has gained increasing importance in light of anthropogenic climate change and projected accelerated warming over Greenland with average temperatures projected to increase at a rate 1.2–3 times faster than the global average (IPCC 2007). Climate warming will continue to have consequences for Greenland and Greenlanders, many of them negative: rising sea levels will increase coastal erosion, melting permafrost will influence infrastructure stability, reduced sea ice thickness and coverage will impact traditional subsistence activities, and warming coastal water will affect the population health and spatial distribution of commercially harvested fish species (ACIA 2005). Potential benefits have also been identified including enhanced opportunities for resource development and exploitation of hydrological resources as the ice cap recedes, improved shipping, and new opportunities for commercial fishing (Nuttall 2008).

While the physical changes induced by climate change within Greenland have been explored by many researchers, human dimensions research is in its infancy. Exceptions to this trend include the work of Hamilton et al. (2003) who examine the connection between climatic variability and the availability of cod and shrimp, which has caused significant structural shifts within Greenlandic fisheries. The social, economic and cultural significance of this transition has also been described by Nuttall (1992), Caulfield (1997) and Dahl (2000). This work largely concerns climate variability and few studies, to our knowledge, have explicitly assessed vulnerability to climate change in Greenland.

The following chapter examines the vulnerability of Greenlandic food systems to climate change through a case study from Qeqertarsuaq municipality. The work draws upon the vulnerability approach of CAVIAR (described in Chapter 1), developed in an Indigenous food security context by Ford (2009) and recognizing the importance of multiple socio-economic-political-environmental stresses affecting vulnerability to food insecurity. As the social, economic and political characteristics of Greenland and the Qeqertarsuaq community shape the present and future vulnerability of the food system, this chapter begins by describing the context within which this study is situated. The methodological approach and methods are then described before highlighting the climatic and non-climatic stresses influencing the exposure-sensitivity of the Qeqertarsuaq food system. The qualities of the food system determining adaptive capacity and the overall vulnerability of the food system are then explored in relation to current and future changes influencing the system.

11.2 Local Attributes

11.2.1 Social, Economic, Political, and Biophysical Characteristics of Greenland

Greenland is the world's largest non-continental island with a total area of 2.1 million km^2 (Statistics Greenland 2007a), and a population of 56,648 confined to the coastlines along the south, west and east of the country, with the north and northeast remaining largely uninhabited. The majority of Greenland's inhabitants live in 18 towns ranging in size from Nuuk with a population of 15,000, to towns of fewer than 1,000 people. The remaining 9,648 residents live in traditional settlements, of which there were 58 in 2007 (Statistics Greenland 2007b). Settlements are small, often with fewer than 100 inhabitants, and are largely based on subsistence hunting and fishing. The number of settlements in Greenland continue to decrease as the Home Rule Government (HRG) promotes the provision of services in larger centralized towns, a process that began in the late 19th century and was accelerated during a move towards 'modernization' in the 1960s (Caulfield 1997; Dahl 2000; Nuttall 1992).

From 1979 until June 2009, Greenland was a self-governing overseas administrative division of Denmark, between 1953 and 1979 it was a province of Denmark and prior to this period it was a Danish colony. Following a vote for greater devolution in 2008, Greenland is now a country within the Kingdom of Denmark. Under the newly devolved constitution, Denmark has retained jurisdiction over foreign policy and defence while Greenland assumes responsibility for financing and managing the criminal justice system, the coast guard, police and some foreign affairs, in addition to health care, education and fisheries management which were previous responsibilities of Greenland's HRG. Greenland is not part of the European Union, having chosen to leave the European Economic Community in 1985, shortly after achieving self-rule in 1979, to preserve autonomy of fisheries management amongst other reasons.

The primary mainstays of the Greenlandic economy are renewable resources, particularly fisheries and fish processing, with important revenues from mining, hydro-electric and hydrocarbon development (Nuttall 2008). In 2007, fisheries exports accounted for 87% of all exports from Greenland (Statistics Greenland 2007a). Parallel to commercial development of renewable resources, the hunting of land and sea mammals is an important subsistence activity, with opportunity for hunters to sell products on a small scale. The coexistence of subsistence-based resource harvesting and waged employment in many Greenlandic communities is characteristic of a 'mixed-subsistence/cash' economy (Caulfield 1997). The harvesting of animals and the cash economy in Greenland are so closely intertwined that Dahl (1989) argues differentiating between the two sectors is meaningless. In 2006, the livelihoods of approximately 5% of all Greenlanders depended entirely on hunting, with 11.5% partly dependent on hunting (Statistics Greenland 2007a). In the mid 1990s the HRG began promoting increasing diversification of the economy through developments in tourism, public sector administration, and technology-based industries.

11.2.2 Qeqertarsuaq Municipality

This study focuses on Qeqertarsuaq municipality, located on Disko Island off the west coast of Greenland (Fig. 11.1). The municipality encompasses all of Disko Island and includes: one town, Qeqertarsuaq, with a population of 1013 people, 90% of whom are *Kalaallit* (Greenlandic Inuit); and Kangerluk, a small settlement with a population of 42 (Table 11.1) (Statistics Greenland 2007b). The language of local Inuit is the West Greenlandic dialect of *Kalaallisut* (Greenlandic Inuit), with Danish comprising the second language of many residents (Caulfield 1993).

Fig. 11.1 Qeqertarsuaq, Greenland. *Source*: Illustration by Adam Bonnycastle 2008

Table 11.1 Socio-economic characteristics of Qeqertarsuaq and Greenland in general

Characteristics	Qeqertarsuaq	Greenland
Population (with settlements)[a]	1055	56,643
Persons per house[b]	2	2.6
Average household income (Dkr)[c]	219,082	274,890
Unemployment rate (%)[d]	2.4	8.6
Population growth 1992–2007 (%)[a]	−11	2.2
Inuit (%)[b]	90	89
Life expectancy[b]	–	70 (female) 65 (male)
Main occupation[b]	Hunting and fishing	Public administration

[a]Statistics Greenland (2007b)
[b]Statistics Greenland (2007a)
[c]Statistics Greenland (2007c)
[d]Statistics Greenland (2007d)

The community has a mixed subsistence-cash economy composed of subsistence hunters and fishers as well as waged employment (Caulfield 1993). Similar to mixed economies found elsewhere in the North, both are closely linked with cash income helping capitalize and support subsistence activities (e.g. Caulfield 1993). Locally harvested animals known as *kalaalimernit* or 'Greenlandic' foods are widely consumed and are a highly valued component of the local diet. The majority of these foods are marine species as Disko Bay, with a depth of over 800 m, is rich in shrimp, many fish and whale species (Caulfield 1997). Typical animals consumed include harp seal (*Pagophilus groenlandicus*), narwhal (*Monodon monoceros*), minke whale (*Balaenoptera aeutorostrata*), reindeer (*Rangifer tarandus*), eider duck (*Someteria mollissima*), Greenland cod (*Gadus ogac*), Arctic char (*Salvelinus alpines*) and Greenland halibut (*Reinhardtius hippoglossoides*). In surveys by Poppel et al. (2007), 45% of Qeqertarsuaq households reported participating in hunting and fishing. Surveys by Goldhar et al. (2009) document that 66% obtain at least half of their food from traditional sources; a quantity that is among the highest in Greenland and is generally higher than other Arctic regions.

Hunting and fishing are tightly regulated in Greenland, with two legally defined categories of hunters forming the basis of the licensing system: occupational and non-occupational hunters. In May 2008 there were 46 occupational and 150 non-occupational hunters in Qeqertarsuaq. Applicants have to meet specific criteria to obtain an occupational hunting license, harvesting a minimum portion of their food from traditional sources, in addition to meeting income criteria. Licensing has important implications as species access and dispossession rights are differentiated by license sub-group. Non-occupational hunters and fishers are restricted from harvesting certain species, and are further restricted from selling their catch at the local outdoor market (*kalaaliiaraq*) or to Royal Greenland fish processing plants (owned by the HRG) who deal primarily with occupational licensed hunters and fishers (Tables 11.2 and 11.3).

Table 11.2 West Greenland hunting licence restrictions, 2008

Occupational licence	Occupational and non-occupational licence
Polar bear	Caribou
Walrus	Musk ox
Minke whale	–
Fin whale	–

Table 11.3 Regulated fish species, 2008

Off shore	Near shore
Greenlandic halibut[a]	Greenlandic halibut[a]
Snow crab[a]	Snow crab[a]
Lumpsucker	Lumpsucker
Atlantic halibut	Scallops
Capelin	Shrimp
Deepwater prawn	Atlantic salmon
Redfish	–
Atlantic herring	–
Round-hear greandier	–
Catfish	–
Haddock	–
Atlantic cod	–

[a] Only occupational licensed fishers are permitted to sell their catch to the fish factory

The wage economy of Qeqertarsuaq is based on commercial fishing, seafood processing, public administration, tourism, and seasonal labour. Public employment makes up an important part of the economy and is primarily provided by the Royal Greenland Company which owns the local fish processing plant employing seasonal workers, and the local municipality. The commercial economy in Qeqertarsuaq is strong, with an unemployment rate of 2.4% in 2007; one of the lowest in the Arctic. Additional socio-economic indicators for Qeqertarsuaq generally favour well compared with other Indigenous peoples in the Arctic and other Greenlandic communities. While specific health data is not available for Qeqertarsuaq, communities in Disko Bay report good health, with 93% believing they have 'good to very good' health in surveys by Poppel et al. (2007). Household income is also relatively high at an annual average of 219,082Dkr (39,000 $US) in 2006 with 82% of residents living above the US poverty line. This is partly reflective of the success of the commercial fishery, highly dependent on lucrative shrimp sales.

11.3 Methods

This study was conducted with the support of community residents of Qeqertarsuaq and through the assistance of two local researchers. The town of Qeqertarsuaq was selected given the long history of research in the social and biophysical sciences in the community commencing with the establishment of the Arctic Station by the University of Copenhagen in 1906. During a consultation visit in 2007, residents expressed interest in the study and participated in the development of the project design and research objectives, thereby enhancing the local relevance of the study. A mixed methods approach was employed consisting of a series of food surveys, semi-structured interviews, key-informant interviews and participant observation during 8 weeks of fieldwork in 2008. The methods aimed to describe how the food system operates in Qeqertarsuaq, and identify and characterize exposure-sensitivities and adaptive capacity, as per the CAVIAR framework.

Research began with 61 food surveys and semi-structured interviews carried out during March/April 2008 (Goldhar et al. 2009) and were followed by 14 further semi-structured interviews in August 2008 with a sample of women and adults age 55+ that had participated in the March/April portion of the study. All surveys and interviews were conducted with the help of a local interpreter, translating into the West Greenlandic dialect of *Kalaallisut* when necessary. Participation was voluntary and confidential.

11.3.1 Food Survey

A food survey comprising 35 closed-ended questions was administered to a random sample of 61 community members, with a participation rate of 61% (see Goldhar et al. 2009). The survey aimed to provide a rapid and generalized characterization of the nature and structure of the food system in Qeqertarsuaq, prevalence of food insecurity, and determinants. The survey draws upon the U.S. Department of Agriculture's (USDA) Food Security Module (FSSM), adapted and pre-tested for use within an Inuit context (Ford and Berrang-Ford 2009; Goldhar et al. 2009).

11.3.2 Semi-Structured Interviews

A semi-structured interview was conducted with all 61 survey participants in March/April to allow respondents an opportunity to elaborate on issues raised in the survey, and to provide the research team with a more comprehensive understanding of local food system characteristics and food security, in addition to the nature and determinants of exposure-sensitivities and adaptive capacity. Fourteen additional semi-structured interviews were conducted in August with a random sample of women and adults age 55+ who had participated in the March/April portion of the study. Interviews lasted between 15 min and 2 h, and were primarily conducted in participants' homes. The interview location was chosen in an attempt to balance researcher-respondent power dynamics (Falconer-Al Hindi 1997, Crang and

Cook 2007), and broaden the means of communication available to participants, allowing respondents to draw on household items or photos during an interview.

11.3.3 Key Informants

Further semi-structured interviews were conducted with a small group of key informants to provide context to issues and concerns raised by local residents. These informants included the manager of the fish factory in Qeqertarsuaq, municipal administrators and Home Rule Government representatives working in the Ministry of Fisheries, Hunting and Agriculture.

11.3.4 Data Analysis

Basic descriptive statistics were used to describe responses to the food security survey and explore differences by respondent characteristic (see Goldhar et al. 2009). Food survey responses in section four (see Appendix) were categorized by severity of food insecurity in accordance with procedures outlined by the USDA and illustrated in table 4 (Bickel et al. 2000, USDA 2007a, USDA 2007b). Semi-structured interviews were transcribed and analyzed for content with the help of local researchers. The CAVIAR framework was used to synthesize findings from the surveys and interviews and to identify and characterize exposure-sensitivity and adaptive capacity in the food system. Potential data misinterpretation was minimized by discussing results with available participants during door-to-door visits. Results were further disseminated through the distribution of translated pamphlet materials to the homes of all participants, the community museum and municipal office, encouraging residents to contact members of the research team with questions and feedback.

11.4 Results

11.4.1 The Qeqertarsuaq Food System

The Qeqertarsuaq food system is comprised of interdependent traditional and store-food sectors typical of ‘dual food systems’ (Ford 2009). The harvesting and consumption of traditional foods are described as an integral part of local social customs, cultural health and identity with widely recognized nutritional advantages over store-bought alternatives. The significance of Greenlandic foods was emphasized by many respondents.

> Greenlandic foods are very strong, I don't know how to explain it. Without Greenlandic food I am nothing. A freezer box without Greenlandic food is nothing (Kristian).

Traditional foods may be accessed by individual or household harvesting, through food sharing and trading within the community, by purchasing foods directly from hunters, or through the open market. Processed, frozen Greenlandic foods (primarily fish) are available at the local 'Pilersuisoq' grocery store in Qeqertarsuaq.

Although traditional foods were consistently preferred by respondents, store foods (or *qallunaamernit,* 'Danish' foods) form an important component of the Qeqertarsuaq food system. Traditional foods are sometimes consumed with store-bought ingredients such as spices, chicken or rice. Store foods can be purchased in Qeqertarsuaq at the main grocery store, a second store that sells bread and a limited variety of packaged goods, and a third store that sells confections, open seasonally.

11.4.2 Exposure-Sensitivities of the Food System to Climate-Related Risks

The exposure-sensitivity of the food system to climate-related risks is determined by the nature of the food system and the characteristics of climatic and non-climatic conditions which affect food availability, accessibility, and quality. Within the traditional food sector, the availability of animal species, the number of safe hunting days each season, the cost and availability of necessary hunting and fishing equipment, the prevalence of harvesting skills, the cost and availability of country foods sold within the community, in addition to dynamics of food sharing networks all play a role in determining access to Greenlandic food. Store food access is primarily determined by the frequency of store food shipments and cash income availability. Not all community members will be equally sensitive to climatic and non-climatic risks influencing the food system, and traditional and store food sectors will experience exposure-sensitivities relative to the unique characteristics of each sector.

11.4.2.1 Traditional Food System

Within the traditional food sector, the presence of sea ice (known as *vestisen*), storm frequency and general climatic variability have direct implications on the availability of animal resources, the number of safe harvesting days each season, and the capital investment needed to hunt. Changes in these environmental characteristics thereby directly influence traditional food harvests, cash income incurred in the community, and hence food security. While changing environmental conditions influence the food system at the community-scale, the exposure-sensitivity of individual residents varies relative to individual circumstances. Hunting equipment can be relatively expensive and scarce for subsistence harvesters with limited access to cash income, making it particularly difficult for harvesters to equip themselves for both winter and summer hunting and fishing seasons. Resource restrictions and hunting preferences therefore combine to create harvesting sub-groups that include winter harvesters, summer harvesters and year-round harvesters, each with unique exposure-sensitivities to changing environmental conditions.

Recent variability in sea ice coverage has had implications on traditional food access for winter and summer harvesting sub-groups. Respondents identified winter 2008 as the first year in roughly a decade when the bay froze, with considerable reductions in sea ice coverage leading up to 2008. These observations are consistent with Hansen et al. (2004) who document a decrease in sea ice coverage in Disko Bay by roughly 50% between 1991 and 2004 with reductions noted at both freeze up and break up. A prolonged open water season has had negative consequences for winter harvesters, whose primary capital investments involve maintaining dog teams and in some instances snowmobiles, decreasing traditional food access and food security for these individuals, while benefitting summer harvesters. Individuals with access to diverse hunting equipment, greater cash income, and who are able to hunt in all seasons have had sufficient resources to adapt to changing sea ice dynamics.

Decreases in sea ice coverage in Disko Bay were also linked by Qeqertarsuaq residents with reductions in seal harvest in recent years. Reflecting on this decline one respondent noted,

> When we have no more ice, seals cannot feed their babies (Maren).

As harp seals (*Pagophilius groenlandicus*) breed on sea ice in spring, reductions in sea ice coverage in Disko Bay directly influences the availability of seals. Harp seals are commonly hunted through summer and fall providing valuable food resources of cultural significance within the community, in addition to economic benefits through the sale of seal meat and skins. Changing ice conditions have also influenced the relocation of seal populations and the availability of seals in regions outside of Disko Bay. Hooded seals (*Cystophora cristata*) in the Avanersuaq region of North Greenland are moving northwards with reductions in the range of sea ice, ringed seals (*Pusa hispida*) are becoming increasingly rare around Sisimiut in central West Greenland as fjords are no longer covered with ice in winter, and sightings of young harp seals around Maniitsoq vary relative to sea ice conditions (Hovelsrud et al. 2008; Petersen 2004). One quarter of survey respondents identified environmental conditions such as sea ice extent, hazardous weather and a general lack of animal resources as the primary barrier restricting their consumption of Greenlandic foods from March 2007-March 2008 in Qeqertarsuaq.

11.4.2.2 Store Food System

Store foods are delivered by air and sea to Qeqertarsuaq, with extreme weather, sea ice conditions and climatic variability determining the availability of these foods. Periods of up to one month are common before winter restocking is possible due to storms, leading to frequent shortages of fresh fruits, vegetables, packaged milk and milk products. An increase in storm frequency and unpredictable weather conditions may reduce the number of helicopter flights and the frequency of winter restocking thereby restricting the availability of store foods in winter. During summer months, sea ice formation and break up dates determine the length of the shipping season. In contrast to potential winter changes, an increase in length of the open water season may increase summer store food access in Qeqertarsuaq. As a greater quantity of foods may be transported at less cost through shipping, these benefits may extend beyond summer shipping months if non-perishable items are stocked for purchase in future months. Store foods do not represent an equal substitute for fresh, nutritionally rich, and culturally significant traditional foods that may be threatened by the same environmental changes benefitting store food access.

11.4.3 Adaptive Capacity

11.4.3.1 Facilitators of Adaptive Capacity

Food System Diversity

The diversification of the food system in recent decades to include store food options, while not nutritionally or culturally preferable to traditional foods, buffers the food system, helping increase local food security and reducing risk of hunger by providing alternatives when traditional foods are inaccessible. Similarly, traditional foods are often important when store food access and availability is limited. The presence of both traditional and store food sectors in Qeqertarsuaq therefore increases the capacity of the food system to adapt to climatic and non-climatic stressors. Store foods are consumed in greater excess when traditional food access is restricted (such as in winter) and are regularly consumed by non-hunters, women and elders who experience additional barriers limiting traditional food access. As 'Danish' foods are poorly regarded by many community members, particularly elders and those with strong connections to the land-based economy, increased consumption of these foods can be characterized as a reduction in food quality, an integral component of food security (Ford 2009; Gregory et al. 2005; VanEsterik 1999).

Food Sharing and Trading

Food sharing networks are an important component of the Qeqertarsuaq food system, forming the primary means of traditional food access for some members of the population. The practice of food sharing in modern hunter-gatherer societies is described at length in the literature (see Hovelsrud-Broda 2000 for a discussion regarding East Greenland), and is shaped by 'complex rules based in kinship and other social relationships' (Wenzel et al. 2000:1). Within Qeqertarsuaq, residents noted sharing foods amongst extended family units across various households and sending foods through the mail to family members living outside the community as far away as Denmark. Seventy-seven percent of respondents in the food survey reported receiving shared food from someone outside their household in the last year, of whom 98% received shared food from family members.

Women, elders and non-hunters reported receiving a greater portion of food from food sharing networks within the study, highlighting the role of these networks in strengthening the food system and supporting food security in the context of environmental change. The enhanced value of food sharing when animal resources are limited was articulated by one participant,

> Seal is harder to obtain than it was before, but if you have community and friends you will never go hungry (Louise)

Food sharing practices can benefit hunters when a hunting trip is unsuccessful and may aid hunters as they adapt to changing weather and sea ice conditions noted by many participants.

While food sharing provides an invaluable resource within the Qeqertarsuaq food system supporting all community members– women, elders and non-hunters in particular– many elders participating in the study noted a reduction in the breadth of food sharing networks over time. In previous years, traditional foods were shared with elders, neighbours, widows and other community members known to have limited access to traditional foods, in addition to one's own family. While the quantity of Greenlandic foods consumed by the community has decreased and some hunters have begun selling their catch, food sharing networks have tightened. The internalization of food sharing within extended family units restricts accessibility for non-hunters with limited cash.

Traditional foods are also traded, often for gas, the use of boats or hunting supplies that are exchanged for the goods harvested through the use of this equipment, providing another useful coping mechanism in Qeqertarsuaq when traditional food systems are stressed. The practice of trading increases the accessibility of hunting for some community members by supplying essential gas and bullets, allowing hunters to harvest beyond the restrictions of their cash income. By decreasing the financial burden of harvesting, trading may indirectly transfer foods that would be sold on the market into food sharing networks. By supporting hunters and supplying foods directly to community members, trading increases community food security. One respondent stated,

> It's easier for us because we now give gas to hunters and get food in return (Ane)

Hunter Support Programs

Financial support and subsidies offered to hunters by the HRG encourage harvesting by increasing the viability of subsistence livelihoods. In 2008, the HRG subsidised the sale of seal skins in Greenland by 150Dkr (26.79 US$) allowing an average skin to sell for 100 Dkr (17.85 US$). Hunters may also apply for financial support from the HRG to replace hunting equipment lost or damaged due to unexpected circumstances (such as extreme weather events), and reflects an important component of adaptive capacity. However, despite the frequency of equipment damage in Qeqertarsuaq, few of the hunters interviewed had applied for such assistance nor did they know anyone who had in previous years. Access to financial resources in Qeqertarsuaq is a major determinant of the ability to hunt, harvest traditional foods and cope with environmental variability and change, and lack of interest in harvest support (or barriers limiting the accessibility of harvest support) is an area requiring further examination.

Experience-Based Knowledge

The process of adapting to environmental change is not unfamiliar to Qeqertarsuaq residents, having experienced climate warming of similar magnitude in the 1920s and 1930s as in the last decade; like many Arctic peoples, they have lived with a high degree of natural climate variability for over 4,000 years. Many residents expressed an understanding that environmental changes may necessitate changes in human behaviour, influencing the harvesting and consumption of Greenlandic foods.

> If the climate gets warmer like in recent years some animals might disappear. We might have to adapt that they are not allowed anymore. You cannot control the nature (Laila)

When reflecting on the future, the multiple stresses presently influencing subsistence livelihoods were described as increasing in intensity. Residents expressed doubts regarding the future viability of subsistence livelihoods, and in extension, access to Greenlandic foods,

> Being a full-time hunter has no future. I would rather say to my children, don't like Greenlandic food because in future it will be more difficult to get. (Kristian)

Some residents conveyed a sense of optimism regarding the effects of future climate variability and change, while others expressed ambivalence.

> We adapt to climate changes, so do the animals. (Karl)

> We don't live in eternity, so there's not that much concern. (Otto)

While individual sentiments regarding the possible outcome of future changes vary, the collective experience of climatic variability and an intimate awareness of the connections between environmental changes and traditional food procurement (as developed through subsistence livelihoods, local and traditional knowledge) strengthen community capacity to respond and adapt to food system stresses.

11.4.3.2 Barriers to Adaptive Capacity

Price and Sale of Traditional Foods

The price of country foods relative to local income plays an important role guiding access and is one factor, among many, influencing the capacity of Qeqertarsuaq residents to adapt to changes influencing the food system. Both wage-earners and non-wage earners described Greenlandic foods as expensive when purchased within the community, regardless of whether these foods were bought directly from hunters or at the grocery store. The cost of purchasing Greenlandic foods was clearly identified as a barrier restricting access for non-hunters with limited alternative means of acquiring these foods. One woman stated,

> Buying Greenlandic food is very expensive even though we both have paying jobs. It's very rare that hunters sell meat for less than board prices off the market. Board prices are too high. (Ane)

Board prices are established by an organization representing Greenlandic hunters called *Kalaallit Nunaani Aalisartut Piniartullu Katuffiat* (KNAPK, or the 'Organization of Hunters and Fishermen in Greenland') who negotiates price agreements for hunting and fishing products with Royal Greenland (Nuttall 1992). These prices represent the cost paid by Royal Greenland when purchasing from hunters and fishers, while functioning as minimum selling prices for hunting and fishing products sold within the communities. The minimum prices ensure hunters receive adequate income to sustain subsistence livelihoods, though residents report prices have increased at a faster rate than local income in recent years, rendering the purchase of Greenlandic foods impossible for some community members. As the cost of fuel and other hunting supplies increase, subsistence livelihoods become increasingly dependent on cash resources. Increased economic burdens borne by the hunting community are expressed in rising food prices at the outdoor market, a change which indirectly impacts Greenlandic food access and food security in Qeqertarsuaq.

In addition to the cost of buying Greenlandic foods, the infrequency of selling traditional foods in the community restricts access for many non-hunters and wage workers. Greenlandic foods harvested in Qeqertarsuaq may be consumed immediately by a hunter's household, frozen for future use, shared with extended family members (both living in the community and through mail), sold to the Royal Greenland fish factory, or sold to community members. Seventy-eight percent of individuals surveyed live in a household that did not sell any Greenlandic foods in the last year.

Resource Management

The ability of the food system and Qeqertarsuaq residents to adapt to changing climatic conditions is influenced by resource management strategies employed by the HRG. The centralization of government control over harvesting quotas and seasons was identified as an additional stress on the Qeqertarsuaq food system influencing the quantity of annual harvest. In the context of recent climatic variability, the migration patterns of local animal populations have shifted, outdating the hunting seasons of some species in Qeqertarsuaq. The eider duck season begins June 15th for all of Greenland despite significant differences in the biophysical characteristics and climatic conditions experienced in northern and southern municipalities. While the season dates were reflective of hunting needs in the south, eider ducks were arriving (and leaving) up to 2 weeks earlier in Qeqertarsuaq at the time of this study. This shift reduces the quantity of eider ducks harvested as species migration patterns no longer coincide with hunting season dates.

Many hunters stated present quotas (particularly narwhal), were unrepresentative of the health of local animal populations and weren't determined through a participatory process that consulted local knowledge (Table 11.4). The disparity between the population status of harvested species and harvesting quotas may unnecessarily restrict traditional food consumption with negative implications on local food security.

Greenland began restricting the harvest of white and black narwhal in 2004 in response to abundance estimates produced by the North Atlantic Marine Mammal Commission (NAMMCO) and international pressure, influencing the availability of whale meat in the traditional food system. The International Whaling Commission (IWC) determines Greenland's quotas for large whales such as fin, bowhead and minke whale while NAMMCO, the Northwest Atlantic Fisheries Organization (NAFO), the International Council for the

Table 11.4 Quotas for selected species, 2008

Species	Quota
Polar bear	10[a]
Fin whale	19[b]
Minke whale	5
Caribou	20 (occupational), 5 (non-occupational)
Muck ox	5 (occupational), 5 (non-occupational)
White narwhal	16
Black narwhal	19

Quotas for Qeqertarsuaq unless otherwise stated

[a] Quota for West Greenland, including: Nuuk, Maniitsoq, Sisimiut, Kangaatsiaq, Aasiaat, Qasigiannguit, Ilulissat, Qeqertarsuaq and Uummannaq

[b] Quota for all of Greenland, including: Nanortalik, Qaqortoq, Narsaq, Paamiut, Nuuk, Maniitsoq, Sisimiut, Kangaatsiaq, Aasiaat, Qasigiannguit, Ilulissat and Qeqertarsuaq

Exploration of the Sea (ICES) and Canada-Greenland bilateral relations determine quotas for narwhal and other smaller cetaceans (whales and dolphins) and pinnipeds (seals and walruses). Many hunters expressed frustration with the involvement of the IWC and 'biologists' in determining Greenland hunting quotas. One hunter stated,

> Greenlanders would not regulate ourselves. It is the other forcing us to regulate. We have lived, we have survived in many years because of these animals so why should we be forced by other people to stop hunting those animals? (Kristian)

While reflecting the need to preserve animal stocks, the hunting regulations process has created significant conflict, particularly during times of stress (see Hovelsrud and Winsnes 2006 for a response to this issue, and Sejersen 2001 for an example regarding the beluga hunt).

11.4.4 Food Insecurity and Existing Food System Vulnerability

Food security levels in Qeqertarsuaq represent a measure of 'hunger' or 'worry' associated with not attaining adequate food resources and can therefore be interpreted as an illustration of existing food system vulnerability. The food survey documented the majority of survey respondents experience a high level of food security, with only 8% of respondents experiencing some level of food *in*security (Table 11.5). A greater portion of women were food *in*secure than men, with prevalence of food *in*security higher among adults age 55+ than other age groupings.

While respondents demonstrated a high level of food security in the food survey, the majority of participants noted difficulties accessing culturally-relevant, Greenlandic foods, in part due to climatic risks. The existing vulnerability of the traditional food sector is therefore higher than the vulnerability of the food system as a whole, comprising both traditional and store-food sectors. Greenlandic foods, or *kalaalimernit*, are of high cultural significance in Qeqertarsuaq and are consumed by all respondents

Table 11.5 Qeqertarsuaq food security results and categorization

Category		Description	Total (%)
Food secure	High	No reported indications of food access problems or limitations	50 (78)
	Marginal	One or two reported indications. Little or no indication of changes in diet or food intake.	5 (8)
Food insecure	Low	Anxiousness of food sufficiency and shortages, indication of reduced food intake.	5 (8)
	Very low	Reports of multiple indications of disrupted eating patterns, reduced food intake and loss of weight.	0 (0)

(Goldhar et al. 2009)

Table 11.6 Qeqertarsuaq survey responses by demographic characteristic

Characteristic		Total (%)	Ate <1/3 Greenlandic food past year	Food secure
Total		61(100)	21 (34)	55 (90)
Sex	male	28	6 (21)	26 (93)
	female	33	15 (46)	29 (88)
Age	18–34	14	5 (36)	14 (100)
	35–54	27	10 (37)	24 (89)
	55+	20	6 (30)	17 (87)
Occupation	Wage earner	38	14 (37)	36 (95)
	Occupational hunter	14	2 (14)	12 (86)
	Non-occupational hunter	20	7 (35)	20 (100)
	Never hunt or fish	27	12 (44)	23 (85)

(Goldhar et al. 2009)

with access varying for different occupational and demographic groupings. Women reported eating less Greenlandic foods than men in survey results (Table 11.6), while elders described significant barriers restricting Greenlandic food access in the interviews. Greenlandic food access is also restricted for non-hunters, as traditional food consumption increases with hunting frequency. The vulnerability of women, non-hunters and elders to climatic and non-climatic risk influencing the traditional sector of the food system is therefore greater than other demographic groupings in Qeqertarsuaq.

This existing vulnerability is further heightened by the quantity of food received through food sharing networks by women, non-hunters and elders, which have decreased in breadth over time. While food sharing networks are transitioning from inter-family to intra-family networks, residents also noted a reduction in the harvest of some animals (such as seal) and sharing quantities of food in proportion to the success of their hunt. Future climatic and non-climatic risk restricting traditional food harvests may therefore have a disproportionate effect on residents relying on food sharing.

Increasing amounts of capital needed for subsistence hunting, illustrated through rising fuel and commodity prices, not only result in rising food prices, but may further restrict the quantity of food entering food sharing networks as hunters are compelled to sell more of their catch to sustain subsistence livelihoods. An increased prevalence of selling traditional foods in Qeqertarsuaq would benefit waged workers and non-hunters with access to cash income, and may limit traditional food access and food security for groups relying on food sharing if foods are sold that would have otherwise been shared. Other economic considerations include the strength of the lucrative fishery sector, vulnerable to future climate variability and change. If fish stocks were to decrease, as they did during the 1960s, the reduction of cash income in Qeqertarsuaq stemming from unemployment would negatively affect food security. Diversification of the local economy and increased financial support of subsistence livelihoods may become invaluable strategies supporting Greenlandic food systems in the context of climate change.

The slow response time on behalf of the HRG regarding eider duck hunting season dates illustrates a need for adaptive resource management strategies in the context of environmental change. Describing this apparent human-environment disconnection, one participant stated,

> Everything is changing, the only thing that is not changing is us, people. (Kristian)

A decentralized, participatory approach to resource management placing greater decision-making power at the local community-level, called for on behalf of KNAPK (Mølgaard 2006), and complimented by increased flexibility of hunting regulations in conjunction with climatic variability is needed.

11.5 Conclusion

This study represents a preliminary analysis of food system vulnerability to climate change in Qeqertarsuaq, Greenland. Stresses influencing the food system were found at multiple temporal and spatial scales, with implications for exposure-sensitivity and adaptive capacity. Changing sea ice conditions, as influenced by climatic variability and change, were found to be a primary determinant of food system stress and local food security. Sea ice changes, the effects of resource management strategies employed by the HRG, changing animal population dynamics (such as the availability of harp seals and shifting eider duck migration patterns) and the high cost of purchasing traditional foods are mediated through community food system supports such as food sharing and trading networks and financial assistance offered to subsistence harvesters. This relationship is further influenced by longer-term changes affecting Inuit livelihoods and community dynamics such as Greenland's increasing autonomy and economic self-sufficiency, in addition to the institutional structure organizing hunting rights and resource access.

While residents experience high levels of food security in Qeqertarsuaq, access to Greenlandic foods for non-hunters, women and elders is threatened, compromising food quality. Greenlandic foods are an integral part of the local economy, cultural identity and social practices in Qeqertarsuaq. Beyond threats to food security, by undermining the subsistence economy, climate change threatens Inuit culture in Greenland, as it does within indigenous communities across the circumpolar region (ACIA 2005).

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Appendix: Section 4 of the Survey Questions

1. Some people might say, 'We worried whether our food would run out before we got money to buy more or were able to go hunting or fishing.' In the last 12 months, did that happen *often*, *sometimes*, or *never* for you or your household?
2. Some people might say, 'The food that we bought, hunted or fished just didn't last, and we were not able to get more.' In the last 12 months did that happen *often*, *sometimes*, or *never* for your household?
3. Some people might say, 'We couldn't afford to eat healthy meals.' In the last 12 months did this happen *often*, *sometimes*, or *never* for your household?
4. Since March last year, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough food?
5. In the last 12 months, did you ever eat less than you felt you should because there wasn't enough food?
6. In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food OR were not able go hunting or fishing?
7. In the last 12 months, did you lose weight because you didn't eat enough food?
8. In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough food?

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Chapter 12
Climate Change, Vulnerability and Adaptive Capacity in a Multi-use Forest Municipality in Northern Sweden

E. Carina H. Keskitalo

Abstract The impacts of climate change may be especially large on areas where conflicts regarding renewable resources such as multi-use forests already exist, and may increasingly impact sectors where access to resources is already limited. Drawing upon the CAVIAR framework for analysing current and future exposure-sensitivity and adaptive capacity in Gällivare municipality, northern Sweden, this chapter describes the socio-economic and environmental context of, and current and potential adaptations to, changes in forestry, reindeer husbandry, and winter tourism. The chapter concludes that these land use sectors are impacted by considerable economic and market pressures, with the result that conflicts between sectors have become increasingly pronounced. While climate change will eventually affect all land use sectors, impacts may be felt most immediately by those with the smallest existing margins for their activities, such as reindeer husbandry.

Keywords Adaptive capacity · Forestry · Multi-use forest · Reindeer husbandry · Sweden · Tourism

12.1 Introduction and Study Approach

Large parts of Sweden are sparsely populated and have traditionally been dependent on land use activities such as forestry, which up until the 1970s was the dominant employer in many northern communities. Forest use has also been important for a number of other interests such as hunting and berry picking. Many of these sectors rely on the same land areas, which may sometimes result in conflicting land use demands. Today, while the outtake from forestry is maintained, forestry industry structure has changed into larger companies, fewer local sawmills and frequently, non-local logging entrepreneurs. Overall, these

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trends have contributed to decreasing the employment basis for forestry at the same time as other interests have become more pronounced, for instance in the increase of tourism as an occupation, in increasing economic demands on reindeer husbandry and extended environmental protection. This contributes to changes both in the economic dimensions of land use and the possibility of maintaining land use based occupations in smaller municipalities, as well as to an increased sensitivity to environmental changes with regard to potential areas of conflict or narrowly scheduled seasonal activities among the sectors.

Gällivare municipality, situated in far northern Sweden (Fig. 12.1), is well-suited as an illustration of these dynamic changes. Gällivare has traditionally been a natural resource-based municipality, encompassing large protected areas, forestry, reindeer husbandry and tourism, as well as significant mining interests. The area includes a large number of interests, typical for a multi-use situation. Included amongst these and in addition to the sectors mentioned above, are hunting, fishing, berry and mushroom picking, snowmobile recreational and local use, and wind and water power generation. Whilst there are considerable environmental protection interests in the area (for instance, the main environmental protection areas are included within the UNESCO Laponia World Heritage area), a large focus among existing interests in the areas has been placed on use values and competitiveness within a market context (cf. Keskitalo and Lundmark 2010). The Gällivare case is thus interesting as an intersection between a number of different interests and as an illustration of both local and global (such as international market) impacts on land use.

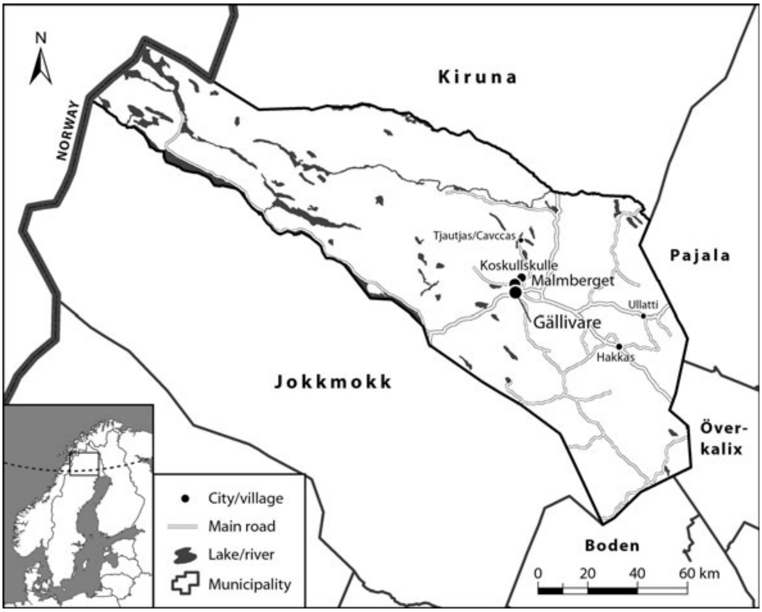

Fig. 12.1 Gällivare municipality. *Source*: GIS graphics courtesy of Magnus Strömgren

This study surveys the renewable resource focused sectors of forestry, reindeer husbandry and tourism in Gällivare municipality from the perspective of local vulnerability and asks how local land use pressures, as well as pressures originating from elsewhere, may form land use practices. The study applies the CAVIAR (Smit et al. 2008) framework for vulnerability assessment, which is a broad formalised framework with focus on both present and future stresses but otherwise in general agreement with other lines of community vulnerability assessment (cf. Ford and Smit 2004; Keskitalo 2008a; Turner et al. 2003).

In accordance with the CAVIAR framework, *vulnerability* is a particularly relevant approach to target responses to change in local communities in that it refers to the 'manner and degree to which a community is susceptible to conditions that directly or indirectly affect the well-being or sustainability of the community' (Smit et al. 2008, 4; cf. Chapter 1, this volume, Smit and Wandel 2006). A vulnerability framework thus targets the number of influences that may impact diverse communities. Vulnerability is a function of both exposure-sensitivity and adaptive capacity. *Exposure-sensitivity* refers to the 'manner and degree to which a community is sensitive to and exposed to particular conditions, forces or stresses' (Smit et al. 2008, 4), including for instance climatic conditions or natural hazards. Thus, exposure-sensitivity refers to the number of stresses that may impact communities and the way in which these are sensitive to such stresses. *Adaptive capacity* reflects the 'individual's or community's ability to cope with or adjust to or recover from an exposure-sensitivity' (ibid., cf. Keskitalo 2008a, 2010), which depends on their social and economic situation as well as governance and political systems, technology, knowledge, and traditions, among other factors.

The CAVIAR framework targets (1) current exposure-sensitivity to changing environmental conditions (including climate) and socio-economic conditions; (2) peoples' general adaptive capacity and adaptations to these changing conditions; (3) potential future exposure-sensitivity depending on trends or expected changes; and (4) potential future adaptive capacity and adaptations to these changes. To correspond with the CAVIAR framework, the paper is organized broadly into these sections.

12.2 Method

The study has been conducted through semi-structured interviews with municipal land use officials and people active in the main renewable land use sectors (forestry, reindeer husbandry and winter tourism) in Gällivare municipality, a sparsely populated municipality with in total around 19,000 inhabitants. The interviews were structured to provide an understanding of the general socioeconomic situation of the interviewees including present problems and possibilities, adaption potential to identified changes and, finally, how sensitive and adaptive they perceived themselves to be in relation to specific climate changes. Vulnerability and adaptive capacity were seen as encompassing both the underlying social vulnerability and vulnerability to climate change (with a focus on climate change) (cf. Smit et al. 2008).

The broad, occupationally related interview questions concerned whether interviewees have observed any changes over the time they have been active (employed or self-employed) in their respective occupations, what they recognise as the problems and possibilities for themselves, how they could adapt to any continuation in the changes they have seen, how they would be affected by a range of expected climate change impacts (stated in lay terms, for instance 'how would it impact you if spring came earlier'), and how they could adapt to this. Often, interviewees also state that such environmental changes are ongoing and explain measures they have employed so far. The results are generally based on personal experiences, sometimes in relation to the wider industrial or production context (such as 'since many herders have problems with this, it's also a problem for meat provision') (cf. Keskitalo 2008a).

The interview selection targeted the existing companies in the case study area with their main registered activity within the focal sectors as well as administration for the focal sectors in the case study area. In total, the study encompassed 27 persons (beyond these, two winter tourism companies were unavailable for interview). The semi-structured interviews were undertaken in local language (Swedish) mainly during autumn 2008, and were recorded and transcribed in full; translations in the text are author's translations of the original. For forestry and forest administration the selected interviewees were the main land owners Sveaskog, as well as their Model Forest representative, the private forest company SCA, the Common Property Board that manages high latitude forests, the representative of the two Common Forests under which a portion of private owned land is organized, the Swedish Forest Agency administration, the private forest owner's interest group Norra Skogsägarna, and the forest coordinator at the municipality. Sveaskog is the largest land owner in the municipality, followed by the Common Forest, SCA (with some 30,000 ha of productive forest land in the Gällivare municipality) and private forest owners. Interviewees from the reindeer herding sector included chairs of the five main reindeer husbandry administrative units which have reindeer grazing in their areas (these are generally referred to as 'reindeer husbandry' in the text). The units are also often called 'Sámi villages' in a direct translation from the Swedish.

Interviewees selected to provide insight into winter tourism interests were drawn from the twelve existing winter tourism-focused companies; in addition were the only environmental protection organisation and the environmental protection administration in the county administrative board included for interview as they represent a perspective on environmental protection which may have some importance for all the above sectors. With regard to climate change features, interviewees were generally asked how would it impact them should winter arrive later, if there were winter thaws, or more or less snow, if spring arrived later or earlier, if accompanied by frost events later during the spring, if the spring flood changed, summers were warmer and drier or alternatively more rainy, if there were more storms, and weather became more unpredictable, if shrubbiness increased (for instance due to warmer temperatures and the tree line moving northward), should the distribution of different species changes, pine was benefitted over spruce, and if forest growth and pests increased (ACIA 2005; IPCC 2001; Keskitalo 2008a; see also further under Section 12.4 and 12.5.)

12.3 Current Exposure-Sensitivities

Current exposure-sensitivities are defined through the 'forces, stresses or processes which affect the livelihoods or well-being of people in the community . . . and explaining the processes and trends that underlie them' as well as their distribution across or within groups (Smit et al. 2008, 7, cf. Chapter 1, this volume; see also Smit and Wandel 2006). Interviewees highlight that stresses are to a large extent created through the interaction between the different land uses, as forests in the area are utilised by multiple and sometimes conflicting interests. Multiple-usage of forest areas is thus apparent in the empirical material. Organisations such as the Common Property Board emphasize the number of different tasks and interests they are responsible for and responsive to, such as forest management, dealing with the questions that arise from being a land owner as well as to managing protected areas without making a profit. Other actors also emphasise the interaction between sectors and the demands placed upon the resource. For instance:

> In general... the majority in Gällivare utilizes the forest for hunting, fishing, berry picking, one sees it as a resource. And when you talk about nature reserves it only sounds of prohibitions . . . now we won't be able to hunt, fish and use these resources and then it's clearly a limitation of the personal interest (environmental protection organization, interview).

In addition, many interviewees also indicate that patterns of forest use have changed to a large extent during the time they have been active. For instance, one person who has been active in reindeer husbandry for over 40 years describes the change from a more limited road infrastructure and major areas with tree lichen forest, no supplementary feeding of reindeer and limited predation pressure, to a situation today with among other things one of Europe's largest copper mines (the Aitik mine) and other smaller mines being situated in the area. In addition there now exists water power generation, the planting of quick-growing contorta or lodgepole pine (*Pinus Contorta*) and the development of a major road that is part of the European road network (E10) leading to an increasing number of reindeer being killed by cars. The planting of dense-growing contorta pine has resulted in a loss of grazing land, difficulty in herding reindeer in the dense planted areas, as well as creating areas that are beneficial to bears which predate on reindeer. As a result, one person states that 'one doesn't really know what is the largest threat, if it is predation or forestry, they go hand in hand today' (reindeer husbandry).

Other actors also describe this large-scale change in their occupational context. An interviewee at the Swedish Forest Agency describes the changes over the last 30 years as including a movement from much smaller to larger districts, entailing that managers are responsible for much larger geographical areas, even though there are fewer managers than there used to be in the smaller districts. Increased technological support has been used to compensate these limited personnel resources, and satellite imagery and inventories relating to environmental protection have been used for forest monitoring. Many of those who were previously local land owners now live elsewhere, many in the capital, and have inherited their forest, resulting in less active forest management and sometimes a limited interest in their own forest plot. The production networks have also changed over time, with few local sawmills remaining (and none in Gällivare municipality) and most wood being sent to the industries by the coast rather than processed locally or regionally.

Large legislative changes have also taken place over time, in particular the new Forest Code in 1993 that has afforded environmental protection and production equal value, entailing the implementation of a general consideration of environmental values at every logging site. In addition, private regulation such as FSC certification has come to play a large role. While coordination between forestry and reindeer herding has existed in certain areas since the 1970s, it has been extended through the voluntary market-driven mechanism of certification, where forest companies that follow certain environmental and social requirements for logging (including concerns for reindeer husbandry) are allowed to brand their products as certified and may gain a market advantage that way (Keskitalo 2008b; Keskitalo et al. 2009). Certification thus impacts both reindeer husbandry and environmental protection interests. While interactions between forestry and reindeer husbandry do to some extent include conflict over land use, the Swedish Forest Agency notes that the interaction has been improved by, for example, more limited ground treatment, use of different machines for logging, and by the recent innovation of reindeer herding plans in many reindeer herding administrative units to correspond to and be comparable with forestry plans. An interviewee notes that, even despite the presence of institutional conflict, there exists considerable interaction between occupational sectors on a personal level as 'many in the forest Sámi villages are also forest owners' (Swedish Forest Agency, cf. Norra skogsägarna).

The pattern of exposure-sensitivities is thus to a large extent shaped by ongoing legislative, technological, and economic development. As a result of these denser and more complex institutional structures, the interaction – and conflict – between interests has also become more regulated and controlled. The forestry and reindeer husbandry sectors for instance maintain institutionalized consultation processes through legislation and certification requirements: for example, the Sveaskog interviewee notes that coordination is required with Sámi/reindeer herding interests on logging, forest fertilization, and road

Table 12.1 Main identified present exposure-sensitivities and adaptive strategies in the case study

Sectors \ Vulnerability	Current exposure-sensitivities	Current exposure-sensitivities relevant to climate	Current adaptive strategies
Forestry	Economic structure (e.g. few local sawmills) Forest structure and environmental protection demands limiting profitability	Limitations in winter roads and winter logging Warmer summers causing fires and drought	Increase productivity Increasing involvement of forest owners in forest management Increasing entrepreneurship and refinement Building all-year roads Modernising machine parks
Reindeer husbandry	Economic structure (e.g. no local slaughter houses) Grazing possibilities limited by forestry and other uses Predator impacts on reindeer	Reindeer grazing limited by winter thaw Impacts on migration and disturbances	Supplementary feeding Reorganising husbandry practices Suggested modifications in legislative and support framework
Winter tourism	Limited marketing Administrative pressures Coordination with other land uses	Impacts from winter thaws and shortened or unpredictable season length	Development of marketing possibilities Further product development

development. There also exists a consultation obligation with settlements when affected by nearby logging.

While the statements above provide an overview of change, interviewees in the different targeted sections provide much more detailed sectorial descriptions. Sections below describe the current exposure-sensitivities perceived by interviewees in the main sectors in focus, i.e. forestry, reindeer husbandry, and winter tourism, as well as the specific climate and weather-related requirements of actors. The main identified exposure-sensitivities and adaptive strategies in the case study are summarized in Table 12.1.

12.3.1 Forestry

The requirements stipulated by the market structure and demands for wood products as well as the access to wood resources required to meet these, were emphasized by interviewees from the forestry sector. A focus was thus placed on the market context and economic factors. Regarding the lack of forest product refinement in the area, interviewees note both the relatively limited role for forestry in Gällivare, given the difficult-to-rejuvenate forest and the large environmental protection areas, as well as economic market pressures. For instance, Norra Skogsägarna once had a sawmill in the area, but notes:

> it doesn't work having inland sawmills . . . we have some in the [neighbouring] Pajala area . . . still alive, you really hope that they will subsist, but it is not easy for small sawmills today . . . due to the competition . . . the pressure comes from outside . . . and you have to struggle . . . and try to get your share of the raw material that exists (Norra Skogsägarna, interview)

Interviewees also describe that for most forest owners logging is undertaken by entrepreneurs that are hired by the firms (whereas a generation ago it would have been undertaken locally). Beyond impacts from the economic structure, the forest structure in the area also limits local profitability to forestry. For instance, one interviewee notes: 'The further inland you get the worse it grows . . . and the further north, the worse it grows' (SCA, interview). Since all of Gällivare is in the forest area considered difficult to rejuvenate, all logging requires permission from the Swedish Forest Agency (cf. SCA, interview). The forest structure has also to some extent made possible large environmental protection areas which, together with other environmental protection demands, affect forestry. This creates a relation between forestry and environmental protection that has often been described as adversarial (Keskitalo and Lundmark 2010), especially as protection has been placed on a par with production since the 1993 change in the Forest Code.

Interviewees in forestry thus often conceive of environmental protection demands as limiting the profit that can be taken out of forestry. One of the forest owners with the largest environmental protection obligation is Sveaskog, which being 'state owned has the eyes on us more than other companies do' (Sveaskog, interview). Given its ownership of a large land area, it may, however, also find it easier to take account of different interests. Sveaskog has large voluntary set-asides in Gällivare municipality, something that the interviewee suggests to be some 30% of Sveaskog's forest land, to be compared with a national target for Sveaskog of 20% set aside for environmental protection. He notes that the early 2000s saw a transition to large environmental set aside protection areas, while the focus in the last few years has started to shift towards production again. Noting Sveaskog's existing-voluntary aims, he states that 'if [these] increase even more it starts to become difficult to maintain forestry . . . [there] is a limit' (Sveaskog, interview). The requirement for voluntary set-asides exists in particular within the Forest Stewardship Council (FSC) standard, considered by some as the more demanding form of certification, in addition it is the currently dominating form of certification among forest companies in Sweden (cf. Keskitalo et al. 2009). Sveaskog, SCA and the common property board are all certified by the FSC.

12.3.2 Reindeer Husbandry

Reindeer herding is based on the natural migration of reindeer between summer and winter pastures, where they are mainly dependent on ground lichen grazing in winter. Drawing upon examples from the area, a 'Sámi village' or reindeer husbandry administrative unit which has reindeer grazing in the areas may have 20–30 active members and some 6,000–7,000 reindeer. Many of the members in the Sámi village also have subsidiary employment alongside reindeer husbandry, although they may be out in the field almost daily during the winter season (around October – May). Migration may be undertaken with herders employing technology such as snow mobiles or all terrain vehicles to follow the herd, or utilizing trucks in which reindeer are driven between areas rather than migrating. The latter is partially a result of the increasing fragmentation of areas by roads or other infrastructure that make previous herding routes untenable. In some instances, road transportation may also be due to increased efficiency with fewer animals lost or mixed with other herds along the way, thus maintaining the slaughter volumes required by higher economic demands on reindeer husbandry (Moen 2006).

Reindeer often move across large areas and routes may vary depending on grazing conditions, thus herding is impacted by activities on land traditionally used by reindeer, such as forestry, mining, or hydroelectric power that changes water levels in lakes, wind power development, and the railroad passing through the Gällivare municipality area. This implies that the impact as a whole from multiple activities, across the areas Sámi villages use, needs to be assessed, rather than only impacts from any one land use activity.

The need to secure economic returns from activity is as essential in reindeer herding as in forestry. One person notes that 'the biggest problem really is that . . . if you compare with other costs, the price [we are paid] for the reindeer meat does not increase to the same extent' (reindeer husbandry). Reindeer herders suggest, for instance, that more of the slaughter and processing should be local. However, EU requirements on slaughter have restricted the number of local slaughter houses, although access to slaughter facilities within the Sámi community exists in other municipalities or in dispensary summer slaughter houses. The Sámi village is prohibited from having economic income other than from reindeer herding, even if individuals, who are members in a Sámi village can have other income.

While forestry in Gällivare has a smaller significance than in many other municipalities, it remains a major focus of contention for reindeer herders in this as in other areas (cf. Danell 2005; Keskitalo 2008a; Moen 2006). This is a result of the impact of forestry and especially logging on grazing and thereby the food resources necessary for maintaining reindeer: 'The more they log they more it is destroyed and the worse are our possibilities to keep reindeer herds, so that we can maintain so many reindeer that we can live on it' (reindeer husbandry, interviewee). Sámi villagers who are in the forest lands all year round are more affected by forestry than mountain Sámi, but mountain Sámi – who are in the forest lands in winter – also note major impacts. As one interviewee states, since this is the time during which it is most difficult for reindeer to access grazing, the forest lands and 'winter grazing is the bottleneck' (reindeer husbandry, interview). In addition to effects on grazing, forestry practices such as clear cutting impact the accessibility of forage for reindeer, as driving winds pack the snow so hard that the reindeer cannot dig down unless there is very little snow. Other interviewees note that if many high tree stumps are left this may impede reindeer movement and herding by snowmobile, and that limiting costly forestry practices such as clearing, might support herd accessibility. Fertilization used in forestry may also limit the growth of lichen foraged by reindeer, as although it increases forest growth it impacts lichen growth negatively as lichen thrives on nutrient-poor soils. The means by which lichen foraged by reindeer, grounds are assessed (to be over or under the percentage where no fertilization can take place) may vary greatly from person to person and between forestry management and reindeer husbandry. One person notes that 'we are always coming up short because it is the billion incomes of industrial forestry that is counted against us' (reindeer husbandry, interview).

Given these contentious points and the differences in economic endowment between reindeer herding and especially large-scale forestry actors, coordination and consideration plays a large role. However, transaction costs incurred, such as attending meetings for coordination between reindeer husbandry and forestry, may be more affordable and less problematic for (larger-scale) forestry than for reindeer herders. As a result the potential for increasing the consideration shown by forestry to reindeer husbandry through international or market means is highlighted by some of the interviewees. One reindeer husbandry interviewee notes that certification has a large importance on forestry-reindeer husbandry relations, as having 'good relations with the indigenous population . . . has a high impact in Europe' (reindeer husbandry, interview).

Beyond forestry, interactions with other land uses are also emphasized. Snowmobiles may for instance scare reindeer off tracks, and even if snowmobile supervision areas are set up by the municipality these are not necessarily monitored. One person also notes that there has been much more tourist activity recently which may scare reindeer. If reindeer are disturbed it results in increased herding and monitoring costs for the Sámi village. Interviewees here note that nature reserves are beneficial as they retain tree lichen forests and limit disturbances, however herders also note that reindeer husbandry has not been afforded a role in determining which areas are chosen. In some areas where forest is sparser (i.e., in the mountains), predation by bears, wolves and wolverines have a large impact. Coordination mechanisms exist, for instance with the County Administrative Board and the Swedish EPA, although reindeer herding representatives argue that Sámi land use should have a larger authority to impact predation: a larger role has here recently been appointed to the Sámi Parliament, a Sámi-elected advisory body to the state. In relation to the general multi-use problematique, reindeer herders also consult with other interests such as Common Forests, Sveaskog, large scale forest companies and other non-forestry sectors, such as the railroad administration Banverket, and the Boliden mining company.

12.3.3 Tourism

In Gällivare, most winter tourism companies are to date small-scale, and there exist few companies that have tourism as their main occupation. Some target only the local and domestic markets, and drop-in tourists, due to limited facilities (such as not being able to offer tour packages), while others target the international market (either for summer or winter tourism, or both). Tourism activities may include trekking in summer, river rafting in spring, cabin lodging, skiing, reindeer sled tours, dog sledding, snowmobiling, sauna, and cultural evenings (where for instance Sámi traditional culture is described). One person explicitly describes his work as ecotourism, with the aim of leaving no lasting marks in nature by, for example, varying trails.

The tourism companies to a large extent emphasize marketing as important for retaining their businesses. One small tourism company remarked that they mainly target the international market and specific countries where they have marketing connections through a specific travel agency, while another company targets the domestic market and (to a more limited extent) international markets, where such connections exist. Many of the companies collaborate as they have limited products themselves. A company may, for instance, have snow shoeing but not access to reindeer and thus coordinate activities depending on customer requirements. However, 'since we cannot offer lodging, food, flights, a full concept, we cannot direct ourselves to foreign travel agencies or so' (tourism company, interview).

Many companies also mention administrative constraints. EU regulations on food safety prohibit cooking using river water, although this has been done traditionally, which makes it difficult for a small company to provide outdoor cooking facilities. Many companies note the administrative strain placed particularly on small companies, such as changing dog pens regulation, applying for permission to drive snowmobiles in natural parks or for outdoor cooking permits.

> You start with this because you are interested in nature, or dogsledding, or snowmobiling, or hunting and fishing . . . you do not have this business management thinking as a basis (tourism entrepreneur, interview).

Interviewees note that the municipality has the potential to provide support services regarding applications, and to consult them on the development of walking paths and cabins that can be used also for tourism. Interviewees also note that due to the seasonal character of for example winter tourism it may also be difficult to retain personnel year-to-year.

Interaction with other sectors, in particular regarding issues that may limit access to resources, are also emphasized by some of the companies. One person notes that:

> If you are to work with ecotourism, then very much is about anchoring your activities ... with all the different actors and specific interests: hunters, dog- and outdoor interests ... every bureaucrat has their salary, they are paid to attend all these meetings, but for me this is time that I'm not paid for (tourism entrepreneur, interview).

The same person notes that hunting and fishing activities for instance are impacted by a number of actors, from authorities such as the Swedish EPA to the EU, to hunting organisations, local hunting clubs and the public. Comments on sectorial interactions and interests are also made, in particular with regard to the posited new management system for Laponia, where Sámi interests will have the majority say: 'reindeer husbandry wants to prohibit all dogsledding in Laponia ... Tourism companies do not have any say in the Laponia Council' (tourism entrepreneur, interview). Another tourism entrepreneur notes that in Laponia resource use is more difficult to coordinate than when coordination takes place informally: with, for instance reindeer husbandry, 'it has become more of a political level ... and then it is harder to reach consensus decisions' (tourism entrepreneur, interview). Forestry is, however, hardly mentioned at all. One person notes that he has access to large wilderness areas and does not need to enter production forests or the Sveaskog eco-parks, thus production forestry for him does not constitute a large impact on his tourism activities. Infrastructure and road access for tourism is sometimes a problem, however at the same time tourism companies note that major asphalted roads and power lines should not be visible in areas that are marketed as the 'last wilderness in Europe'. One person notes that the most important thing for his tourism activities is the absence of roads, logging and planting of non-native tree species, and that the environment should be untouched.

Overall, tourism, reindeer herding and forestry thus place largely differing requirements on the environment, with forestry targeting production while naturalness to some extent is a value for the two other sectors. This makes for institutional conflicts over land use rights and management.

12.3.4 Existing Weather and Climate-Related Requirements of Actors

In general, many of the interviewees note changes across time in weather patterns. In particular, interviewees note that the winter, defined in terms of continuous snow on the ground, starts later and that thawing events have been more frequent. This is in agreement with other studies in the areas (cf. ACIA 2005; Keskitalo 2008a). For instance:

> [35 years ago] in autumn ... we biked on the ice and went skating ... today it is not certain that you can do this ... because one day is cold and the next day ... not (reindeer husbandry, interview).

> It is warmer now ... during my youth it was almost a given that first snow came around October 15 ... now... it can take until Christmas before there is a snow cover' (Common Property Board, interview).

Two tourism companies make similar comparisons of winters during the 1990s and now, noting that there have been warmer winters with more snow during the last eight years: for instance, during the 1990s, average winter temperatures were often between –10 and –25°C, while the last eight years have been between 0 and –10 or –15°C.

In forestry, the main impacts people note regarding changing conditions are warmer and shorter winter seasons placing constraints on transport and logging possibilities. For instance:

> we have seen already the last 15 years that this is happening ... for forestry it means that road networks and roadsides ... do not freeze up and are torn up by wheel marks when wood transports are made (Common Property Board, interview).

This means that the period during winter when roads can be used is reduced: 'We always have problems finding ... somewhere to log in spring when the frost goes out of the ground and roads are closed ... if spring arrives earlier it would be more expensive' (SCA, interview). Thawing and increased precipitation may further impede road access due to cold water welling up creating ice, while a thick snow cover ensures tall tree stumps and limited accessibility. Snow that falls late in spring, due to more unpredictable weather, may also impact spruce plants, although frost damage is relatively uncommon in this area by comparison to southern Sweden (Sveaskog, interview).

Several interviewees also note that some recent summers have been dry, with implications for forestry. One person notes that 2006 was an extremely warm and dry summer, causing both forest fires and drought (Common Property Board, interview) and even requiring re-planting of plantations due to decreased plant survival (SCA, interview). Interviewees note that hotter summers may increase forest fire risks, whilst more rain in summer may result in waterlogged ground that impedes production logistics. Regarding storm risks, the lower height that trees grow to, the higher proportion of pine and birch, and the decreased extent of spruce forest with superficial roots may also contribute to making forests less storm sensitive in this area than further south (Sveaskog, interview). On the question of tree line extension, the interviewee notes: 'we do not practice forestry that high anyway ... it is most often protected land' (Sveaskog, interview). As a whole, very few interviewees consider changes that would cause an impact, but that are not already noticeable or influential within the context of the existing regulative system.

For reindeer herding, which is impacted by day-to-day changes in weather or weather patterns that impair grazing resources, interviewees provide detailed descriptions of changes they have noted over the time they have been active. Given that the winter season is the most problematic for grazing, most comments focus on icing and thawing events in winter, as well as impediments to migration. This corresponds to the well documented observation, in relation to potential climate change, that ice crusts formed over snow impede reindeer access to ground lichen (Henttonen 1995; Sweden 1994; Rees et al. 2008). One person notes 'now we can have thaws and rain ... up until Christmas and we do not know until far into January how the winter will turn out' (reindeer husbandry, interview). This may have drastic consequences for grazing:

> Unsteady weather with rain and wet snow that falls and thaws now and then and having some freezing events ... that was what happened ... the winter before last, when it took out almost all reindeer grazing in Sweden (reindeer husbandry, interview).

Such winters, where the ice layer may develop just over the lichen, are much more detrimental than winters where dry cold snow falls on frozen ground, and any later thaw thus mainly affects the surface of the snow layer which may thereby soften up as new snow falls. One person notes, however, that an event in a recent winter with major rain in January also resulted in rain and melted water at ground level, causing icing directly on ground lichen with detrimental consequences for reindeer herding. In addition, one person notes that if it is windy during thaws, this speeds the drying and potentially prevents the development of a ice layer. The issue of iced-over pastures or snow also impacts migration (Rees et al. 2008). For instance:

> Earlier there was an ice crust on snow when we moved westwards ... in a day ... 12 hours of migration you got however far ... today there is no ice crust on snow, we have to rely on our migration routes and snowmobile trails ... that is established trails ... Earlier ... you knew that you were leaving ... you just went for the marshland areas and migrated. Today you need established paths (reindeer husbandry, interview).

Reindeer herders have also noted impacts in summer. One herder describes the optimal conditions:

> Our optimal summer is really ... warmth from June 15 to July 25 ... because the heat makes the insect come and help driving the reindeer up above the tree line to the mountain areas, it is easier to gather them ... and the warmth makes the mountainsides grow green ... but this warmth from ... 25 July towards August is the worst you could imagine ... grounds grow dry, greenery [dry up] ... flecks of ice and snow [in the mountain] disappear ... [and there are] insects (reindeer husbandry, interview).

Warmer temperatures can under some conditions result in more mosquitoes, limit growth potential for ground lichen and benefit other plants such as shrub/tree growth in the mountains. Insect disturbances and drought in summer, curtailing grass availability, are well documented negative impacts on reindeer herding as a consequence of warmer temperatures, as they reduce reindeer possibilities to graze and thus put on weight in time for slaughter (Heal et al. 1998; Kumpula 2001). Excessive warmth will restrict their capacity to graze as the reindeer will spend daytime in mountain areas on snow patches, both to cool themselves and to evade mosquitoes (reindeer husbandry).[1]

Finally, for the winter tourism sector, a large impact in terms of weather patterns and events can be particularly revealed by thawing events in winter. Three separate companies note that thawing events in a previous winter have had a major impact on their dog sledding activities, skiing activities, and snowmobiling activities, respectively (cf. Hall and Higham 2005). One person additionally notes that more limited thawing leads to 'wetter snow [which] makes it more difficult for us to travel by sled [have sled tours]' (tourism entrepreneur). Low seasons are in periods of transition between summer and winter activities: 'in May . . . there is too much snow to trek and too little to go skiing or snowmobiling' (tourism company, interview).

12.4 Current Adaptive Strategies

The definition of current adaptive strategies or management responses to exposure-sensitivities includes 'ways in which individuals, groups or organisations have adapted to the conditions and changes that have affected them' (Smit et al. 2008, 8; cf. Chapter 1, this volume; Smit and Wandel 2006). In relation to the stresses identified by interviewees described in the previous section, interviewees to a large extent focused on economically motivated adaptation. This concurs to a large extent with the literature, highlighting the need to view the stresses of globalization, including economic market change, and climate change in combination (cf. Keskitalo 2008a; Leichenko and O'Brien 2008; O'Brien and Leichenko 2000). The following section describes existing adaptations and perceived adaptive capacity in the forestry, reindeer husbandry and tourism sectors respectively, and discusses the potential for existing forums for consultation to support adaptation.

In forestry, adaptation strategies are aimed at both increasing productivity and involving forest owners in forest management and logging on their estates. Methods for increasing productivity included information extension initiatives (for instance *Kraftsamling Skog* including recommendations on use of fertilization, thinning and contorta pine) (Norra skogsägarna, interview).[2] Noting that Norra Skogsägarna has many elderly forest owners and also forest owners who live elsewhere, the Norra Skogsägarna interviewee states

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[1] However, one person also notes that while mosquitoes and flies may disturb reindeer and impede grazing, it is also not good to have too few mosquitoes and flies, as some existence of these keep the herds gathered in the forest land. One herder also notes that rainier periods during summer, potentially due to more extreme events, may impede reindeer gathering and the calf marking that is undertaken then, as the reindeer are difficult to keep to one area in conditions of cold and rain.

[2] Others, such as SCA, note, however, that since reindeer husbandry disapproves of contorta they try to limit such plantations (SCA, interview).

that 'we need to get the persons who now inherit forests to start thinking along new lines' (Norra skogsägarna). Many interviewees also note that the level of entrepreneurship and refinement in the area could increase. Several interviewees in different sectors note that traditionally there has existed a large reliance upon the state, and that this may have limited the entrepreneurship in forests. For instance:

> I think they have a little more, to use the word, attitude, at the coast . . . there you have been successful with getting your children a bit more engaged than we perhaps have here. We have some form of attitude that . . . the state's pie never runs out (Norra skogsägarna, interview).

In response to changes in weather patterns during the last few years, interviewees also note that there exists some awareness regarding the implications of these observations on transport. The time during winter when roads can be used is shrinking, hence new all-year roads may have to be built. In addition, the forest machines used would require to be able to work on weaker soils without destroying them (this would require that entrepreneurs to re-invest in and update machinery) (Common Property Board, interview).

In reindeer husbandry, current adaptive strategies include that reindeer herders may use emergency fodder such as pellets during periods when winter thaw and re-freezing creates a layer of ice over the ground lichen that reindeer cannot dig through. However, many interviewees noted bleak possibilities with regard to the future of reindeer herding, particularly as a result of the increasing costs and increasingly limited grazing access (cf. Danell 2005, Tyler et al. 2007). As one person expressed it: 'Without land, no reindeer' (reindeer husbandry, interview). One herder notes that the economic situation places a large pressure on reindeer husbandry:

> [It has] forced the Sámi village administrative unit to start thinking along new trajectories. You need to re-organise, quite simply, in order to salvage as much as possible of the ground grazing and the limited tree lichen grazing that [exists, so]. . . that you can use it systematically . . . and that [not] all the money is spent on fodder (reindeer husbandry, interview)

This person suggested that a small fee per cubic meter of logged forest could be diverted to supplementary reindeer feeding. Many other interviewees also emphasized the role of forestry, and voiced concern that adaptive measures suggested within forestry, for instance increased fertilization, would have negative consequences for reindeer husbandry. 'The more fertilization objects that arise, the more field surveys we need to do if we want to limit it . . . we have to go out there and motivate it to get it stopped' (reindeer husbandry, interview). One Sámi village also notes that they have been sued by land owners over grazing rights, and that they cannot afford to go to trial because of the costs. This person suggested that since the state has allowed reindeer herding in the area for hundreds of years, and administered the division into Sámi village administrative units, 'someone should have entered into this from the state and stated that this cannot be tried as there exists a reindeer herding right in the area' (reindeer husbandry, interview). As another way to increase the resources for reindeer husbandry, one person noted that if the restriction on Sámi villages having economic income only from reindeer husbandry were to be loosened, it would be possible for these units to also gain other supplementary incomes. This could be for instance through tourism administered by the Sámi village, or to own and administer helicopters jointly between villages, as many villages currently rent helicopter time for herd monitoring.

As a result of the current situation, some weather impacts are potentially 'tipping the scale' for reindeer herding. During a bad winter with thaws, leading to the development of ice crusts over the ground lichen, significant costs for supplementary feeding, which constitutes a major adaptation, may be incurred. If the situation is considered an emergency, the state will later reimburse 50% of costs. However the remainder may cause significant financial strain on reindeer herders. 'According to animal husbandry legislation we are required to feed the reindeer although we cannot afford it' (reindeer husbandry, interview). These problems make one herder even note that '[if weather becomes more unpredictable over all] then I don't think one should be practicing reindeer husbandry' (reindeer husbandry, interview).

The tenet of these comments was in general shared across reindeer herding interviewees, although there is variation between the Sámi villages. Compared to a forest Sámi village, which often has more geographically proximate grazing areas, a mountain Sámi village, with grazing from coast to coast, has 'more variation in height levels and can find places [for grazing in different conditions]' (reindeer husbandry, interview). Adaptive capacity may thus differ depending on specific conditions.

For tourism, there also exists a diversity of adaptive capacity expressed by interviewees and groups. One person notes that companies that have a broader product line are not as sensitive to shifts in demand as a single activity entrepreneur, and that 'one has to be a bit of a jack of all trades' (tourism entrepreneur, interview). A shared concern among many interviewees was the development of marketing possibilities, such as a destination company, able to market the location beyond the reach of existing companies such as *Visit Gällivare* and *Swedish Lapland*. For instance, one person noted: 'The major limitation ... is our marketing ... how do we find customers?' (tourism entrepreneur, interview). Given the relatively little development in the tourism sector, some interviewees note that they may need to develop their products further to be able to compete. For instance, one person notes that certification according to 'Nature's Best' – a Swedish ecotourism certifying organisation – would be an avenue for development: 'the great advantage of certification is that you actually systematise your thinking and your acting' (tourism entrepreneur, interview).[3]

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[3] One company also notes that as the rent land from Sveaskog, Sveaskog has offered free certification.

Involving all the sectors to some extent, the existing consultation forums and practices can also be regarded as potential adaptation sites. These fora play a role in shaping the institutional setting for the sectors, and may to some degree impact adaptation possibilities. Reindeer husbandry notes their cooperation with the municipality evidenced by the ongoing developments of a Sámi economic centre in Gällivare and that there exist venues, such as dialogue meetings and a model forest cooperation area, organized by Sveaskog. The Laponia management structure may also shape adaptive possibilities in the areas that fall under its control. In this case, there exists a potential for Sámi influence, even a Sámi majority. The Laponia management system will be subject to governmental decision in 2010. 'As we see it today we want it to become an area . . . with its own governing board and own administration and management' (reindeer husbandry, interview). Such a development might support reindeer husbandry, although it may have less favourable impacts on tourism, as described above.

12.5 Future Exposure-Sensitivities

Future exposure-sensitivities include scientifically documented trends or probabilities of change in the range of exposures, including posited changes in climate. A focus has been placed on climate change impacts, and the continuation of trends previously noted by interviewees. Projections in general describe a more temperate climate with delayed and milder winters with thaw periods and accompanied by increased precipitation (ACIA 2005; IPCC 2001; Lange 2008; Lundmark et al. 2008). Spring may arrive earlier due to increased temperatures, but may be delayed by increased snow and thereby delayed snow melt in some areas such as valleys or local low-lying areas. The rate and scale of snow melt will also influence the seasonality and strength of the spring flood (Høgda et al. 2001). Warmer temperatures and a longer growing season may improve forest growth significantly, especially supporting Scots pine (*Pinus sylvestris*) over Norway spruce (*Picea abies*), but may also cause heat stress or drought (Layton and Pashkevitch 2000; Sygna et al. 2004; Wolf et al. 2008). The likelihood of thaws, re-freezing in spring, storms or other extreme weather events may increase (Sygna and O'Brien 2001).

While interviewees in general did not relate questions about impacts from, for example, an earlier spring to climate change impacts literature, an exception to this was the environmental protection organisation which noted risks from projected species change, explicitly referring to scientific literature. The interviewee noted that white foxes may be outcompeted by red foxes, invasive species that require longer growing seasons may be able to establish themselves in higher-lying areas, weak competitors that have adapted to a low competition environment, as well as species that populate specific niches, will be displaced, ticks may spread to the area, and drier summers may result in drier wetland

Table 12.2 Main identified future exposure-sensitivities and adaptive strategies in the case study, especially related to climate

Vulnerability / Sectors	Future Exposure-sensitivities	Future adaptive strategies
Forestry	Winter logging Spring flood impact on areas Spring re-freezing impacts on forest Increases in pests Storm felling or damage	Continuation of present strategies such as building of all-year roads and modernization of machine parks Changes in forest management, potentially to accommodate uncertainty
Reindeer husbandry	Winter thawing events and iced-over pastures Multi-facetted impacts from storms/strong wind Impacts on migration	Continuation and enhancement of present strategies such as supplementary feeding and movement of reindeer with trucks Potential changes to management systems
Winter tourism	Shorter season causing loss of income and predictability for booking	Potential shift in focus for tourism (e.g. shift of seasonal focus to summer activities)

areas thus encouraging trees to establish themselves on wetland areas (environmental protection organisation, interview). The interviewee also noted that such changes will require species migration routes. While this may be possible in Gällivare with its large protected area, he noted that forestry further south is far more fragmented, thereby limiting the areas for different species movement (environmental protection organisation). Regarding impacts on the winter season, the interviewee noted that ‘it impacts ground fauna … very much if it is a thick snow cover or not and stable conditions’ (environmental protection organisation, interview). The diverse future exposure-sensitivities and adaptive strategies in different sectors are described below and summarized in Table 12.2.

For forestry, the Swedish Forest Agency noted that delayed winter would make it more difficult to transport wood out of forestry areas and thus reduce the carrying capacity on the ground. Thawing in winter decreases the snow depth and may improve access for forest machines and transport; however, ‘there can be a problem with [winter] roads … [which] do not last as long as earlier when they lasted until April, mid-April. Now you have to leave [areas harvested by the use of winter roads] almost in February’ (Swedish Forest Agency, interview). This is because no roads apart from winter roads may exist to many logging sites (Swedish Forest Agency, interview). A shorter winter season and thaws in spring will thus impact logging and transport negatively (Norra skogsägarna, interview; cf. Sweden 1997; IPCC 1998). Interviewees also noted that more snow in winter will result in higher tree stumps, as less of the tree can be harvested, and allow animals to cause grazing damage higher up the stems (Common Property Board, interview). More precipitation will cause a stronger spring flooding (environmental protection organisation, interview). A more intensive spring flood, on account of more snow in late winter (higher precipitation during frozen period), could cause flooding of roads and impede logging (Common Property Board, interview).

Interviewees also noted impacts on forestry from frost events in spring, especially in combination with pests. Spruce is especially frost-sensitive and could be impacted by spring re-freezing. The main species currently planted is pine, although spruce is common in some areas and in reserves. However, as a result of an increased and detrimental impact of fungi (Swe. *törskatesvamp*, varieties *Cronartium flaccidum* and *Peridermium pini*) on pine stands during the last four warm years, more spruce may be planted in the future (Swedish Forest Agency, interview). The impact of fungi and pests such as the large pine weevil (*Hylobius abietis*) may increase in the future if the climate is warmer and/or wetter (potentially due to more precipitation falling in the form of rain rather than snow, cf. IPCC 2001). This is especially likely if monocultures of trees such as pine are maintained. Interviewees note, for instance, that forests may become less sensitive if more spruce and even birch is planted (Swedish Forest Agency, interview; SCA, interview). Pests may result in trees being increasingly vulnerable to frost stress (freezing and thawing over time, which may result in flowering before winter has passed and subsequent damage during later frost events) (Common property board, interview). By contrast, the environmental protection organisation noted that more pests are potentially beneficial for birds feeding on pests (environmental protection organisation, interview).

Storms also have a large impact on forestry. Potential effects are well documented in Sweden, in particular following the hurricane Gudrun in 2005 in southern Sweden and the major storm felling that resulted (Swedish Commission on Climate and Vulnerability 2007; Bergh et al. 2007). More storms may increase windfall of trees, which in the case of smaller windfalls, may not be utilized for wood production, and also increase unpredictability in planning (Swedish Forest Agency, interview). More storms could cause breakage of standing wood and make for unplanned logging during times that are not optimal, or may go to waste if breakages take place when it is too difficult to log wood volumes. Such events would impact the industry, make planning in forestry more difficult, and also cause problems for public access to forests (Common Property Board, interview) and potentially to infrastructure such as electricity lines.

For reindeer husbandry, the earlier described changes during winter could become even more severe, to the extent that thawing events and iced-over pastures threaten the sustainability of reindeer husbandry. Regarding projected changes, herders also note that increased precipitation, something that has already been noted in some winters, may bring problems if there is much snow that doesn't melt prior to calving season, a period when calves need warm weather and snow-free ground for good grazing (reindeer husbandry, interview). The impact of less snow, on account of a higher proportion of precipitation falling as rain, was not much commented upon by herders. One person noted that such a situation would potentially be beneficiary as snowmobile traffic might decrease, illustrating the complex interlinkages between climate and social practices:

> A lot of snow and decreased access also supports reindeer herding in the way that snowmobiles follow set routes ... the disadvantage is that it is more difficult for the reindeer to get ahead and find grazing (reindeer husbandry, interview).

Regarding the risk of a larger spring flood related to increased precipitation, herders noted that the existing wetlands in the area may mitigate a large spring flood by being able to absorb much of the water (reindeer husbandry, interview). Increased water levels in rivers may impede reindeer migration. As described above, warmer summers were also largely seen as beneficiary for reindeer husbandry.

Regarding the impact of increased storms, herders commented in particular on situations that were more familiar to them, such as strong winds. One herder noted that strong winds may have some beneficial impact in making lichen fall from the trees, but may also serve to scatter reindeer herds, as reindeer graze on fallen lichen. Reindeer may also walk against the wind, thereby moving the herd and increasing the requirements for monitoring. Herders also noted that some of the potential impacts, such as increased forest growth, will have indirect impacts on reindeer herding. Increased forest growth may have a fertilizing effect on forest grounds (through fallen leaves and pine needles) that may limit lichen growth. There are also other interacting effects. Increased logging, which limits available shade for reindeer, interacts with increased heat in summer to tire reindeer. It has also been noted that lichen may be outcompeted over a longer term in warmer temperatures by species such as shrubs (Guisan et al. 1995; Henttonen 1995; IPCC 1998).

For tourism, companies in general noted that a shorter winter season or thawing in winter could have major detrimental effects (similar effects of unreliable snow cover are noted for the Scottish highlands by Harrison et al. 2005). One tourism company noted that if they were to work with larger foreign tourist agencies and book for instance dog sledding, it would be a disaster if thawing (giving thawing events in a previous year as an example) prevented the activity. 'If it thaws very, very, strongly in that way it will be more difficult to bring activities through, the weather will be worse, there will be fewer people who buy activities' (tourism entrepreneur, interview). A shorter winter season would also mean that winter-centred tourism companies lose some of their income; for instance, one company currently maintains full winter activities until the end of April and notes that 'If that changes, it will encumber us' (tourism company, interview).

Two separate companies note that tourists may also be particularly interested in the extreme conditions that are seen as typical for the location (very cold temperatures and much snow), which may limit interest in less dramatic experiences. However, another company/entrepreneur notes to the contrary that: 'if the temperature is warmer so that we do not have these cold days below 25–30 degrees the advantage is that the climate is more pleasant and people buy more activities' (tourism company, interview).

Regarding changes in summer and spring, one tourism company notes that a warmer summer might dry up creeks and thereby result in lower insect stress on reindeer and improved cultural summer activities; one person also notes that hotter temperatures in southern Europe could discourage tourists from travelling there and attract them to the more moderate climes here (Hall and Higham 2005 similarly note the potential shifts in mobility patterns). Re-freezing in spring could disturb migratory birds that have started to lay eggs, thus limiting bird populations with subsequent effects upon hunting related tourist activities. Similarly, another tourism company notes that warmer drier summers may limit mosquito populations and as a result bird populations (impacts on tourism from ecosystem change are also noted by Hall and Higham 2005). The same interviewee notes that species such as bats and ticks are moving northward, and that a warmer climate may also increase overall biological diversity as more species to establish in northern areas. Another tourism entrepreneur notes that the most important environmental factor is that 'we are able to retain the snow [season]' (tourism entrepreneur, interview), as 'fewer and fewer areas have a real winter, it may be an advantage for us' (tourism entrepreneur, interview). A third person notes that

> the most important factor is that there are not too large fluctuations in climate . . . one year we have snow until May and the other we have snow until March (tourism entrepreneur, interview).

Finally, in addition to the risks related to climate changes, interviewees in addition also note the possibilities of changes in attitudinal trends in society. For instance, one person noted that whereas the catch from fishing often used to be sold, now many come to fish and then release. On the other hand, and possibly to a larger extent, people may be losing their connection to nature and thereby an interest in protecting areas as they spend less time outdoors than indoors (environmental protection organisation, interview). One of those few who commented on increased forest growth and a higher timber line noted attitudinal impacts as well as potential political impacts. Increased forest growth might, in a first phase, result in increased shrubbiness which impedes access and hunting, and create forests which may be perceived as less beautiful, and thus less desirable, to tourism or local recreation (environmental protection organisation, interview). Attitudinal change may thus also interrelate with forest use in the future.

12.6 Future Adaptive Capacity

Future adaptive capacity, in response to the future exposure-sensitivities, is dependent on forms of capital, technology, institutional arrangements which, amongst other factors, may either facilitate or constrain adaptation. For forestry, much of future adaptation potential can be seen to lie in technological, forest management and planning responses. Technological responses include roll-outs placed on the ground to enable forestry machines drive in rainier winters (Sveaskog, interview). Similarly, as the period during which winter roads can be used is shrinking, new all-year roads may have to be built. In addition, forest machines would need to be updated to models that are able to work on weaker soils without destroying them. This would, among other things, require forest entrepreneurs to make re-investments to update their machinery (Common Property Board interview). 'The technological part ... that is maybe what is possible to change' (Sveaskog, interview). Another person noted the many potential responses in terms of changing forest management practices, which are, however, difficult to foresee:

> Instead of leaving seed trees if you get a lot of wind ... you could plant more ... If there is a lot of snow perhaps you have to thin more carefully so that snow won't split the trees ... you have to consider some other forest management methods, or improve forest management methods (SCA, interview)

In case of more unpredictable weather the entire forest planning system might have to adapt: 'you would have to plan in an entirely different way ... you have to have alternatives all the time' (SCA, interview). 'There would be more work and it would be costlier' (SCA, interview).

The issue of forest growth was brought up by a number of interests, mainly in relation to changing the planning system with regard to forest planting and in regard to potential implications on resource distribution. One person noted that if forest grows better it will be positive for forestry: 'it is just to manage the transition ... with this long time cycle that we have in forestry' (Common Property Board, interview). However, improved forest growth could also result in changed resource distribution and priorities that exacerbate ongoing conflicts over resource use. One interviewee noted, for instance, that with improved forest growth,

> then forest companies will want to have an ever larger [piece of the] cake up here ... they will then fight for making it possible to log ... and have re-planting and growth (environmental protection organization, interview)

> Forest will probably not be a resource that will be sufficient [for all] in the future ... then there may exist other political orientations that think that we should start using this as a resource ... not only retain it for future generations (environmental protection organization, interview)

The same person notes that 'then the question is if we should retain this as a national interest ... nature reserves and national parks and so on' (environmental protection organisation, interview).

Such pressures, on top of the current resource stresses impacting reindeer husbandry, could have additional effects, not only on the sector as such, but on local communities and Sámi culture at large, particularly should reindeer husbandry be further impacted by fragmentation of grazing areas (tourism entrepreneur, interview). A continuation of current trends in reindeer husbandry would entail that more reindeer are moved with trucks due to constraints on migration routes, or that reindeer are collected in pens for supplementary feeding on account of thaw in winter (environmental protection organisation, interview), thereby altering the management system to adjust to changing requirements. For tourism, one person noted that a shorter winter season and thawing events would require changing the product offered to tourists, potentially taking advantage of larger summer tourism. This has also been suggested by Gyimóthy (2006, 257), who notes that 'destinations must assess and revise their soft infrastructure and marketing activities'.

However, tourism companies as well as other actors mainly reflected on factors related to their current situation, rather than potential results of uncommon and unfamiliar events. Thus, relatively few in forestry discussed the impacts of a raised tree line and potential over time for increased logging; similarly, in reindeer husbandry, few discussed the impact of severe storms on reindeer but rather commented situations such as strong winds that are more familiar.

12.7 Discussion and Conclusion

The study shows that the stresses and adaptive capacity among actors in forestry, reindeer husbandry and tourism in the Gällivare municipality are to a large extent related, sometimes in a negative way, through the use of a common resource. The level of regulation as well as market pressures and integration has increased for all of these sectors, with the result that conflicts between sectors have become more pronounced. The interviewees focus on the situation today and on economic pressures (cf. O'Brien and Leichenko 2000). Climate change is attributed importance particularly as a result of possible economic effects (cf. Keskitalo 2008a).

For reindeer husbandry, the linkage to climate change, including extreme weather events, is the most apparent in the material. This is due to the recurrence of thawing events in winter to the limited economic margins for the sector (cf. Tyler et al. 2007; Keskitalo 2008a). In the material, the pronounced impacts on forestry are to a large extent short-term impacts that influence accessibility. However, at the level of forest companies and forest owners' organisations in Sweden, adaptation to climate change has recently gained a larger prominence. Adaptations such as new plant material and revised forest management strategies that address changing temperature, precipitation patterns and storm risks are being discussed (KSLA 2009). For tourism, the relatively low risk attributed to climate change may to some extent be a result of the socio-economic structure of tourism in the area, with few and rather small companies that have limited expenses and may be able to relatively easily adapt their activities.

The consideration of the low infrastructure cost in small-scale tourism represents a contrast to earlier studies of regional forestry and reindeer herding where the small-scale actors in the sectors expressed a large vulnerability (Keskitalo 2008a). While forest industry and reindeer husbandry are both dependent on access to large areas for grazing or extraction, and maintain considerable infrastructural expenses in terms of machinery, sawmill equipment and herd maintenance, small-scale tourism actors describe themselves as relatively adaptable. This may be due to relatively low costs and limited reliance solely on tourism at present. However, were the tourism sector and reliance on tourism in the area to increase, it is possible that tourism would also exhibit larger economic and infrastructural dependencies. In the longer term, changes in climate may have the potential to change the balance between sectors resulting in differential benefits for different actors. Such changes may also alter the rights distribution and the environmental protection value that to some extent support retaining large areas that may be of benefit both to reindeer husbandry and tourism.

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Chapter 13
Local Effects of Global Climate Change: Differential Experiences of Sheep Farmers and Reindeer Herders in Unjárga/Nesseby, a Coastal Sámi Community in Northern Norway

Stine Rybråten and Grete K. Hovelsrud

Abstract Unjárga/Nesseby municipality is located in the inner part of the Varanger fjord in eastern Finnmark. Combining reindeer herding, agriculture, coastal fisheries, hunting and gathering has been of fundamental importance to the population in this coastal Sámi community for centuries. Although today this combination of activities no longer provides the same level of livelihood sustenance in the municipality, natural resource based activities and different kinds of harvesting remain of great significance for the residents, as economic activities, for recreation and in people's sense of belonging. This chapter looks at the interlinkages between maintaining and developing the important nature based industries of sheep farming and reindeer herding in Unjárga/Nesseby, and the locally experienced outcomes of global climate change. Consistent with the CAVIAR framework, we assess exposure-sensitivities and local adaptation strategies to changing conditions influencing these livelihoods. We present a preliminary analysis of the linkages between future climate trends and the adaptive capacity of the local animal husbandries. Our main focus is on the four recent years of extensive moth larvae outbreaks [larvae from autumnal moth (*Epirrita autumnata*) and winter moth *(Operophtera brumata)*] that have resulted in widespread birch forest mortality in Unjárga/Nesseby municipality. The persistent moth larvae attacks are likely to be a result of a milder climate. As these alterations have radically changed the landscape, sheep farmers and reindeer herders in the community are introduced to new livelihood challenges, as well as opportunities.

Keywords Animal husbandry · Climate change · Adaptive capacity · Coastal Sámi · Norway

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13.1 Introduction

Being a sub-Arctic community, the seasonal changes in Unjárga/Nesseby are reflected in the nature-based activities carried out in the municipality throughout the year. Even though seasonal variation and annual fluctuations are part of the residents' everyday life, recent climate related changes have created concerns regarding future possibilities for current nature-based activities. Additionally, other drivers of change bring challenges and opportunities to every day life of the inhabitants in this coastal Sámi community.

In this chapter we look at the interlinkages between maintaining and developing the nature based industries of sheep farming and reindeer herding in Unjárga/Nesseby, and the locally experienced outcomes of global climate change. The goal of this chapter is to analyze how and to what degree sheep farmers and reindeer herders in Unjárga/Nesseby experience and respond to climate change and other drivers of change. Our findings illustrate that practitioners of the two livelihoods have different perceptions of the same changes, even though they occur under similar conditions. Combining these experiences with downscaled climate projections, we also examine possible future exposure-sensitivities and adaptation needs for animal husbandry in this coastal Sámi community in Northern Norway.

In the following sections we give a presentation of the Unjárga/Nesseby municipality and its historical context of local animal husbandry, before we turn to the methods used in our research and outline the present situation of sheep farming and reindeer herding in the community. Further, we look at how consequences of climate change, combined with land use changes and reduction in grazing land, create a set of exposure-sensitivities for both sheep farmers and reindeer herders in Unjárga/Nesseby, where special attention is given to the recent years' extensive moth larvae outbreaks in the municipality. With this as a backdrop, we analyze the adaptive capacity of the reindeer herding and sheep farming livelihoods, before finally discussing the challenges and opportunities farmers and herders in Unjárga/Nesseby may face with regard to future climate change.

13.2 Unjárga/Nesseby – the Community

Unjárga/Nesseby municipality, with its 878 inhabitants,[1] is located in the inner part of the Varanger fjord in eastern Finnmark at 70°N and 29°E (see Fig. 13.1). The coastal Sámi municipality is bilingual, with Sámi and Norwegian as official languages. Combining reindeer herding, agriculture, coastal fisheries, hunting and gathering has been of fundamental importance to the population in

[1] By 1 January 2009. Statistics Norway (http://www.ssb.no/kommuner/hoyre_side.cgi?region = 2027).

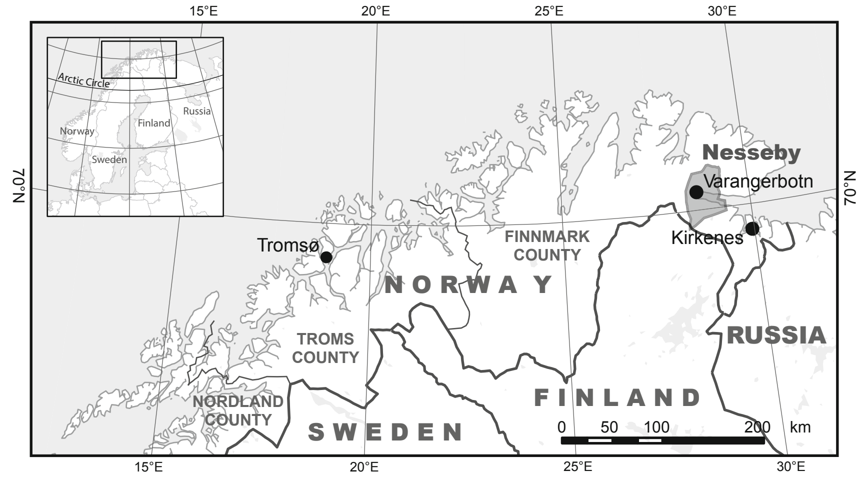

Fig. 13.1 Map of Unjárga/Nesseby municipality in Eastern Finnmark, Norway. *Source*: Map by Winfried Dallman

Unjárga/Nesseby for centuries. Although today this combination of activities no longer provides the same level of livelihood sustenance in the municipality, natural resource based activities and different kinds of harvesting remain of great significance for the residents, in terms of economy, for recreation, in identity formation and in people's sense of belonging.

During the last 50–60 years, the municipal service sector has grown steadily. Most current employment positions are connected to the service and public sector. In addition, tourism is a growing business in the community. Nevertheless, the economic and cultural significance of primary industries such as sheep farming, reindeer husbandry, and fisheries continue to be important livelihoods in the municipality.

In this chapter we focus on the animal husbandry activities of sheep farming and reindeer herding. These two land-based primary industries are both dependent upon the uncultivated pastures and are exposed to the same climate elements. Nevertheless, the local consequences of a changing climate are not necessarily experienced the same way, and as we will show the two livelihoods are differently affected.

13.3 The Historical Context Of Animal Husbandry in Unjárga/Nesseby

The first humans that settled in the inner part of the Varanger fjord arrived more than 10,000 years ago. Numerous remains, from the first settlements established shortly after the end of the last ice age and up until today, can be found along the coast of the Varanger peninsula. Most of the abundant cultural remnants inland of the peninsula originate from the Varanger Sámi and from their long-established utilization of the area (Nilsen 2003). Thus, the inland area of the Varanger peninsula has been, and still is, an important resource area for the Sámi population in the region.

Unjárga/Nesseby municipality occupies the core land of the old Sámi Várjjat siida[2], which formerly also included more extensive areas along the Varanger fjord (Odner 2000). In the 1500s, the Varanger Sámi made up more than 10% of the population in Finnmark and about 1/3 of the coastal Sámi population in Norway (Nilsen 1990).

The Varanger Sámi have roots in both coastal Sámi and reindeer herding Sámi traditions, and extensive resources in the fjord and the abundance of wild reindeer inland were of fundamental importance to the Várjjat siida. A combination of farming, fishing, reindeer herding and hunting activities constituted the basis of existence for the Unjárga/Nesseby inhabitants up until the middle of the 1900s.

Keeping domesticated reindeer was common practice among the coastal Sámi, and a family commonly owned between two to 50 animals. The Sámi kept reindeer for the milk, the meat, and the hide, and for transportation purposes (Nilsen 1991). In the 1600s, a reindeer herding Sámi population was established in the Varanger area. The initial herds were small and herding was combined with farming and fishing. Only for the last 30 years has reindeer herding in Unjárga/Nesseby been a single occupation (Nilsen 1990). Hunting wild reindeer came to an end around 1700, although there were still wild reindeer present on the Varanger peninsula until the 1800s.

Keeping cows for milk appears to already have started in the 1700s. For a long period, most families kept a small herd of sheep and one to three cows, mainly for own household consumption. The establishment of an eastern Finnmark dairy around 1950 caused some families to stop with cow farming and turn to store bought milk. Others increased their herd size and specialized in dairy farming (ibid.). Since then, extensive alterations within the agricultural industry and societal changes in general have led to a decrease in number of dairy farmers, from 50 farms in Unjárga/Nesseby 60 years ago, to one single dairy farmer in today. Currently, sheep farming is the most important agricultural industry in the municipality.

The occupational specialization that characterizes the economic activities in Unjárga/Nesseby today began evolving in the 1920s. Formerly, the combinations of resource based activities that constituted the coastal Sámi livelihood was seen as a necessity, as the activities were highly integrated. Starting in the early 1900s, the initial Sámi subsistence economy underwent a progressive transition to a market oriented economy, influenced by Norwegian societal changes and modernization processes. Construction work became an

[2] The Siida was the old Sámi social system, existing till the 1600s. The concept Siida could describe both the (local) community and the territory this community had the right to use (VSMČ 2005).

important source of income, and gradually the telegraph and the local port facilities created year-round employment for both men and women in Unjárga/Nesseby. At this time, being the greatest source of income, the fishery was seen as the most important activity among the Sámi resource based industries (Hoëm 2007).

Occupational specialization continued to evolve in the 1930s, however during the years of World War II, people partially returned to the traditional subsistence economy as a response to the scarcity of essential commodities. Once again the inhabitants in Unjárga/Nesseby made use of the land on a large scale to produce what they needed for their livelihood. According to Hoëm (2007), the period from 1940–1945 promoted a strengthening of the Sámi community life, an actualization of self-supplied activities, and consequently an increased focus on Sámi culture as well as Sámi economy.

A certain degree of self-sufficiency and a combination of activities is still valued among many of the Unjárga/Nesseby inhabitants today, although occupational specialization is needed to ensure efficiency and profitability in the primary industries, as well as in the other occupations in the municipality.

13.4 Study Approach and Methods

The highly visible and wide-ranging moth larvae outbreaks recently causing extensive reduction in the birch forest area over large areas in Unjárga/Nesseby and adjacent municipalities, have resulted in a broad engagement and comprehensive discussions among local inhabitants, in the media and among natural scientists (see e.g. Jepsen et al. 2008; 2009; Tømmervik 2009). For this study, we were interested in how these considerable changes in the regions forest might (or might not) affect the livelihoods of local sheep farmers and reindeer herders, as the affected areas make up parts of their animals' pastures.

The empirical data for this study were collected during one year of continuous fieldwork in Unjárga/Nesseby, from January 2008 to January 2009. The methods applied are consistent with the methodological framework of the CAVIAR research program (as outlined in Chapter 1).

A scoping visit to Unjárga/Nesseby took place in August 2007. During this visit, contacts were established and preliminary interviews were conducted. Additionally, baseline information was gathered in advance of, as well as during, the fieldwork period. Focusing broadly on people's relations to nature (including weather and climate), participation in different local nature-based activities constituted an important part of the fieldwork activities. Participation of this kind was not only crucial in learning about the different nature-based activities practiced in Unjárga/Nesseby, but it also provided the background for formulating locally relevant questions and conducting in-depth conversations. Semi-structured interviews were carried out throughout the fieldwork period, and the interviewees included representatives from the primary industries, state employees, local government employees and senior citizens. In addition to participant observation, semi-structured interviews and conversations, information was also obtained from local town meetings, literary sources and the media.

During conversations and interviews, efforts were made to avoid questions relating directly to climate change, in order to mitigate researcher led bias which may overshadow other important aspects of local human-nature related conditions. Instead, the questions addressed change in more general terms. In this way, the chance of restricting narration and directing the answers of the interviewees were reduced.[3] As illustrated in this chapter, both sheep farmers and reindeer herders brought up climate-related experiences of change in their nature-based activities. These experiences will be discussed in detail, following a presentation of the present day context of sheep farming and reindeer herding in Unjárga/Nesseby.

13.5 Unjárga/Nesseby Sheep Farming and Reindeer Herding of Today

Like many other small communities in the outskirts of Norway, Unjárga/Nesseby has experienced a population decline since the mid 1900s. Nevertheless, from the 1950s, the number of sheep farms in the municipality has doubled, to the present number of 13 sheep farms with more than 1,300 sheep. Currently, sheep farming is the most important agricultural industry in the municipality, with approximately 70 people directly and indirectly involved, corresponding to the amount of people associated with the local reindeer herding industry.

In 2002, the Old Norwegian Sheep breed (*dološ sávza* in Sámi and *villsau* in Norwegian) was introduced in Unjárga/Nesseby when six farms jointly bought a total of 30 sheep. The Old Norwegian Sheep farms now count ten, with more than 800 sheep on pasture during summer (Bjørkli 2008).

Different reasons are given for the establishment of Old Norwegian Sheep farms in Unjárga/Nesseby. Some refer, with fondness, to the old local sheep they grew up with, regionally called the Sámi sheep. This breed disappeared between the 1960 and the 1980s, and the Old Norwegian Sheep are seen as a good replacement for the former Sámi sheep breed. The farmers note that the Old Norwegian Sheep have retained most of the breed's original instincts, they are small and light-footed, take good care of their lambs, have a strong flocking instinct and seldom fall prey to predators. The latter is important in light of the reported increase in number of predators in the region, and the choice of sheep breed is discussed below as an adaptive strategy. The Old Norwegian Sheep breed has a versatile grazing pattern, utilizing 'everything', including grass,

[3] This is consistent with Marino and Schweitzer (2009, 210) who argue that '*not talking* about climate change proved the best method for understanding local conceptions of change'.

heath, herbs, shrubs, tree bark, leaves and twigs. This gives the meat a mild but rich taste, reminiscent of game.

The Old Norwegian Sheep are smaller, the number of offspring is lower and their slaughter weight less than modern breeds bred for high meat yield. As this attribute makes the Old Norwegian Sheep farms in Unjárga/Nesseby initially unprofitable, farmers have found means to increase the value of local production. Cooperation with the local reindeer slaughter house ensures minimal travel between farm and slaughter. This enhances sheep welfare, and accordingly their market value, permitting the branding of 'short-travelled' sheep meat.[4] With only limited advertisement effort, the consumer demand exceeds the offer of locally produced meat. Production of refined and differentiated products is currently under development.

The sheep in Unjárga/Nesseby are kept either inside fences in the barn during parts of the year, utilising remote pastures from mid June towards the end of September. The reindeer, on the other hand, make use of the pastures throughout all seasons. As in other parts of the circumpolar north (see e.g. Oskal et al. 2009), reindeer herders in the Unjárga/Nesseby district, Várnjárga, follow the migratory patterns of their reindeer from the summer pastures in coastal grass areas on the Varanger peninsula, to winter pastures in the lichen rich inland areas, close to the Russian and Finnish borders (see Fig. 2.1).[5] The reindeer herders are thus able to make use of the mountain and tundra areas for valuable food production. In this way, their livelihood strongly depends upon the health of natural pasture resources and the productivity of the ecosystems (Burkard and Müller 2008).

The demand for efficiency and productivity has resulted in major changes to the Várnjárga reindeer herd structure over the last 20–30 years. Traditionally, old male reindeer were not only a symbol of status, but in hard winters their strength could influence the survival rate of the herd positively, as older males were able to dig through hard snow and ice layers in the snow to get to the food. Currently, the number of large, older males has been significantly reduced, because it is economically profitable to slaughter the males when their growth rate has reached its peak. Most males are now slaughtered when they are 1.5 or 2.5 years old (VSMČ 2005). The expensive and work intensive management of older males, who tend to travel considerable distances during the mating season, is another reason for the change in herd structure. In 2007/2008, the proportion of male reindeer in the Várnjárga district comprised about 5% of

[4] The local reindeer slaughter house in Unjárga/Nesseby is also approved for smaller animals such as sheep.

[5] The reindeer pastures located within the boarders of Unjárga/Nesseby municipality only make up a small proportion of the total grazing land of the Unjárga/Nesseby reindeer herding district. During summer the reindeer mainly utilize the more northern and eastern parts of the Varanger peninsula, returning to Unjárga/Nesseby municipality in the autumn on their way to the winter pastures.

the herd (Reindriftsforvatningen 2009). To ensure a high production of calves, the herders have increased the proportion of female reindeer in the herd.

During the last years, both summer and winter pastures in the Várnjárga reindeer herding district have been rich, resulting in good growth among the animals and high slaughter weights. For the 2007/2008 season, the Várnjárga district, together with its neighbouring district, had the highest proportion of slaughtered reindeer calves among all the reindeer herding districts in Norway.

Being reliant upon a terrestrial natural resource, both reindeer herders and sheep farmers retain important knowledge concerning their natural surroundings. With an experience-based understanding of their environment, as well as the weather patterns and climate variations pertaining to it, changes 'out of the ordinary' (where 'ordinary' refers to a vide variety of expected conditions) are noted, assessed and eventually responded to.

13.6 Local Perceptions of and Responses to Current Exposure-Sensitivities

Being a sub-Arctic community, the seasonal changes in Unjárga/Nesseby form the basis for nature-based activities carried out in the municipality throughout the year. In recognizing that unusual patterns of wind, rain, snow, frost and temperature depend upon local understanding of time, seasonality may be described as 'the most basic scaffolding of people's sense of time, not only structuring perceptions of fluctuations in resource availability but also deployment of adaptive responses' (Roncoli et al. 2009, 94).

Even though seasonal variation and yearly fluctuations are part of everyday life for the Unjárga/Nesseby inhabitants, they have experienced recent climate related changes that have generated concern about the future possibilities of practicing current nature-based activities. Local observations of general changes include alterations in wind directions and wind strength, shortened winter seasons with diminishing snow depth, heavier rainfalls, and extensive moth larvae outbreaks in the birch forest. With respect to reindeer herding and sheep farming there are also other important drivers of change recognized locally, such as encroachment/reduction in grazing land, forest regrowth, increased tree line elevation and predator increase.

Without animals grazing within and close to the community, a regrowth of the cultural landscape has taken place. Additionally, the tree line has extended, and is locally reported to have moved several meters up the mountain sides over the last decades (see also Tømmervik et al. 2008). Reindeer herders have noticed an expansion of and increased growth in dwarf birches (*Betula nana*) in the pastures, causing the animals to avoid areas obstructed by birch regrowth.

The Norwegian Reindeer Husbandry Administration (*Boazodoallohálddahus* in Sámi and *Reindriftsforvatningen* in Norwegian) considers loss of pastures to be the greatest threat to the future existence of the Norwegian reindeer herding industry (Reindriftsforvatningen 2009). It further stresses the importance of including the cumulative effects (i.e. the collective, long-term effects) of constructions and grazing land reductions, in order to maintain the flexibility needed to deal with shifting climatic conditions in the different seasonal pastures. This flexibility is also seen as an important aspect with regard to future climate change outcomes given diverse requirements for land use and pasture areas among the different reindeer herding districts (ibid., see also Oskal et al. 2009).

In Unjárga/Nesseby, reindeer herders express concern that local cabin development and associated human traffic may affect their animals grazing land. This represents an additional livelihood stressor in near future. Some are worried that human activities may result in more extensive disturbance, beyond the immediate land area affected. With respect to the experienced encroachment of the pastures, brought up by both sheep farmers and reindeer herders, protests have been launched against the suggestion of cabin developments in the current municipal development plan. Farmers' and herders' increased engagement with decision-making processes, through hearings and open meetings, may be seen as an adaptive strategy to avoid the loss of grazing land for their animals.

The sheep farmers and reindeer herders concern about the increase in predators in recent years has led to more applications for hunting permits, local hunting team agreements and attempts to influence the national predator management regulations. Some farmers have even mentioned replacing their modern sheep breeds with Old Norwegian Sheep to be better prepared for the predator increase, as their strong flocking instinct results in fewer animals lost to predators. If actually carried out in the future, this might turn out to be an adaptive strategy to a local change in predator pressure.

Describing the complete multiplicity of change experienced and described by our local partners in Unjárga/Nesseby would exceed the scope of this chapter. Here we focus on the highly visible and much discussed wide-ranging moth larvae outbreaks and their effect upon local sheep farming and reindeer herding livelihoods in Unjárga/Nesseby. Living in a sub-Arctic community, where resources harvested from uncultivated land have always been of major importance when compared to resources harvested from cultivated land, the forest and the mountain plains still make up important resource areas locally. Extensive deforestation, as a result of long-lasting moth larvae outbreaks, might thus influence the local resource supplies available. The following sections will describe the effects and the responses to the moth larvae outbreaks in detail.

13.6.1 Moth Larvae Outbreaks

Outbreaks of the autumnal moth (*Epirrita autumnata*) and winter moth (*Operophtera brumata*) occur in the circumpolar region, causing defoliation of an array of different host trees. In northern Fennoscandia, where Unjárga/ Nesseby is located, it is mainly the birch trees (*Betula* spp.) that are affected (Tenow et al. 2007). Large but short-lived outbreaks of moth in mountain forests are quite common, and occur cyclically in both moth species at intervals of approximately 10 years (Hylen et al. 2007). The female moth of both species lays her eggs on birch stems and branches, where the eggs overwinter and hatch at leaf burst the following spring. The eggs are extremely cold-tolerant and their lethal temperatures are as low as approximately –35°C for winter moth and –36°C for autumnal moth (Hagen et al. 2008). Both species have spring feeding larvae, and the timing between larval hatching and birch budburst is critical for the survival and development of the larvae (Jepsen et al. 2008).

A distinct altitudinal differentiation in species-specific outbreak areas has been reported for the two moth species. While autumnal moth is predominantly found close to the forest limit, winter moth outbreaks have primarily occurred at lower altitudes (Hagen et al. 2007). During the last 15 years there has been a strong northward and eastward expansion of winter moth core outbreak areas in northern Norway, while autumnal moth outbreaks seem to have expanded into colder, more continental regions. During the same period, an increase in both mean annual and minimum winter temperature has occurred (Førland et al. 2009; Jepsen et al. 2008). Still, the winter temperatures in Unjárga/Nesseby have not been below the lethal threshold for overwintering larvae eggs for many years, and thus the climate sensitivity of the moth species must be linked to other factors than the temperature-dependent egg survival. This is consistent with recent studies of the altitudinal expansion of winter moth in regions characterized by mild winters (Hagen et al. 2008). Hence, other climate sensitive attributes of the moth ecology are likely to be involved, and further intensified research on population dynamics, in relation to climatic variables, is called for (Jepsen et al. 2008).

The presence of winter moth outbreaks in regions previously affected solely by autumnal moth is likely to increase the effective duration of local outbreaks and will therefore have profound implications for the birch forest ecosystem. Defoliation by moths adversely affects the growth of host trees for several years following an outbreak, and prolonged outbreaks are known to cause forest death over large areas (ibid., Jepsen et al. 2009; Tenow and Bylund 2000). Local observations in Unjárga/Nesseby clearly confirm these biological findings.

The five recent years of continuous moth larvae attacks in Unjárga/Nesseby have left distinct marks on the landscape (see also Tømmervik 2009). As mentioned above, the moth outbreaks occur cyclically, and a birch tree can survive being attacked by moth larvae for 1–2 growing seasons. If a birch is attacked three years in a row, it is highly likely that the tree will die (Fylkesmannen i Finnmark 2006). The recent extensive and long-lasting moth outbreaks in Unjárga/Nesseby, most likely a result of a milder climate (Hagen et al. 2007; Jepsen et al. 2008), have consequently resulted in radical changes in the birch forest.

13.6.2 Moth Outbreak Effects on Pastures

Productive fertilization and light conditions following the extensive moth larva attacks on the birch forest have caused the amount of wavy hairgrass (*Avenella flexuosa*) to increase significantly in the moth outbreak areas. As pointed out by sheep farmers, reindeer herders and biologists (e.g. Bjørklund 2009), this grass is a useful species for sheep in spring and for both sheep and reindeer in late autumn. As an early season species the wavy hairgrass is valuable to the sheep in the first part of the grazing season. After flowering, the grass loses almost all its nutritious value and is avoided by the animals. On the other hand, if the grass *does not* flower it retains the ability to stay green and nutritious for a long time, and can even withstand a certain amount of frost. Both sheep farmers and reindeer herders in Unjárga/Nesseby have referred to examples of their animals finding fresh, green wavy hairgrass beneath the snow in late autumn.

Flowering of wavy hairgrass during summer can be avoided if the grass grows in a shady habitat or if it is grazed (Bjørklund and Haugen 2009). As a vast amount of the birch forest is currently dead and leafless, less shady habitats can provide prolonged nutritious grass availability for grazing animals in late autumn. For this to occur, the wavy hairgrass has to be grazed before flowering in the summer time, to sustain a nutritious autumn pasture. This brings about an intriguing co-benefit situation where sheep grazing during summer can have a possible positive effect on late autumn reindeer pastures.[6]

13.6.3 Moth Outbreak Effects on Berries

Large areas of the Unjárga/Nesseby forest are currently dead, and even heath and berry plants have been damaged (see Fig. 13.2 and 13.3). This illustrates the range of these recent moth larvae outbreaks. As a result of the damaged berry plants, people have experienced a decrease in the previously substantial berry harvest. The consequence for people in Unjárga/Nesseby is that some travel long distances to pick berries elsewhere, while others may only obtain the much longed-for berries through barter or as gifts. The local harvesting activities, such as berry picking and ptarmigan snaring, are currently not as important for subsistence in the municipality as they were in the past. Still, the possibility to combine different activities, and make practical use of the local landscape, remains of great significance to the residents, and constitutes an important part of what it means to live a good and meaningful life in Unjárga/Nesseby. The berries have now disappeared from localities that were previously known for abundant harvests. These berry picking areas are significantly connected to

[6]See also Mysterud and Austrheim (2008) for a discussion on how sheep grazing may contribute to maintenance of grasslands, with potentially positive and negative summer forage effects on reindeer.

Fig. 13.2 Moth larvae damaged birch forest. *Photo: Stine Rybråten/CICERO*

Fig. 13.3 Even mountain birch and heath have been killed over vast areas by the moth larvae outbreaks. *Photo: Stine Rybråten/CICERO*

memories and stories, some of them spanning several generations. People have therefore expressed worries that important continuations of local connectedness will be challenged by the moth outbreaks. Lately, it has been observed that berry plants are starting to recover at some of the exposed sites. Nevertheless, people still drive considerable distances to new, rich berry sites to secure their yearly store.

13.6.4 Moth Outbreak Effects on Moose Hunting and Ptarmigan Snaring

The moth attacks on the birch forests cause local concern about consequences for the ecosystem as a whole. The disappearance of the birch forests is also likely to have negative consequences for the moose and ptarmigan populations through the reduction of the choice of feed. Uncertainty about the consequences of moth outbreaks upon the moose stock resulted in reduced hunting quotas in Unjárga/Nesseby municipality in the autumn of 2008. The ptarmigan population has also decreased in the last couple of years, which may be caused by several factors, including a decline in the number of rodents, leaving the ptarmigan chicks more vulnerable to predators such as fox and birds. In addition, there is a local concern that the reduced quantity of fresh buds in the winter time has reduced available ptarmigan feed, thereby leading to population decline. As a consequence, some of the otherwise eager ptarmigan hunters did not lay their snares in the early winter of 2009. 'We need to save the few ptarmigans we've got now', one experienced senior woman explained. Moreover, the moth larvae outbreaks have affected the ptarmigan snare material, as dead birch branches lose their flexibility and therefore easily break.

13.7 Local Adaptation to Current Changes

Sheep farming and reindeer herding have century long traditions in Unjárga/Nesseby, and both livelihoods are well adapted to the sub-Arctic seasonal changes as well as to the fluctuations within particular seasons. Still, some of the recently experienced changes and their accumulative effects upon the husbandry industries are not to be found in the historical repertoire of the livelihoods.

Moth larvae outbreaks in Unjárga/Nesseby have never reached such proportions as during the period between 2005 and 2009. These outbreaks will likely have future consequences for the sheep farmers and reindeer herders, in both positive and negative terms. It is difficult to assess the long-term consequences of the moth larvae outbreaks, but some of the short-term effects have already been responded to.

Apart from the vast areas of defoliated and partly dead birch trees, the most striking change caused by the recent year's major moth larvae outbreaks has been the increased abundance of grass in affected birch forests. Whether this is beneficial to the grazing animals in the area depends upon a series of factors. Following a moth outbreak, the vegetation will eventually become more diverse. This is supported by farmers and reindeer herders who have already started to see other grass species, herbs and plants entering the hairgrass dominated areas. The time needed before the vegetation composition returns to 'normal' is not yet known, and it is unknown which species may settle in these affected localities given projections of future temperature and precipitation. Other possible changes might influence the access of food, wellbeing and survival rate of sheep and reindeer on pastures. Warmer summers combined with increased humidity may lead to increased numbers of insects and the arrival of new insect species, causing a rise in disease and subsequent decline in sheep and reindeer slaughter weight. If the future brings increased rain during reindeer calving in spring, more calves might suffer and eventually risk death from hypothermia. More precipitation in summer might also have a negative effect on the nutritional value and general quality of the agricultural production of hay. On the other hand, a possible increase in the growing season is viewed as positive, because of the potential opportunity for new species production and higher yields.

The degree to which the sheep and the reindeer manage to adjust to the recent changes in pasture conditions, will affect the livelihoods of sheep farmers and reindeer herders who depend on these animals well-being and survival. To date, both sheep and reindeer have managed to make use of the altered composition of their summer pastures in and near birch forests. Thus, the vast moth-induced changes in the landscape which initially caused great concern among the Unjárga/Nesseby inhabitants have, when it comes to sheep farmers and reindeer herders, caused fewer problems than expected. In other words, the adjustments of the animals can be viewed as influencing the adaptive capacity of the farmers and herders.

Sheep farmers and reindeer herders have different opinions about how the extensive moth outbreaks may impact the forest pastures used by their animals. Some sheep farmers perceive the moth larvae attacks as clearly advantageous, and point not only to the positive effects of increased light, but also to the favourable fertilization of the soil from the moth larvae faeces. Others consider the ecosystem changes negative, stressing that reduced biodiversity caused by wavy hairgrass monoculture will be a disadvantageous outcome of the widespread moth outbreaks. Among reindeer herders, a concern that grass will displace lichen in parts of the winter pasture and thus reduce its nutritional value has been raised.

Flexibility in the animal husbandry industry is an important factor in local adaptation to changes in sheep farming and reindeer herding livelihoods. This includes the fact that more than one income is needed in most of the households in either of the industries, as well as the resilience incorporated in self-sufficiency and combination of activities. For both sheep farmers and reindeer herders a wage earning spouse, or additional income from alternative activities, such as fishing, carpentry or teaching, ensures increased livelihood flexibility.

To maintain several jobs can be particularly challenging, but this might have less to do with time or logistical constraints and more to do with policy restrictions. In other words, policy restrictions can generate constrains to local adaptation. One sheep farmer put it this way:

> I used to go fishing on the fjord in the winter time, together with another sheep farmer. We only had a small boat, but still caught decent amounts of cod. Now I'm left out of the fishermen census because according to the new rules I earn too much from other work than from the fisheries. I still work some other places than on the farm, but less now than earlier on, since the farm has grown and most of the investments are done. It is an articulated goal in the Norwegian agricultural policy that a farm should be self-supported. But I don't mind working outside the farm as well. We've been used to that here, over the years.

In parts of the year, when reduced reindeer herding and sheep farming activity creates the opportunity for other kind of work, important income can be earned which may prove invaluable with regard to future security, such as the purchase of supplementary animal feed when usual food sources are scarce. Political regulations emphasizing industry efficiency and productivity may well diminish this important source of flexibility, or adaptive strategy, in the Unjárga/Nesseby animal husbandries.

13.8 Future Challenges and Opportunities

In estimating the challenges and opportunities sheep farmers and reindeer herders in Unjárga/Nesseby may face in the future, climate change projections have been developed through close collaboration with local partners and the Norwegian Meteorological Institute (met.no). As a basis for these projections, locally observed weather variation and climate change, relevant to community livelihoods and activities, were discussed in Unjárga/Nesseby and presented to the climatologists. Next, the Norwegian Meteorological Institute developed downscaled projections of the locally identified climate elements. A main scenario was based upon output from the regional climate model HIRHAM (Haugen and Haakenstad 2006), but adjusted to the local topography by a method developed by Engen-Skaugen et al. (2007). In order to get a measure for uncertainty of the main scenario, the projected local changes in temperature and precipitation, from the main scenario, were further compared with the results from empirical-statistical downscaling (Benestad et al. 2008) from a large multi-model ensemble.

The next step will be to present the locally downscaled climate projections in Unjárga/Nesseby, to enable discussions of future challenges and opportunities with our local partners. In this dialog other relevant and non-climatic conditions such as social structure, economy, demography, and resource management will be included. The discussion of possible future challenges and opportunities that follows is based on preliminary informal conversations with our local partners in the sheep farming and reindeer herding industries. The discussion constitutes our first round of analysis of the linkages between future climate trends and moth outbreaks, and is related to our partners' current observations on local change.

A whole range of issues emerges when assessing the climate projections downscaled for Unjárga/Nesseby municipality. As described, the extensive moth outbreaks have resulted in changes in pastures affecting both sheep and reindeer, which may lead to further unanticipated situations. Moth larvae outbreak dynamics are, as we have seen, complex with many unresolved questions. Nevertheless, climate warming and changing seasonality seems to be an important factor in the distribution range of different moth species (Jepsen et al. 2009, 2008; Hagen et al. 2007). For now, nothing certain can be said about future moth outbreak rates in Unjárga/Nesseby. However, as the temperature will is expected to increase in the years to come, cold temperatures will no longer be a

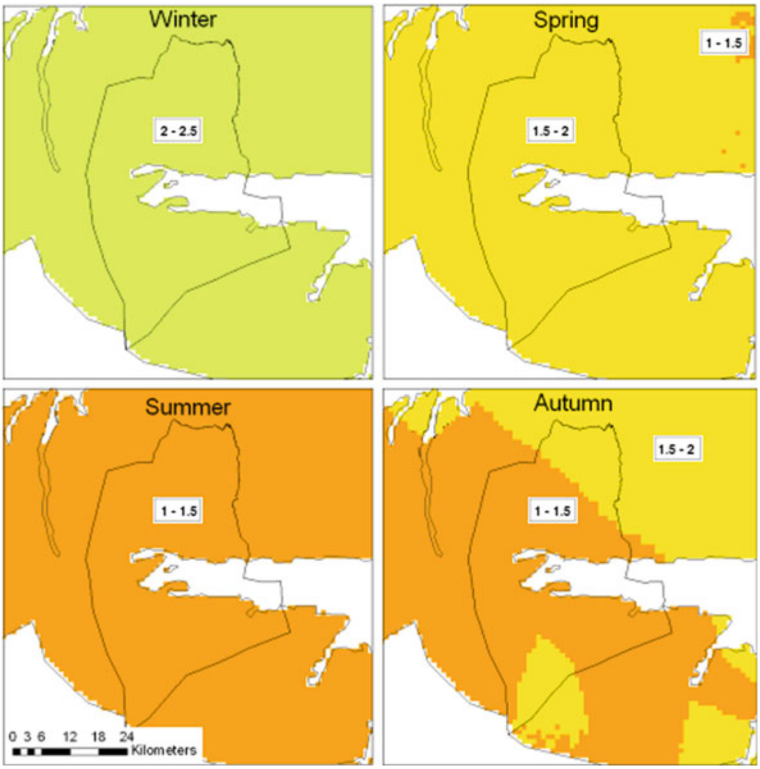

Fig. 13.4 Change in seasonal mean temperature from (1981–2010) to (2021–2050). Global model ECHAM4/OPYC3 GSDIO, Emission scenario IS92a. Downscaled with regional climate model HIRHAM to 25 km^2 and empirically adjusted to 1 km^2 *Source*: Torill Engen Skaugen, Norwegian Meteorological Institute.

limiting factor in possible future moth outbreaks. The downscaled climate projections for Unjárga/Nesseby regarding future temperature development (Fig. 13.4), show a 2–2.5°C increase in winter temperature from the 1981–2010 projection, to the 2021–2050 projection. This means a change in mean annual winter temperature of −14 to −8°C, to a mean of −12 to −6°C (see Fig. 13.5 and 13.6). Additionally, Fig. 13.7 shows a decline in number of days with temperature below –10°C in autumn, winter and spring towards 2050, with the decrease in number of cold days during winter as the clearest trend.

In addition to the projected temperature increases shown in the figures below, the downscaled projections for Unjárga/Nesseby show that increasing winter temperatures and winter precipitation is presumed to be greatest in the reindeer winter pasture areas. An increased number of winter season days with temperatures around zero, combined with augmented precipitation, will enhance the likelihood of icing in reindeer winter pastures. This can restrict the reindeer in accessing their food. On the positive side, the possibility of joint

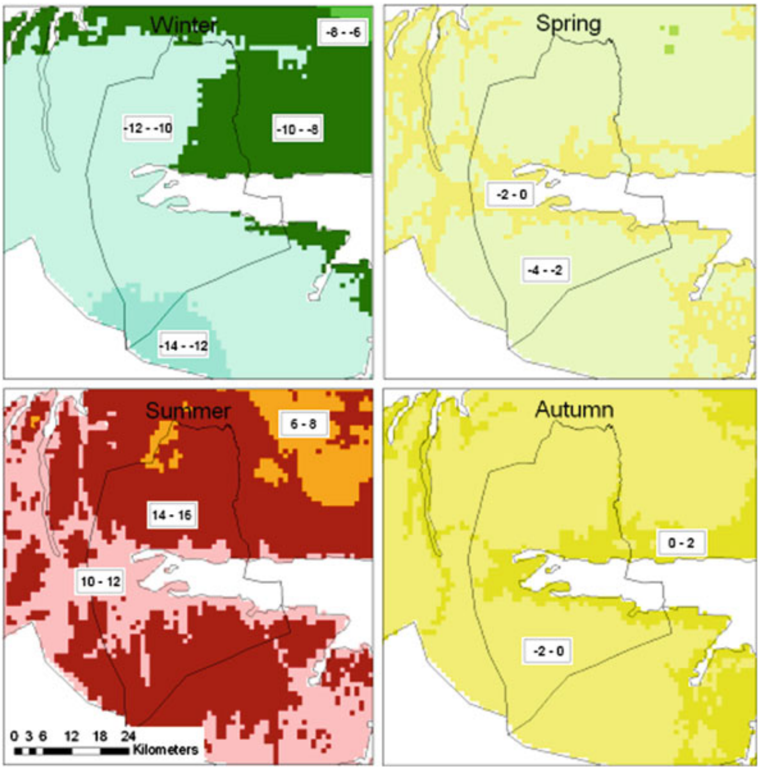

Fig. 13.5 Seasonal mean temperature for the reference period 1981–2010. Global model ECHAM4/OPYC3 GSDIO, Emission scenario IS92a. Downscaled with regional climate model HIRHAM to 25 km^2 and empirically adjusted to 1 km^2 *Source*: Torill Engen Skaugen, Norwegian Meteorological Institute.

grazing of sheep and reindeer could be one way to take advantage of the moth outbreak situation.

Most sheep are gathered from their pastures when the autumn sets in. Hence, only the last sheep to be gathered would benefit from late nutritious hairgrass held 'fresh' through summer grazing. The reindeer, on the other hand, migrate through some of the sheep grazing areas in Unjárga/Nesseby municipality on their way to the inland winter pastures and could clearly benefit from fresh wavy hairgrass, sustained by the earlier grazing of the sheep. If such a joint grazing could take place, where sheep and reindeer made use of the same area at different times of the summer season, the extensive moth larvae outbreaks in the area could be favourable to the reindeer herd at this time of the year.

To date, both sheep and reindeer have managed to make good use of the moth affected parts of their pastures. This indicates that adjustments by the animals make farmers and herders less vulnerable to changes affecting their

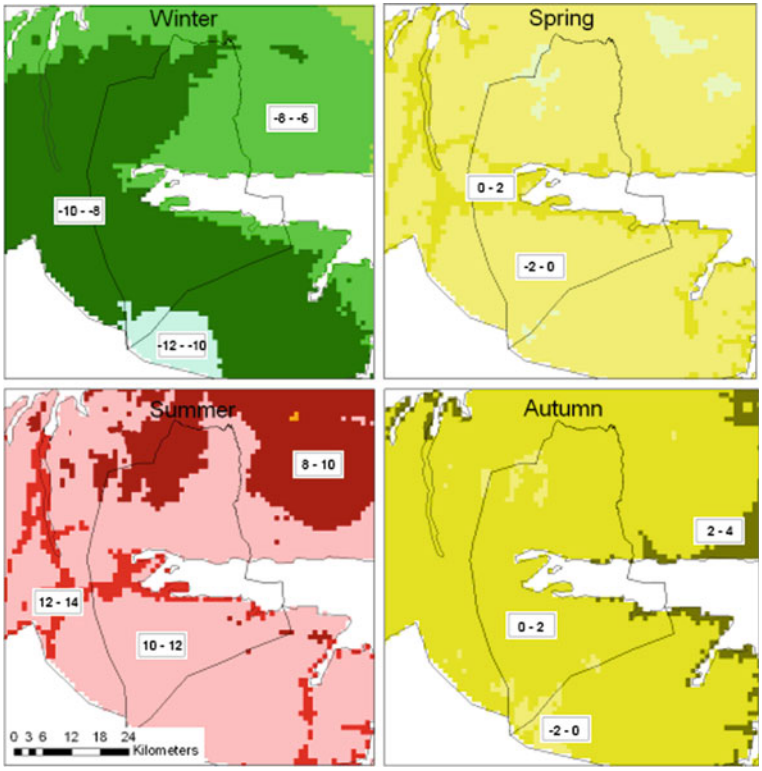

Fig. 13.6 Seasonal mean temperature for the scenario period 2021–2050. Global model ECHAM4/OPYC3 GSDIO, Emission scenario IS92a. Downscaled with regional climate model HIRHAM to 25 km^2 and empirically adjusted to 1 km^2 *Source*: Torill Engen Skaugen, Norwegian Meteorological Institute.

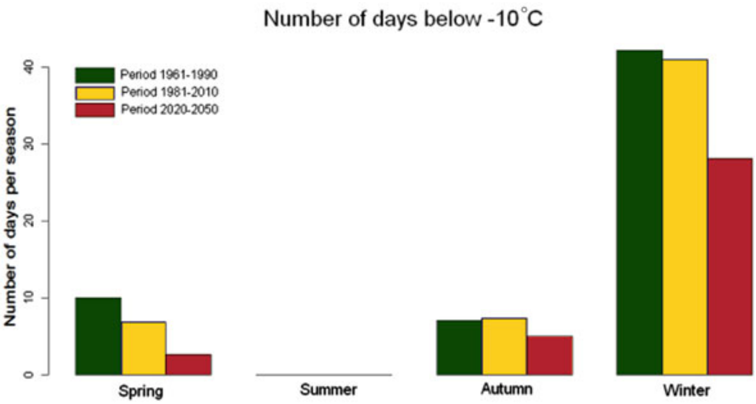

Fig. 13.7 Number of days with temperature below –10°C
Source: Hans Olav Hygen, Norwegian Meteorological Institute.

animals' pastures and subsequently their own livelihoods. This is illustrative of the close links between the people and the natural resources. Still, with further climatic change and inevitable alterations in socio-economic and political systems, as well as management structures, it is difficult to assess the future adaptive capacity of the sheep farmers and reindeer herders in Unjárga/Nesseby. The flexibility of both animals and owners will be important in this context. For the animals this will include the ability to make use of new areas, utilise older areas in new ways, and take advantage of new species. For the sheep farmers and reindeer herders, their adaptive capacity will be affected by their possibility to *let* their animals adjust, i.e. that the pastures are not reduced, and by their opportunity to earn additional income. Furthermore, experiences, attitudes and feelings connected to ones home place, and way of living, will influence ways of reacting to change. Activities such as berry picking, hunting and/or snaring remain important to many reindeer herders and sheep farmers in Unjárga/Nesseby, as well as to other inhabitants in the municipality. Although the economic yield of these activities might not be crucial, they are clearly important as recreational activities, in identity formation and for the sense of belonging. Ways of living are constantly changing, but a close attachment to both livelihood and local nature will influence the motivation for, and intensity in, adapting to severe changes in ones home place.

13.9 Conclusion

Sheep farming and reindeer herding in Unjárga/Nesseby today are inherently relatively climate adjusted livelihoods, having experienced and adapted to change throughout history. But within these livelihoods the 'traditional' repertoire of ways of coping with changes in natural and societal conditions might not suffice today, as alterations to land-use patterns or occupational practice did not occur in previous periods of adaptation to anywhere near the same extent as today. Future land use changes and the expansion of physical constructions, such as cabins, might lead to further reductions in today's grazing land, and thus limit the adaptive capacity in sheep farming and reindeer herding in years to come. Combined with the fact that projected climate changes appear to be more severe than previously experienced climate variability, this might well suggest that earlier ways of contending with climatic variation might not be adequate for coping with future climate change. Land use changes and reduction in grazing land, combined with consequences of climate change, thus creates a set of exposure-sensitivities for both sheep farmers and reindeer herders in Unjárga/Nesseby.

To increase the adaptive capacity of livelihoods, several factors have to be present and combined. As we have seen, the adaptive capacities of sheep farming and reindeer herding livelihoods depend, to a high degree, upon the animals' ability to adjust to change. Additionally, the possibility of combining different activities and to make practical use of the local landscape remain of great significance to both sheep farmers and reindeer herders, and constitutes an important part of what it means to live a good and meaningful life for them in Unjárga/Nesseby. Flexibility among both animals and owners, combined with the experiences and attitudes connected to people's home place and way of living, as expressed by local farmers and herders, will likely have a positive effect on their ability to adapt to future climate change.

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Chapter 14
Community Adaptation and Vulnerability Integrated

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Abstract The goal of the CAVIAR project is two-pronged: capturing the particular social and environmental conditions that combine to create exposure-sensitivities and require adaptation in case study communities across the Arctic; and applying a common framework that anchors integration of results in a pan-Arctic assessment of community vulnerability and adaptability. At the core of the CAVIAR project is designing and framing the research in collaboration with the local communities allowing us to understand the particular processes and conditions in each locale, which is a prerequisite for understanding adaptation and vulnerability to change. This undertaking has required a fundamentally interdisciplinary collaboration, across and between social and natural sciences, and between scientific and local/traditional knowledge. By involving the local communities in setting the parameters of the research we have identified the aspects of Arctic communities (such as livelihoods, income, social interactions) that are susceptible to changing conditions. The purpose of integration, on the basis of the case specific particularities, is to generalise the processes and conditions which shape vulnerabilities in the Arctic, and gain insights into adaptive capacity to deal with future changes. It is clear that the lives and livelihoods of people in the Arctic are sensitive to the effects of a changing climate, but they are also sensitive to changing economic, institutional and social conditions. While natural resource based livelihood dependence had a large share of attention, other prominent issues included municipal services, infrastructure and the impacts of industrial expansion.

Keywords Vulnerability · Adaptation · Integration · Scientific and traditional/local knowledge · Adaptive strategy and capacity · Climate change

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14.1 The Scope and Intent of the Book: A Summary

The CAVIAR project has two main elements. The first of these is to apply a common framework that anchors the collection of particular social and environmental conditions across the Arctic that combine to create exposure-sensitivities requiring adaptation by case study communities. The second element involves the integration of these results to identify characteristics of vulnerability that are shared or similar across the Arctic and those that are distinct to places or cultures. An underlying feature of the CAVIAR approach is the determination to design and frame the research in collaboration with local communities. This has allowed us to understand the particular processes and conditions in each locale, a prerequisite for understanding the ways that communities are exposed and sensitive to changing conditions and the adaptations they have employed. The purpose of integration is to generalise about the processes and conditions which shape vulnerabilities across the Arctic, and gain insights into adaptive potential with respect to future challenges.

The case studies have required an interdisciplinary collaboration, across social and natural sciences, and between scientific and local/traditional knowledge. By involving the local communities in setting the parameters of the research we have, as researchers, committed ourselves to address aspects of societal and environmental systems that are pertinent to Arctic people, in order to understand interactions between human and physical processes. For example, community susceptibility to flooding events requires an understanding of hydrology and processes relating to occupancy and hazard management; the sensitivity of fishing communities and the fishing industry requires knowledge of marine fisheries ecology, ocean-atmosphere interactions, and decision-making in the industry in order to understand variation in the distribution and abundance of commercially important fish stocks and how this may affect fishers; and to explain the vulnerability of community infrastructure requires knowledge of geomorphological processes relating to permafrost and coastal erosion and of infrastructure design and function. These have been necessary challenges for assessing community vulnerabilities.

Employing a common framework enabled integration of research results from a variety of disciplinary backgrounds encompassing differing theoretical and methodological approaches. Despite these differences, the case studies are unified by seeking to identify attributes of communities pertaining to vulnerability: current exposure-sensitivities, current adaptive strategies, future exposure-sensitivities and future adaptive capacity. A challenge in integrating the CAVIAR research results is to extract commonalities with regard to the framework without losing the uniqueness of each case study.

Chapter 1 described the CAVIAR framework and how the concepts of exposure-sensitivities, adaptive strategies, adaptive capacity and vulnerability are applied. The conditions and processes presented in this volume, and integrated in this chapter, are those that were identified locally as being important to the wellbeing of the respective communities. While natural resource based livelihood dependence had a large share of attention, other prominent issues included municipal services, infrastructure and the impact of industrial expansion.

14.2 Overview of Communities

Of the 14 chapters in this book 11 present evidence drawn from 16 case studies, situated throughout the Arctic. These cases not only represent geographical distribution, but also encapsulate a broad range of demographic, economic, institutional and cultural diversity. The case studies have provided insight into the opportunities, constraints and complexities encountered by Arctic communities in attempting to reduce their vulnerability to a multiplicity of stressors. In achieving this, the case studies have drawn attention to discernable features, some unique others common, across these communities. Prominent amongst these are, community size and location with respect to larger urban and commercial centers, the position of the community within municipal and wider governance frameworks, the degree of reliance upon a natural resource base and or primary industries, and the role of indigenous people's traditional activities.

Chapter 1 describes the CAVIAR framework and case study methods employed, most of which are familiar to the disciplines of ethnography, sociology, social anthropology, geography, resource management, health research and sustainability and development initiatives. All studies were grounded within the CAVIAR framework, and applied a collaborative and participatory approach, to determine together with local partners, the particular focus and study parameters. See Table 14.1 for an overview of the communities.

The degree of natural resource economic dependency provides a compelling metric to review community diversity, especially as this constitutes one of the central themes within the case study chapters. Case study communities range from near single resource dependency, as described in the studies of the reindeer herders of Yamal and Nenets Autonomous Okrug (Tyumen and Archangelsk Oblast), to areas and regions supported by a more diversified economic base such as in Whitehorse and Hammerfest sustaining a combination of industrial, service and public sector employment. The positioning of indigenous or traditional economic activities also varies considerably within the communities, from providing essential subsistence support in the cases of Fort Resolution, Arctic Bay, Tuktoyaktuk and Ulukhaktok, as part of a mixed local economy, to comprising the entire livelihood base of reindeer herders in the Nenets region of North West Russia.

Chapter 4, documents the most complete example of single resource economic dependence associated with the Nenets traditional reindeer herding activity. Reindeer herding also constitutes the main economic activity in

Table 14.1 Case study communities description

Chapter no.	Case study communities	Region and country	Community population	Approximate indigenous population[a]
	Lebesby	Eastern Finnmark, Norway.	1350	5% Sámi
2	Hammerfest	Western Finnmark, Norway.	9,500	n.a.
	Vestvågøy	Nordland County, Norway.	11,000	n.a.
3	Tuktoyaktuk	Inuvialuit Settlement Region, Canada.	950	97% Inuit
	Ulukhaktok		400	99% Inuit
4	Krasnoye, Naryan-Mar	Nenets Autonomous Okrug, Russian Federation.	6400[b]	15% Nenets[c](R)
	Priuralskij district	Yamalo-Nenets Autonomous Okrug, Russian Federation.	26,435[d]	5% Nenets (R)
5	Arctic Bay (Ikpiarjuk)	Nunavut, Canada.	690	84% Inuit
6	Nelmin Nos, Naryan-Mar	Nenets Autonomous Okrug, Russian Federation.	6400[b]	15% Nenets (R)
7	Fort Resolution	Northwest Territories, Canada.	500	92% Métis, Chipewyan Dene[e]
9	Ivalo	Inari Municipality, Finland.	6861	33% Sámi[f] (R)
10	City of Whitehorse	Yukon Territory, Canada.	26,000	18% First Nations, Métis and Inuit[g]
11	Qeqertarsuaq	Disko Island, Greenland.	1013	90% *Kalaallit* – Greenlandic Inuit
	Kangerluk		42	
12	Gällivare Municipality	Norrbotten County, North Sweden.	18,959[h]	20% Sámi
13	Unjárga/Nesseby Municipality	Eastern Finnmark, Norway.	878	70% Sámi

[a]An (R) is written where the percentage refers to the indigenous population in the wider region. Otherwise the proportion refers only to the case study community

[b]This figure refers to the population of European Nenets in the entire Nenets Autonomous Okrug (2007)

[c]Proportion of European Nenets in NAO. Barentsinfo.org http://www.barentsinfo.org/?Deptid=26342 This differs from the 2002 Russian census which showed 7754 Nenets in NAO, constituting 18.7% of the NAO population

[d]Population and proportion of Nenets in Yamalo-NAO. Figures from Russian 2002 Census http://www.perepis2002.ru/index.html?id=87

[e]Fort Resolution 2006 Census data. Statistics Canada. http://www.statcan.gc.ca/start-debut-eng.html

[f]Inari Municipal Website: http://www.inari.fi/web/index.php?id=3

[g]Yukon Bureau of Statistics 2006 Census. Available from: http://www.eco.gov.yk.ca/stats/

[h]From Facts about Norrbotten 2007, produced by the County Administrative Board of Norrbotten

Nelmin Nos, and is perceived as crucial to the identity of the region. However livelihoods in the region are supported by other subsistence hunting activities, and forced sedentarisation policy has led to the development of alternative urban opportunities in the region, coupled with the extension of extractive industries. The contrast between the nature of community resource dependency and wider regional resource diversity, especially in the case of extractive industries, is particularly stark in the case studies from North West Russia, and reappears as a frequent theme in a number of the other case studies.

Indigenous peoples and their degree of dependence upon traditional livelihoods and activities is a perpetual source of variance between CAVIAR sites. In the two Inuvialuit communities of Tuktoyaktuk and Ulukhaktok subsistence hunting and fishing continue to be practiced by the majority of residents, and retain a central cultural and economic importance, not least as providing food security for many families. However, these communities are reliant on a diversity of occupations ranging from extractive industries, such as oil and gas, the service sector including shipping and retail, and public service employment in education or health services. A similar pattern is seen in Arctic Bay, and the wider Nunavut region, where predominantly coastal communities base their economies on a combination of subsistence harvesting (primarily marine), wage employment, and tourism in some areas. Alternative employment opportunities and economic diversification have reduced the economic dependence of Dene and Métis in Fort Resolution upon subsistence hunting and fishing activities, however in similarity with the communities described above, and for a combination of both economic and cultural reasons, many livelihoods remain centered on land based activities.

The communities of Gällivare, Lebesby, Vestvågøy and Unjárga/Nesseby are perhaps more typical of the Northern European region in retaining a dependence upon renewable resource based livelihoods such as multi use forestry, fishing, fish processing (stockfish in Vestvågøy), small scale agriculture and animal husbandry (particularly reindeer in Gällivare and both sheep and reindeer, by coastal Sámi, in Unjárga/Nesseby). In addition traditional Sámi subsistence hunting and gathering activities continue. However the nature of some of these livelihoods has altered as technological developments have contributed to industrial intensification, mechanisation and occupational specialisation. The economic bases of these communities are also supported by a range of public sector employment and support mechanisms, in addition to the development of new diversified income opportunities such as wind farms and tourism.

The study of Qeqertarsuaq in Western Greenland presents a picture not altogether dissimilar to the case studies described above, in terms of mixed cash-subsistence economies. Traditional, typically marine foods are a vital resource for inhabitants in terms of a subsistence component to the local economy, diet and cultural value. In addition Qeqertarsuaq has a strong commercial economy, with a low unemployment rate, predominantly based on fish processing. Integration of community economies beyond community or even regional boundaries, as in the case of the Qeqertarsuaq's fish exporting industry, raises an additional complexity to the notion of resource dependency. The extent to which prosperity is connected to processes beyond that community or region is highly pertinent in communities such as Vestvågøy or Qeqertarsuaq, where the strength of their local economy is intrinsically linked to international fisheries markets.

In terms of scale the cities of Whitehorse and Hammerfest constitute the largest case study sites. Whilst the city of Whitehorse is supported by a large proportion of public sector employment, the chapter also discusses the role played and vitality of the cities service sector, particularly adventure tourism. Hammerfest has grown in recent years from a community predicated primarily on the fishing industry, to an important shipping port and the base for the Norwegian oil and gas extraction from the nearby Melkøya facilities (in the Barents Sea). This in turn has encouraged the growth of the city's service sector. In contrasting two large Arctic communities it seems apparent that Hammerfest exerts greater natural resource dependency, and is more intricately integrated into global resource markets.

14.3 Summary of Findings

Case study researchers investigated aspects of livelihoods, economies, culture, geomorphology and infrastructure that influence the current exposure-sensitivities, current adaptive strategies, future exposure-sensitivities and future adaptive capacity. Some common features have emerged across many of the cases and will be reviewed in the sections below. These include, in broad terms, the consequences of changes in coupled social-ecological systems with respect to: resource accessibility, allocation and extraction policy; limited economic opportunity and markets access constraints; demographics; attitudes and perceptions of change; local-global linkages; infrastructure; threats to cultural identity and well-being; transfer of local and traditional knowledge; economic and livelihood flexibility, and enabling institutions. These aspects are rarely independent of each other and frequently combine across scales and sectors.

14.3.1 Current Exposure-Sensitivities

In the absence of a deliberate focus upon climate change by the researchers, discussions of local weather and environmental conditions took place in the context of resource use and access, travel, food security and livelihood flexibility. Climate change alone is not viewed as the most salient factor causing vulnerability in the communities, but as a force that is exacerbating risks and stresses related to resource use and overall wellbeing. Observations of variations in climate and weather are brought to the fore to the extent they have consequences for livelihoods, recreational activities, municipal services and health. Climatic and weather conditions determine *inter alia* access to resources, safety while travelling, fishing or hunting, infrastructure stability, resource productivity, power generation, and the recreational use of nature. Environmental variability is a feature of the Arctic and its resources, but unprecedented changes, such as the magnitude of storms and seasonal dislocation, are posing further challenges to local/traditional knowledge, create hazardous and risky conditions, and alter the resource base. Among the indigenous cases it is recognised that travel safety, resource use and food security may be compromised and challenged should in-depth traditional knowledge be lost and not transferred to young people.

Changes in societal and environmental conditions affect livelihood activities, culture and wellbeing in many of the cases. Recent changes in the generational transfer of local and traditional knowledge are reported in a number of the cases and are influenced by several factors. Detailed local and traditional knowledge concerning environmental conditions, weather and the resource dynamics is important for ensuring safety at sea and upon land, and for the success of the hunting or fishing activity. Changes to time spent hunting or upon fishing activities and practices, due to employment diversification or diminished prey availability, reduce the opportunity for the transfer of knowledge. In addition, less time spent amongst generations diminishes opportunities for knowledge transmission and there are widespread concerns that traditional knowledge will be lost over time. The reduced attainment of traditional knowledge combined with rapidly changing socio-economic conditions, leads to risks associated with travel that may have otherwise been avoided with better awareness of hazards and survival skills. Changes in livelihood conditions and the environment are experienced and perceived as being beyond current knowledge systems, which has in some cases created insecurity on the part of knowledge keepers.

Most of the case communities are located at the periphery of larger commercial or administrative centres, and are dependent upon reliable infrastructure (roads, ice roads, rivers, sea ice, air/sea transport) for receiving goods and selling products. Infrastructural responsibility typically belongs to regional or national governments and the communities are thus dependent upon district policies for infrastructure maintenance and new construction. The provision of adequate infrastructure to ensure the transportation of local products, such as foodstuffs and goods to Whitehorse, is one determining factors in marking current exposure-sensitivities. Another includes facilities to enable the processing of local products, such as sawmills and slaughter houses, and fish landing facilities. Furthermore, several communities face risks to existing infrastructure due to coastal erosion, permafrost degradation, rock slides and/or snow avalanches. The level of community exposure-sensitivity is linked to the manner in which national policies address the maintenance of peripheral communities through financial and political commitments.

Disputes over land and resource-use may contribute to current and emerging exposure-sensitivity in many of the case studies. Some case studies describe the tensions, and contested land use between the sectors such as reindeer husbandry, forestry, tourism and extractive industries. Increased industrial use of the land or sea, such as logging, mining, and petroleum activities has been to the expense of traditional (both indigenous and non-indigenous) and more localised uses, such as hunting and gathering, coastal fishing and reindeer husbandry. In other instances local land use is evolving towards more service oriented activities, such as tourism, posing challenges and opportunities for local communities. Increased resource exploitation has in some cases required increased infrastructure support, such as roads, fences and power lines. These developments are viewed by some as an encroachment, while others perceive these activities in terms of employment opportunity and economic development. An added factor is the changing climatic conditions which have likely ramifications for marine species composition and abundance, grazing conditions or the period of time that people may safely travel over the sea ice.

The patterns of land and natural resource use are also influenced by changing environmental and climatic conditions. Closely linked to resource use exposure-sensitivities are observations of change in the range of resource bases, changing climatic conditions have ramifications for the abundance and distribution of fish stocks and marine mammals, a reduction in reindeer grazing lands, and decline in berry harvests. Current management systems, policies and regulations need to be flexible to allow hunters, fishers, or reindeer herders to adapt to ongoing changes in the resources.

Cultural differences between indigenous groups and non-indigenous governmental institutions create current exposure-sensitivities for both. Time spent engaged in herding or harvesting practices may preclude indigenous groups from participating in decision-making processes, and have negative consequences for their livelihoods. Lack of access to decision-making processes and institutions at the appropriate level results in indigenous peoples having to operate under management regimes with which they do not necessarily agree. Likewise if governmental decisions about land use do not take into account indigenous perspectives this may weaken resource management effectiveness, and create local economic or social problems.

14.3.2 Current Adaptive Strategies

Peoples in the north emphasise and take pride in their claim to have successfully adapted to great long-term natural variability in climate, weather and the resource base. Climate change is generally viewed as being beyond local control and to which adaptation is inevitable. In some of the cases, communities believe that traditional practices and knowledge will be sufficient for dealing with future changes. In other cases, communities recognize that climate change may bring new circumstances in their resource based and require new strategies for successful adaptaion. Across the case studies, current adaptive strategies address a range of environmental and societal changes, but are not typically initiated with specific regard to climate change.

Adaptive strategies are motivated by joint environmental (e.g. sea ice, weather, wildlife) and societal (e.g. regulations, laws, social dynamics, demographics) exposure-sensitivities. By analysing how the multiple drivers of adaptation are linked, and what adaptation strategies are employed, we are better able to understand community vulnerability. For example, the success of reindeer herding is influenced by grazing conditions (snow, ice, encroachment by roads and industrial activities) and the income that herders can generate from their activities. Adaptive strategies pertain to both, such as moving the herd to better pastures, providing supplemental feeding, ensuring an optimal herd size and maintaining social relations and networks to assist in herding activities. Fisheries are influenced by stock size, fish cohort composition and distribution, market opportunity, fisheries regulation and retention of local facilities to support fishery activities (e.g. processing plants, shipyards, distribution networks). Adaptive strategies include keeping abreast of current regulations and influencing future policy generation, targeting different fish species, and diversifying income sources.

Some of the larger communities, or those less reliant upon hunting and fishing, are affected by poor infrastructure provision which disrupts the flow of goods and services, causing vulnerabilities to extreme weather events. Adaptation strategies may include ways to reduce dependence on for example fossil fuels, and plan for a more sustainable community in terms of resource use. In the larger communities there is evidence of long-term planning which considers climate change, while throughout the Arctic there is very little evidence of the same in smaller communities.

Many of the cases emphasise problems associated with the disruption of knowledge (local and traditional) transfers. Communities have devised a variety of adaptation strategies to ensure continued intergenerational transfer of knowledge. These actions include inviting elders and hunters to teach about the local environment and resource use in schools, developing curricula which include local and traditional knowledge, and involving youth in monitoring programmes. This adaptive action is essentially investing in capacity to meet current and future conditions.

Common across the cases are current adaptive strategies that accommodate the multiple drivers of globalization and market integration, environmental change and governance, in order to maintain or increase the productivity of natural resource use activities such as logging, fishing or tourism. These adaptive strategies tend to reside beyond individual communities due to their broad societal prevalence. They are housed within political or managerial decision-making processes, such as national fisheries management, industry groups developing new markets for local products, or cultural groups rejuvenating their language and traditions.

Many adaptive strategies are costly in economic terms and require a steady income to enable action. In some cases, adaptive actions are reliant upon external expertise and advice, such as construction of barriers to reduce the impacts of avalanches or coastal erosion. The ability of communities to seek such advice is influenced by resources available to local institutions and economic provisions.

The role played by municipal or higher level government, in terms of responsibility and preparedness, in facilitating or constraining adaptation determines the central focus of some studies. Other studies provide a contrast by showing that the role of governance is more fragmented and less encompassing in reducing vulnerability. Thus the different case studies describe a significant diversity with respect to the adaptive approaches by governments and institutions.

Current adaptive strategies also pertain to increasing safety while engaging in harvesting and herding activities both in terms of travel and harvesting methods used. Travel is often compromised by changing environmental conditions, thus finding new routes, or adopting new equipment and technology are adaptive strategies that reduce vulnerability. When preferred species become less accessible because of environmental change an adaptive strategy is to target other species as substitutes.

An important integrating theme is the multiple conflicting interests in land- and resource-use, requiring potentially incompatible adaptive strategies, thus creating winners and losers (logging versus reindeer herding, hunting and gathering versus mining or increased shipping, fishing versus petroleum extraction). Adaptation in one area, by for example logging companies, may lead to increased exposure-sensitivity in another, such as reindeer herding, and the added effect of climate change may act as a constraint or facilitator for one or the other interests.

14.3.3 Future Exposure-Sensitivities

Commonly cited future exposure-sensitivities relate to changes in the natural resource base as a consequence of a broad range of stresses which include globalization and socio-cultural pressures, increased industrial pressure, increased competition over resources, and changes in resource management regimes out of step with climate change (see Table 14.2).

Future climate change is seen as important for a range of coupled environmental and societal consequences. These include shorter sea-ice seasons and changing sea-ice conditions with implications for access to and the abundance of resources, in turn affecting wellbeing, hunting costs, safety, price of country foods and food security; melting permafrost with consequences for reindeer herding, infrastructure such as damaged roads and buildings, reduced access to certain communities or hunting grounds; increased likelihood of icing

Table 14.2 Current and future vulnerabilities

Attributes of current vulnerabilities	Drivers of future vulnerabilities
Stress for traditional livelihood activities and culture	• Globalization and socio-cultural pressures • New large-scale resource developments • Migration to urban centers • Change or loss of culturally important wildlife • Cost of living (linkages to global economy) • Increased interest in Arctic for resources, tourism and development
Lack of infrastructure for provision of adequate goods and services	• Warming temperatures, changes in precipitation patterns, and longer warm seasons • Increased need and use of infrastructure by industry
Land use disputes	• Displacement from large-scale resource developments and associated activities • Economic diversification • Changes in resource management regimes • Resource management lacking flexibility to adjust to climate change impacts
Shifting resource bases	• Shifting wildlife due to climate change impacts • Travel risks and reduced access to harvesting and pasture areas • Changes in resource management regimes • Resource management lacking flexibility to adjust to climate change impacts • Economic diversification
Cultural mismatch between local resource users and resource policy makers	• Resolution of indigenous land claims/ commitment of national governments to land claim settlements • Changes in resource management regimes • Increased interest in Arctic for resources, tourism and development

conditions and later onset of winter which degrade reindeer pastures and influence animal health, with consequences for reindeer herders livelihood and wellbeing; and increased ocean temperatures affecting the fish species' distribution, abundance and species composition with consequences for coastal fisheries in terms of access, safety, fish quotas, technology and management. In addition, a warmer climate will shrink the glaciers that feed the headwaters for hydroelectric power, with consequences for some communities. Climate change will further exacerbate the current stressors if these are not reduced in the future. On the other hand, the consequences of climate change may provide new opportunities, reducing the net negative impact. For example, the arrival of new species may not be initially welcome, but may bring potential for new harvesting or commercial activities. Extend growing seasons may allow for greater biological productivity and communities may be able to take advantage of new agricultural opportunities.

A complication in assessing future exposure-sensitivities is that current and future policies will determine the extent to which climate change will impact environments and resources. Current resource management regimes are to some extent taking climate change into consideration when setting policy to protect, for example, marine mammal and fish stocks or prevent habitat degradation. It is highly likely that resource managers, to a much greater extent will have to consider the consequences of climate change on both the resources and the resource users in the future.

Discussions of future exposure-sensitivities reveal that it may be easier for communities to relate to projected future changes in climate than to projected changes in societal conditions. This is also reflected in the fact that we have more tools available for projecting changes in weather related phenomena such as increased temperature or precipitation, and the future of fish stocks than we have to project community development and demographics. Changes in climate occurring together with changes in societal conditions may create 'tipping-points' which cannot be predicted on the basis of current understanding of change. For example, land claims are negotiated between indigenous groups and national governments, and it is not possible to project the outcome of unsettled claims or the impact that they will have on local culture, resource management, or economic conditions.

Construction of new infrastructure, power lines, expanding industrial areas are considered encroachments on wilderness and nature, reindeer grazing land, wildlife and hunting grounds, and on human wellbeing and are common future exposure-sensitivities amongst the cases. The tensions and conflicts that may arise from diverse stakeholder interests in land- and resource use add to this type of future exposure-sensitivity.

Many of the future exposure-sensitivities identified have genesis external to the communities and are related to the consequences of climate change and globalization. This includes increased interests and activities in the Arctic, and a greater reliance on Arctic food sources from outside of the region.

14.3.4 Future Adaptive Capacity

A major determining factor of adaptive capacity emerging from the case studies includes flexibility along several dimensions such as livelihoods, institutions, management, and culture. Other critical factors include institutional capacity, enabling institutions, mechanisms for applying and maintaining traditional and local knowledge, and financial and human resources to facilitate adaptation.

The cases illustrate that local/traditional resource understanding is an important input for governance and management of resource access and activity. A common finding from the case studies is the existence of enabling institutions whose policy and actions reduce the potential for conflicts over land use and resource access. The cases show that when local decision-makers have a greater understanding of changing conditions they are in a better position to engage in short- and long-term planning for climate change impacts on resources, infrastructure and culture. Common throughout the cases are institutions as barriers or facilitators to adaptation. The role of institutions is critical for facilitating or constraining adaptation, and policy restrictions (in terms of restricting diversified income), or institutional regulations (restricting grazing or encroachments) may in some cases serve as barriers for adaptation.

Another related dimension is that future adaptive capacity is contingent upon the connections between the local level and the broader socio-political institutional context of the northern regions. The regulation of natural resources, both access and productivity, is determined at regional and national levels, and may fail to address the combination climatic and societal changes at the local level, where consequences will be most severely felt. Capacity to adapt to future change at the local level is to a large extent dependent upon enabling institutions across societal levels. The role of societal values such as informal social networks and engaged individuals will also be important for future adaptive capacity. Indigenous peoples' capacity to adapt is also contingent upon the outcome of treaty negotiations, relating to resource ownership and access rights, and changing governance systems. Disputed land and access claims are inextricably linked to wider concerns of resource use and livelihood diversification. Central to the discussion of indigenous adaptive capacity was the question of Aboriginal rights, achievement of which would secure land access and use jurisdiction.

With respect to natural resource use a common feature is the increased awareness of the need to monitor the resource base to detect changes and initiate regulatory and management plans. The institutional level at which such monitoring takes place varies between the cases, and depends on the community and management structure, and the prevalent local exposure-sensitivity (e.g. coastal erosion, local wildlife, or fisheries).

A general lack of flexibility in resource management regimes, in terms of not considering climate change impacts on the resource, and by restricting the flexibility of resource users, reduces the ability of hunters and fishers to better respond to environmental (including climate) and societal (including economic) change. Flexibility is seen as a prerequisite for successful adaptation across the cases. In some cases the institutional structure (e.g. tax systems) does not allow for flexibility in livelihood activities, limiting the possible local adaptive strategies and thereby weakening the adaptive capacity.

In several of the cases discussions with government officials revealed that adaptation to climate change was perceived as synonymous with mitigation of greenhouse gases. This may indicate that adaptation to the combined consequences of climatic and societal change may not be understood as important, relevant or high on the institutional agenda. By not acknowledging the need for current and future adaptation, the result may be inadequate future adaptive capacity because of lack of institutional preparedness and lack of flexible, responsive policies.

It is pointed out that current changes will likely be exacerbated with increased warming, and adaptive strategies to deal with these changes will be 'more of the same'. In other words, current strategies will be expanded and/or improved. Thus the perception remains that future exposure-sensitivities will increase in rate or magnitude along the same path as current environmental changes, requiring a similar development of future adaptive strategies. Indicative of this pattern is that few of the cases discussed the possibility of completely new and different adaptive strategies for meeting future challenges or opportunities. This is likely related to the problem of projecting future socio-economic changes to current societal, economic and political development and how this in turn will change the local communities.

14.4 Reflections on Concepts and Methods

Through an interdisciplinary approach and involvement of local community representatives in research design and set-up, we established a methodology for documenting and explaining how combinations of environmental and societal conditions create vulnerability and induce community adaptation. By analysing both bio-physical and socio-economic data, for example on how particular biophysical changes in the fisheries or flow levels in river deltas have had consequences for communities, scientists were able to generate insights on coupled social-ecological systems.

To ensure a holistic understanding of the broad social and environmental changes that are important to local communities, particular topics such as climate change were not introduced in our discussions with our local partners. In some cases aspects of climate or simply weather related topics were raised by the local participants unprompted, often in connection with livelihoods, outdoor recreation, or municipal activities. In other cases the researchers asked deliberate questions about climate and weather topics, and about social and economic change and regulations, in connection with the local activities that were previously defined by our local partners. This approach successfully brought out significant details of local concerns that, with a researcher led bias towards specific topics, would otherwise not have emerged.

When combining projections of climate change with socio-economic exposure-sensitivities we find concerns about future situations that may create irreversible changes to the natural resource base or environmental conditions. Both climate change effects and socio-economic developments are likely to require future adaptation, however as this volume of case studies makes patently clear, it would be a mistake to consider either area in isolation. The convergence of the two sources of exposure-sensitivity is unprecedented and will create a major challenge for successful adaptation. We therefore see a major challenge for future studies to fully integrate climatic and socioeconomic projections when assessing vulnerability.

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