A Decadal Reanalysis of Climate Vulnerability in the Canadian Arctic: The Case of Arctic Bay

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ABSTRACT

The Arctic is widely acknowledged as a global hotspot of climate change impacts. The implications of these changes are particularly pronounced for the Indigenous populations living in arctic regions, whose close association with and dependence on the land, sea, ice, and natural resources increases their sensitivity to climate-related risks. The past decade has seen the rapid expansion of research assessing these risks, which has increased our understanding of how climate change interacts with non-climatic drivers of vulnerability and resilience to affect human society. However, our understanding of the dynamic nature of vulnerability and its determinants over time remains incomplete: while scholarship has developed a baseline and generalized understanding of the human dimensions of climate change, little is known of the long-term dynamics in the context of continuing environmental, economic and societal change.

This thesis contributes to the development of a dynamic understanding of the processes and conditions that influence climate change vulnerability over time by conducting a decadal restudy of Ford et al (2006) in Ikpiarjuk (Arctic Bay), Nunavut. Using a research methodology consistent with the first study, and focusing on risks associated with subsistence harvesting activities, participant observation and semi-structured interviews were conducted in 2015 with 40 participants. Comparing this data to the original data collected in 2004, the thesis finds changes in the biophysical environment have continued and accelerated in many instances over the last decade. Within this context, socio-economic conditions have shaped how the community is experiencing climate change, both exacerbating and abating associated risks. It is found that the increased availability and accessibility of new technologies (predominantly Internet connection and GPS devices) is driving adaptive capacity in the community. In the same way, previous vulnerability assessments have suggested that changes to traditional sharing networks may hinder a community's adaptive capacity. Here, these changes are found to be evolving in ways that facilitate adaptation to both environmental and economic stress.

RÉSUMÉ

L'Arctique est largement reconnu comme un des endroits mondiaux le plus touché par l'impact du changement climatique. Les implications de ce changement sont particulièrement importantes pour les populations autochtones qui habitent dans les regions arctiques, puisque leur association et leur dépendance à la terre, la mer, la glace et les ressources naturelles, les rendent plus sensibles aux risques liés au changement climatique. Au cours de la dernière décennie, on a vu l'expansion rapide de la recherche qui évalue les risques, ce qui a augmenté notre vision de l'interaction du changement climatique avec les moteurs non-climatiques de la vulnérabilité et la résistance, et l'effet de ceci sur la société humaine. Cependant notre compréhension de la nature dynamique de la vulnérabilité, et ces facteurs déterminants au fil du temps, reste incomplète : bien que l'érudition ait développé un point de comparaison et une compréhension générale des aspects humains du changement climatique, on en sait peu des dynamiques à long terme dans le contexte du changement environnemental, économique et sociétal continu.

Cette thèse contribue au développement d'une compréhension dynamique des processus et des conditions qui influencent la vulnérabilité liée au changement climatique au fil du temps, en menant une étude décennale pour réétudier le travail de Ford et al (2006) à, Nunavut. En utilisant une méthodologie de recherche conformée à la première étude, et en concentrant sur les risques associés aux activités à la récolte de subsistance, l'observation de participants et les interviews semi- structurés étaient achevés en 2015 avec 40 participants. En comparant les données avec les données originales de 2004 cette thèse conclut que les changements dans l'environnement biophysique ont continué et ont accéléré à beaucoup d'égards au fil de la dernière décennie. Dans ce contexte les conditions socio-économiques ont influencé la façon dans laquelle la communauté vit le changement climatique en aggravant et en diminuant les risques. Cette thèse trouve que la disponibilité et l'accessibilité des nouvelles technologies (en particulier la connexion Internet et les appareils GPS) pousse la capacité d'adaptation de la communauté. De la même manière les évaluations précédentes de vulnérabilité ont suggéré que les changements aux réseaux de partage traditionnels peuvent empêcher la capacité d'adaptation d'une communauté. Dans cette thèse on trouve que ces changements évoluent de manière à faciliter l'adaptation au stress écologique et économique.

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CONTRIBUTION OF AUTHORS

Lewis Archer, who was responsible for the overall conceptualisation, methodology and analysis of the work, primarily wrote this thesis. Dr. James Ford supervised the thesis, providing feedback and guidance on structure, content and phrasing throughout. Further invaluable feedback and guidance was provided by committee members Dr. George Wenzel and Dr. Tristan Pearce.

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CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

The past decade has seen the rapid expansion of climate change vulnerability and resilience assessments, both globally and with Inuit communities in arctic regions (Pearce et al. 2010; Pearce et al., 2011; Prno et al. 2011; Ford et al., 2012, 2014; Wang et al., 2014; Sejersen, 2015). While these studies have done much to increase our understanding of how climate change interacts with non-climatic drivers of vulnerability to affect Inuit society, the dynamic nature of vulnerability and its determinants remains incomplete (Sejersen, 2009; Ford and Pearce, 2012; Haalboom and Natcher, 2012; Ford et al., 2013; Pearce et al., 2015). Scholarship to-date has developed a baseline and generalized understanding of who and what is vulnerable, to what stressors, in what way and why, and how communities adapt to change, although little is known of the long-term dynamics of vulnerability in the context of continuing environmental, economic and societal change (Adger & Barnett, 2009; Tshakert and Dietrich, 2010).

While scholars within the human dimensions of climate change (HDCC) field are increasingly interested in how, why and to what effect climate change vulnerability and communities change over time, the means by which we might do this – through restudies and longitudinal study design – is largely absent. This thesis is situated in the context of this gap in understanding and seeks to advance the conceptual understanding of climate change vulnerability by way of a longitudinal, community-based restudy in Ikpiarjuk (Arctic Bay), Canada. The work develops a longitudinal mixed methods study design, using fieldwork data from both 2004 and 2015, alongside historical data, to examine the processes and dynamism of climate change vulnerability. Specifically, the study is a restudy of *Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Nunavut* (Ford et al. 2006a), focusing on vulnerabilities and adaptive capacities in the Inuit subsistence harvesting sector.

1.2 RATIONALE

The Arctic is widely acknowledged as a global hotspot of climate change impacts (Larsen & Anisimov, 2014; Comiso & Hall, 2014). The implications of this are

particularly pronounced for Indigenous populations living in arctic regions whose close association with and dependence on the land, sea, ice, and natural resources increases their sensitivity to climate-related risks. Changing ice-conditions, for example, are already inhibiting movement and limiting the potential for subsistence hunting; this has implications for food-security, death or injury while travelling on the ice, as well as mental well-being (Cunsolo Willox et al. 2015; Durkalec et al. 2015; Ford et al. 2014, 2012). Warmer and wetter seasons may also be creating new and hospitable environments for pathogens, with the increased incidence of foodborne, waterborne and zoonotic disease (Evengard & Sauerborn, 2009; Harper et al. 2015). Furthermore, increasing weather extremes are impacting the infrastructure of Inuit communities, which are typically small, remote and coastal. Flooding, landslides and erosion all bring implications for water quality and infrastructural damage to housing, roads or community facilities (Ford et al. 2010a).

Inuit are believed to be highly sensitive to climate-related risks and are already having to adapt (Ford et al., 2015). As a result, over the past decade studies have investigated what makes certain regions, communities, households and individuals more or less susceptible to harm and documented how human systems are adapting (Ford et al. 2015). These studies have contributed to our understanding of how climate change interacts with society in an arctic context, yet our knowledge remains incomplete. For instance, our understanding of how Inuit communities respond to climate change remains static. We understand that vulnerabilities surrounding Inuit subsistence are determined by dynamic interactions between exposure, sensitivity, and adaptive capacity, but the influence of these determinants operating over multiple temporal scales and system feedbacks is little understood (Ford and Pearce, 2012). A number of studies for example, show that accumulated experience of adapting to environmental change builds adaptive capacity over time, as hunters are able to moderate risks based on a wealth of past experience (Gearheard et al. 2006; Ford et al. 2009). However, the temporal aspects of this learning (how quickly or slowly it occurs, and for whom) are not fully understood owing to the lack of studies over longer timeframes. In this way, our ability to identify and examine potential future vulnerabilities and identify sustainable and effective adaptations is constrained (Fazey et al., 2015).

This deficit in understanding is rooted in the conceptual and methodological limitations of contemporary HDCC research (Tshakert and Dietrich, 2010; Ford and Pearce, 2012). An absence of longitudinal study design and monitoring of human-environment interactions has limited the conceptual approaches underpinning most research in both the vulnerability and resilience fields. New approaches and methodologies are thus needed if we are to develop a more dynamic understanding of vulnerability. Longitudinal studies offer potential in this regard; the prospective design of longitudinal studies facilitates the characterization of the long-term dynamics of vulnerability, recognizing processes such as adaptive learning, experience with risk and social restructuring as important agents that often take significantly longer timeframes to become evident. While the standard interviews of retrospective studies are useful in establishing baseline information on vulnerability, they do not sufficiently capture the dynamics of human–environment interactions as they evolve over time. Repeated interviews as part of a longitudinal study design allow for the monitoring of vulnerability processes and are essential herein. Furthermore, repeated interviews underpin respondent validation and reduces participant recall bias through the long-term monitoring of trends (Ford and Pearce, 2012).

1.3 RESEARCH AIM AND OBJECTIVES

This thesis contributes to the development of a dynamic understanding of the processes and conditions that influence human vulnerability to climate change over time. The overarching goal of the study is *to understand how climate change vulnerability has changed over the last decade in Ikpiarjuk*. This will be achieved through two objectives: i) *Identify and characterize the current determinants of climate change vulnerability in Ikpiarjuk, with a focus on subsistence harvesting*; ii) *Compare and contrast the nature and determinants of vulnerability today with those documented in previously conducted research in the community in 2004/05 (Ford et al., 2006*). This is achieved through two methods:

Decadal reanalysis: repeated observation of human-environment interactions over an extended period of time is essential for capturing the dynamics of vulnerability. This study replicates the vulnerability assessment conducted by Ford et al (2006a) in 2004 in Ikpiarjuk, using a consistent approach and methodology, and interviewing

previous and new community members. Data is collected using semi-structured interviews and participant observation, and analyzed through latent content analysis.

Examination of the temporal dynamics of climate change vulnerability in Ikpiarjuk: the study then compares present day vulnerabilities to climate-related risks experienced in Ikpiarjuk to the findings of Ford et al (2006) to examine change over time. Through the combined analysis of data from both this study and the previous (ibid), the work is able to develop an understanding of, among other things: how socio-economic and environmental factors interact in Ikpiarjuk over time to create or abate vulnerabilities to specific biophysical risks, how adaptations affect system dynamics and characteristics to enhance or moderate vulnerability over time, and how internal system dynamics may create novel and hidden vulnerabilities or facilitate adaptive capacity through social learning.

1.4 THESIS OUTLINE

The thesis begins with a review of relevant literature, examining the history and application of vulnerability-based approaches in the HDCC literature and outlines methodological developments and challenges within the literature, with focus on the temporal aspects and dynamic nature of climate change vulnerability. The review provides important contextual background to the following chapters. Chapter three then describes the methods and conceptual framework used in the research, why they were employed, outlines data collection protocols and ethical considerations. Chapter four empirically applies the methods and frameworks as discussed in previous chapters. Focusing largely on vulnerabilities associated with subsistence resource harvesting, the chapter characterizes vulnerabilities emerging through the combination of changing climatic and socio-economic conditions. The themes and characterizations of vulnerability as discussed in chapter four are those of the research participants of Ikpiarjuk, summarized by the author, and related to concepts and similar phenomena reported elsewhere in the academic literature. Chapter five compares and contrasts the findings of the reanalysis as outlined in the chapter four with the findings of the initial vulnerability study. Comparing the characteristics of vulnerability as documented in in 2004 against those experienced in 2015 allows for the broad characterization of the changing nature of vulnerability, its drivers, determinants and influencing factors. The thesis concludes with a discussion of the

implications of these findings for the community of Ikpiarjuk and more broadly contributions of the work to the broader scholarship.

CHAPTER TWO: RESEARCH BACKGROUND

2.1 CHAPTER OVERVIEW

Chapter two examine the history and use of vulnerability-based approaches in the natural hazards and climate change field. This provides important contextual background to the methods, results and discussion sections, which are structured using a vulnerability framing. The chapter begins with the examination and description of 'vulnerability' and related terms 'adaptation', 'adaptive capacity' and 'resilience.' Then, the chapter progress to examine methodological developments and challenges within the literature, with particular focus on our limited understanding of the temporal aspects and dynamic nature of climate change vulnerability. The chapter concludes with a general characterization of climate change vulnerability in arctic communities with a focus on Ikpiarjuk (Artic Bay), Nunavut, Canada.

2.2 VULNERABILITY: CONCEPTUAL CONTEXT

2.2.1 The vulnerability approach

Vulnerability is broadly understood as the susceptibility to harm in a system relative to a stimulus or stimuli. It derives from the Latin word *vulnare* meaning "to wound," and was historically used in reference to a wounded soldier on a battlefield who is injured and thus at greater risk of being killed (Adger, 2006). In modern times, the 'vulnerability approach' has proved an effective analytical tool in identifying and characterizing the susceptibly of various human systems to harm, and has been employed across a number of academic disciplines, for varying risks (natural hazards, climate change risks, national security), and in diverse geographic contexts and livelihood settings (*ibid*).

Varying by discipline and risk, there are many different approaches to vulnerability assessment (see Brooks, 2003; Cutter, 1996; Manyena 2006; Miller et al. 2010). Within HDCC scholarship, vulnerability analyses are often polarized into positivist and social constructivist approaches (Adger 2006; Füssel and Klein 2006; Eakin and Luers, 2006; O'Brien et al 2007; Ribot, 2014). This dichotomy has its roots in vulnerability's antecedent traditions: theories of vulnerability as entitlement failure

and as environmental hazard, each of which has been foundational in the current applications of vulnerability analysis within the context of climate change (Adger, 2006).

The social constructivist theory of entitlements was first developed in the context of food security, explaining vulnerability to famine in the 1980s (Sen, 1981; Drèze & Sen, 1989; Watts and Bohle, 1993). Sen describes entitlements as sources of income, welfare or "alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces" (1984, p. 497). Vulnerability to famine or poverty is exacerbated when populations have insufficient, or lose previously held, entitlements (Sen, 1981; 1984). Through the entitlements approach, determinants of famine were conceptualized not as the result of natural phenomenon alone (e.g. flooding or drought), but as a result of demand for food, and the social and economic means of obtaining it (Sen, 1981; 1984). The entitlements tradition places great emphasis on the multi-scale determinants and the broader political economies that shape vulnerabilities and securities in specific locations (i.e. communities, households) (Watts 1983a; Deere and deJanvry 1984; Blaikie 1985; Bernstein 1996). It maintains an almost exclusive focus on the social determinants of susceptibility to harm, with well-being, social status, power, class, and gender recognized as critical determinants (Brookfield, 1999). While the approach has been seminal in understanding the causes of vulnerability, and directing attention to the underlying causes of vulnerability, it has been criticized for underemphasizing biophysical or ecological risk (Adger, 2006). Within HDCC literature, this approach was evident particularly in the 1990s through the work of Bohle, Downing & Watts (1994) whom conceptualized climate change vulnerability as a function of the political, economic, and institutional capability, maintaining a focus on how entitlements, powerlessness, and exploitation created vulnerability of people and place to climatic risks (Ribot, 2014).

The positivist natural hazards tradition, by contrast, has historically maintained a focus on the biophysical elements of vulnerability. Historically, this tradition understood vulnerability as a function of the nature and frequency of physical risk to which human systems are exposed (Brooks, 2003; Burton et al. 1978). The role of social structures was largely downplayed in this work in favour of the assessment of

the magnitude, frequency, rapidity of onset, and spatial distribution of physical risks (Hewitt, 1983; Cutter, 1996). Such an approach retains a focus on effect over causality, identifying who and what is vulnerable rather than why (Ribot, 2014). The approach has not only informed a significant amount of research in the natural hazards and environmental change literature (Alexander, 1993; Zeidler, 1997; Nicholls et al., 1999), but has also influenced much policy regarding climate-related vulnerability (Bassett & Fogelman, 2013). In contemporary HDCC literature, this work contributes observations and climatic modeling in describing and creating plausible scenarios from which investigation regarding impacts on society commence (see Moss et al. 2010).

From these origins in natural hazards and entitlement theories, in the early 2000s emerged a synthesis of systems-oriented frameworks that sought to understand vulnerability in a holistic manner, encompassing both natural and social systems. This is part of what Cutter (2003) has termed "vulnerability science." This advancement in both thinking and methods developed distinctively through the work of Turner et al. (2003) who argued for an integrative, systems-orientated research approach that incorporates both the social and biophysical dimensions of vulnerability. The framework proposed by Turner et al. (2003) approached vulnerability by analyzing the elements of vulnerability (exposure, sensitivity and resilience) in a bounded system at a particular spatial scale, as opposed to focusing on the multiple outcomes from a single physical stress. A number of integrative vulnerability frameworks emerged at this time (see Turner et al., 2003; Ionescu et al., 2005; Füssel and Klein, 2006; Ford and Smit, 2004). These frameworks view vulnerability as a product of complex interactions between both biophysical and human factors. Many characterize vulnerability as having an external dimension, often referred to as "exposure" of a system to climatic-risk, as well as an internal dimensions of "sensitivity" and "adaptive capacity" (Füssel and Klein 2006; Luers et al., 2003; Turner et al., 2003). This interdisciplinary and integrative approach, referred to as 'second generation' by O'Brien et al. (2007), represents an important advancement in both methodology and understanding of vulnerability.

2.2.2 Vulnerability, resilience and adaptation

The concepts vulnerability, resilience and adaptation are closely related and have been applied in various ways to assess the human dimensions of climate change (Gallopin 2006). Resilience scholarship in the context of understanding social and ecological change emerged from the natural sciences, in particular ecology (Folke 2006; Gallopín 2006), and has been increasingly employed by social scientists working in resource management (Berkes & Folke 1998; Berkes et al. 2003; Adger et al. 2005; Mitchell et al. 2014; Brown & Williams, 2015). In the HDCC literature, resilience refers to the amount of change a system can undergo and still retain the same controls, function and structure while maintaining options to develop (Carpenter et al. 2001; Turner, 2010).

The strength of the resilience framework lies in its focus on the functioning of the social-ecological system as a whole, considering both human and ecological systems (Nelson et al. 2007; Carpenter et al., 2001; Berkes et al., 2003; Folke, 2006). This is particularly important as it becomes increasingly accepted that studying human systems as separate from their ecological context can lead to research that overlooks critical socio-ecological interdependencies, and subsequently recommendations for reducing vulnerability often disregard the effects remedial actions might have on social groups and ecosystems (McDowell et al. 2016). As such, resilience studies focus on the relationships, feedbacks and connectedness between system components, as opposed to the analysis of individual components in isolation (Berkes et al. 2003; Nelson et al. 2007).

Resilience scholarship is also effective in the analysis of a systems' ability to adapt, which is determined in part by: the degree to which the system is susceptible to change while still retaining structure and function, the degree to which it is capable of self-organization, and the capacity for learning (Nelson et al. 2007; Carpenter et al., 2001; Berkes et al., 2003; Folke, 2006). This parallels the approach of adaptation and vulnerability literature, which examines adaptive capacity and multiple scales. Further parallels are apparent between resilience and vulnerability discourses, as both place emphasis on the biophysical or socio-economic dimensions of change

respectively, this convergence offers significant opportunity for integration (Turner, 2010).

Despite these commonalities and potential areas of convergence whereby resilience and vulnerability research may contribute to answering the same questions, it has been argued that the two are kept artificially separate by conceptual constructs, intellectual traditions, and limited interactions between the two academic communities (Miller et al. 2010). In a 2007 study, for example, Janssen et al. reviewed 2286 publications across the three knowledge domains, finding that resilience scholarship is only weakly connected with the other two domains in terms of co-authorships and citations, and vice versa.

Adaptation in the climate change field can be broadly understood as a process, action or outcome in a system intended to better cope with, manage or adjust to a changing condition, stress, hazard, risk or opportunity (Smit & Wandel, 2006). Adaptation, adaptive capacity and vulnerability are closely interrelated; Smit & Wandel (ibid) understand adaptation as a manifestation of adaptive capacity, while the determinants of adaptive capacity are closely related to the structure of social systems, or sensitivities. Much adaptation literature has focused on adaptive capacity, demonstrating that vulnerability is dependent upon levels of exposures, sensitivities, and ability of communities to cope with or respond to specific stresses. The literature has further demonstrated the multi-scale nature of vulnerability; local or community vulnerabilities reflect broader forces, drivers or determinants at the larger scale. Ribot (2014) argues that vulnerability analysis can inform adaptation and resilience studies to direct their analyses toward generative structures, steering them away from their traditional foci on the internally oriented or ahistorical.

2.2.3 Critiques of the vulnerability approach

The use of vulnerability approaches to understanding how climate change interacts with human systems is not without critique; some have questioned the assumptions and terminology used in vulnerability research. While these critiques raise important

points they are not unassailable and have been challenged by vulnerability scholars, and if anything serve to further strengthen vulnerability approaches.

Critiques of the term vulnerability discuss its nomenclature, arguing that the framing of vulnerability is inherently negative, focuses on problems rather than solutions, implicates affected populations as passive victims and controversial Euro-American ideas about traditional Others (Cannon et al., 2003; Cameron, 2012; Haalboom and Natcher, 2012; Hall & Sanders, 2015). These authors argue that the terminology not only detracts from the resilience of affected populations, but also how the term 'vulnerable' may shape a community's self-concept and identity, potentially hindering efforts to gain greater autonomy (Cannon et al., 2003; Haalboom and Natcher, 2012). This critique raises important points, although others have argued that issues of power, scale and colonialism are central to vulnerability studies, which often have a strong focus on socioeconomic drivers, particularly focusing on issuing such as marginalisation, inequality, exploitation and exclusion (Ribot 2011, 2014; Ford et al., 2013; Wang et al., 2014). Indeed, the conceptual antecedents of many climate change vulnerability studies lies in political economy and political ecology (Hewitt, 1983; Watts and Bohle, 1994; Blaikie et al., 1994; Bassett and Fogelman). Ribot (2011) further argues that while vulnerability can be criticised for retaining a 'negative' focus on problems, it leads us to ask important questions such as why are people vulnerable?

Ford et al. (2012; 2014) further this notion, arguing that the nomenclature of vulnerability refers predominantly to the concepts and terminologies employed in and by academic circles, not the outcome of the research. Examination of adaptive capacity is central to vulnerability assessments, and this element of vulnerability approach highlights the significant potential of human systems to respond to climate change both to moderate negative effects and take advantage of changing conditions. In this regard, a content analysis conducted in Ford et al. (2010) found that peer reviewed articles using a vulnerability approach use the terms adaptation, adaptive capacity, and resilience as descriptors of how a human system will experience and respond progressively to climate change risks as frequently as vulnerability. Vulnerability in many studies then, refers to the approach and concepts used not the outcome, linking such work to a long history of vulnerability research in the climate

change and hazards field, and to a plethora of national and international institutions with a mandate for risk reduction (e.g. UNFCCC, UNDP, World Bank).

2.3 METHODOLOGY IN VULNERABILITY ASSESSMENTS: DEVELOPMENTS AND CHALLENGES

2.3.1 Conceptual frameworks of vulnerability

Owing to the diversity of conceptual approaches that frame vulnerability studies, a vulnerability assessment must capture social and biophysical processes as well as complex outcomes and linkages within social systems that may be difficult to capture. As a result, vulnerability, for the most part, cannot be understood as a single metric, nor is it easily quantifiable (Barnett et al., 2008; Hinkel, 2011).

Two main models for conceptualizing, characterizing and assessing vulnerability can be distinguished within climate change literature. Kelly and Adger (2000) categorized these two approaches as 'end-point' and 'starting-point' vulnerability, the differences between the two can be attributed to the utility of the concept across different fields of study and each have roots in their antecedent traditions of natural hazards and entitlements, respectively. A synthesis article by O'Brien et al. (2007) has since more succinctly categorised these two interpretations as 'outcome vulnerability' and 'contextual vulnerability', the distinction between the two illustrates the practical differences between the entitlements and hazards interpretations of vulnerability.

O'Brien et al. (2007) describe outcome vulnerability as a linear result of the projected impacts of climate change on a specific exposure unit, offset by adaptation measures. This interpretation of vulnerability is used to determine the extent to which different scenarios of greenhouse gas emissions lead to 'dangerous interference with the climate system.' Similarly, Kelly and Adger (2000) note that this approach might also be understood as the risk-hazard framework, considers vulnerability as "the end point of a sequence of analyses beginning with projections of future emission trends, moving to the development of climate scenarios, and thence to biophysical impact studies and the identification of adaptive options" (p. 326). Here vulnerability is understood as the 'dose-response' relationship between an external hazard and a system and the related adverse effects. This approach builds on the early natural

hazards work as previously discussed (Burton et al. 1978; Hewitt, 1983; Cutter, 1996; Brooks, 2003) and dominated research in the 1990s and 2000s, remaining common today.

Conversely, the contextual vulnerability approach, takes a multi-dimensional perspective on climate-society interactions. The approach considers the institutional, biophysical, socio-economic and technological conditions that influence the extent of exposure and sensitivity to climate changes, alongside socio-economic changes. Studies that take this approach often apply such a perspective on a specific local setting, investigating how and why groups are affected differently by climate change, often in the context of multiple stressors (often understanding that vulnerability is determined by exposure, sensitivity, and adaptive capacity) (O'Brien et al. 2007). Kelly and Adger (2000), further posit that the contextual approach considers vulnerability as characteristic of social and ecological systems that is generated by multiple factors and processes; it maintains a focus on prior susceptibility to harm (ibid). This approach, which, having emerged from development studies, developed on the fringes of climate research in the 1990s, is now mainstream (McDowell et al., 2016).

O'Brien et al.'s (2007) contribution concludes with the important note that it is neither possible, nor necessarily desirable, to integrate these two interpretations into a unified framework of vulnerability. Each interpretation stems from different framings of the climate-society interactions, with differing conceptual foundations, assumptions and processes.

2.3.2 Methodologies in vulnerability assessment

Within the contextual approach to vulnerability assessment, case study and analogue methodologies are employed in research, and represent the primary methodologies used in the approach.

Case studies

Case study methodologies involve in-depth place-based research that focuses on a particular exposure unit to characterize vulnerability and its determinants (Flyvberg, 2006; Yin, 2009; Ford et al., 2010). Case studies represent frequently used methodologies for answering questions such as 'how' and 'why', and are widely used in research that requires context specific analysis (Flyvberg, 2006; Yin, 2003; Baxter & Jack, 2008). Case studies provide methodological value through a focus on depth of understanding of phenomenon (Patton, 1987; Andrade, 2009).

In vulnerability scholarship, case studies are typically conducted at a local level, often engaging community members and other stakeholders in identifying climate related risks of importance, characterizing how climatic conditions are changing, documenting how related risks are experienced and managed, and assessing how climate change might affect future activities. This process of identification involves significant and close collaboration between researcher and local stakeholder (Ford & Smit, 2004; Smit & Wandel, 2006; Pearce et al., 2009; Ford et al., 2015).

Analogue studies

Analogue methodologies stem from the logical inference that if two things are known to be alike over spatial or temporal scales in certain respects, then they must be alike in other respects. Temporal analogues are used to reconstruct past climates and provide insights into how change over time and driving processes. Temporal analogues are more common in HDCC literature than spatial analogues (Ford et al. 2010), having allowed for the analysis of climatic change, how human systems manage and experience climatic risks and the identification of those processes driving vulnerability and adaptive capacity (McLeman, 2005).

The past decade has seen the widespread use of temporal analogues in vulnerability assessments, and has significantly increased our understanding of how a changing climate affects society, and has identified and characterized determinants of vulnerability and adaptive capacity (see Parry et al. 1988; Duncan, 1992; Horvath,

2007). However, knowledge on the response of society to climate change remains static.

This lack of understanding is rooted in the conceptual and methodological limitations common to contemporary research. Vulnerability assessments have typically employed a retrospective study design, whereby an understanding of the factors affecting vulnerability and resilience are derived from an assessment of how climatic conditions currently affect communities and have done in the past. While this has contributed essential information necessary for characterizing vulnerability, retrospective study design presents a number of challenges. Interviewees often only recount what they have recently experienced, the season during which research takes place influences what is recounted, and details about the nature of risks and coping strategies recedes as time passes (Collings, 2009; Laidler et al., 2009; Huntington, 2011). This creates difficulties in situating current experience in a broader historical context, and accounting for the evolution of or change in vulnerability over time. Furthermore, research to date has been constrained by short-term funding cycles, typically limiting projects to no more than two years. While this has been effective in providing important information regarding who is vulnerable, to what, and how, such an approach is ineffective in capturing the dynamic nature of how human systems experience and respond to change over time (Sejersen, 2009; Ford and Pearce, 2012; Haalboom and Natcher, 2012; Ford et al., 2013; Fazey et al. 2015).

In this way, our static understanding of vulnerability is linked to an absence of long-term research and monitoring of human-environment interactions, limiting the conceptual approaches underpinning research. New approaches and methodologies are thus needed if we are to develop a more dynamic understanding of vulnerability: this need frames this thesis.

2.3.3 Community collaboration & Research methods

A vulnerability assessment is an evolving social process by which researchers and stakeholders enter into a dialogue to identify vulnerabilities and understand the key process shaping vulnerability at different scales (Farrell et al., 2001; Turner et al., 2003; Ford & Smit, 2004; Adger, 2006; Patt et al., 2010). This approach is commonly

known as the community-based participatory research approach (CBPR). The approach is widely recognized to be essential in HDCC research, and is used extensively in the Canadian Arctic (Duerden and Beasley 2006; Pearce et al. 2009), although how effectively it has been used has been questioned (Brunet et al., 2014; Ford et al., 2015). Using a CBPR approach, the researcher is able to identify and pursue culturally relevant research outcomes collaboratively with community members. As such, CBPR can help equalize power dynamic, builds trust, and create a sense of ownership throughout the research process (Castleden et al. 2008).

Within the CBPR approach, contemporary vulnerability studies employ a wealth of methods including interviews, focus groups, risk ranking exercises and PhotoVoice to gather and document a community's experience with climate change (Berrang-Ford et al. 2012). Such methods allow for research participants to detail the risks they experience, the stresses this places on them as individuals as well as the wider community, and speak of the adaptations they may have developed, or would like to develop.

Over the last decade, arctic research has benefitted from an emphasis on a CBPR approach and is increasingly being emphasized by funding agencies, governments, research licencing institutions and the scientific community (Berkes and Jolly, 2001; Pearce et al. 2011; Ford et al., 2015) As such, the importance of engaging communities throughout all stages of the research process, from setting and defining project priorities, to overseeing research activities, to collecting and analyzing data, to disseminating results, is being recognized (Pearce et al, 2009; Ford et al. 2015)

2.4 CLIMATE CHANGE VULNERABILITY IN THE CANADIAN ARCTIC

2.4.1 Climatic Change in the Canadian Arctic: Physical basis

The Arctic is currently experiencing transformative changes in climatic conditions, with warming in the region occurring more rapidly than at lower latitudes and is being amplified through ice-albedo feedback effects (Larsen et al., 2014; Comiso & Hall, 2014). This increase in temperature is manifested in, and causing dramatic change in components of the cryosphere, most notably sea ice extent, thickness and dynamics,

snow and permafrost coverage and predictability of weather. There are significant implications for ecosystems, societies and their interdependencies of these changes.

Increasing surface temperatures

Surface temperature represents a key parameter that dictates and drives change in cryospheric processes (Comiso & Hall, 2014). Over the last 30 years, mean surface temperatures in polar regions have seen an average increase of ~0.60 °C per decade (Jeffries et al., 2013), with the decade spanning from 1995 to 2005 being the warmest in the Arctic since at least the 17th century, temperatures in this decade were recorded to be 2 °C (3.6 °F) above the 1951-1990 average (ibid). While warming over land will be larger than over the ocean (IPCC, 2014), changes in ocean temperatures in the Arctic have also been recorded (Steele et al., 2008; Holland et al., 2008). While increases in Arctic Ocean temperatures have remained modest, temperatures have been shown to fluctuate rapidly, with changes of up to 5°C in a seven-day period (Holland et al., 2008).

Sea ice coverage

The resultant impacts of the increase in surface and ocean temperatures have had significant impact upon the extent and thickness of Arctic sea ice; since 1979, there has been a ~37.9% reduction in summer ice minimum (Perovich et al., 2013; Comiso & Hall, 2014). Decreases sea ice thickness has also been observed with a ~1.8 m reduction in thickness since 1980 (Vihma, 2014). Specific to Canada, Parkinson & Cavalieri (2008) reported decreases in sea ice coverage (between 1979 and 2006) by 19.5% per decade in Hudson Bay, 1.2% decade per decade in the Canadian Arctic Archipelago, and 16.0% per decade in Baffin Bay/Labrador Sea.

Snow coverage

Snow cover extent in the Arctic has decreased with statistical significance; The IPCC (2014) note that snow cover extent has decreased, especially in spring, with a very high confidence. The report further notes that satellite records indicate between 1967 and 2012, annual average snow cover extent decreased significantly, with the last recorded decrease being of the 53% (recorded in June).

Permafrost

Permafrost, land that remains below 0°C for two consecutive years, is a major component of the terrestrial cryosphere; occupying around 50% of Canadian landmass (Smith, 2005). Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) suggests permafrost coverage is not decreasing, but that permafrost temperatures are rapidly increasing and beginning to thaw (IPCC, 2014). However, Canadian specific research has demonstrated change; permafrost warming has long since been reported from the Mackenzie River valley (Mackay (1975), and the southerly limit of permafrost in Alberta was reported to have moved 120km northward between 1962 and 1988 (Kwong and Gan, 1994). More recently, temperatures in permafrost at 24 to 29 metres in depth have been reported to have increased by about 0.6°C between 1989 and 2003 (Smith et al. 2005).

Climate change and wildlife

The loss of sea ice, the primary habitat of arctic mammals, has implications for both marine and terrestrial ecological dynamics, affecting the health, abundance, and migration patterns of a number of species in the Arctic (Walther et al., 2002; Laidre et al., 2015; Moore & Huntingdon, 2008; Bester, 2014). Observed responses of marine mammals to climate change are varied. Range shifts for subarctic and temperate species, especially predator organisms, put arctic mammals at greater risk of predation, affecting both abundance of arctic marine mammals and a transformation of food webs (Wassmann et al., 2011). The abundance and reproductive output of Harp and Ringed Seals (*Pagophilus groenlandicus* and *Pusa hispida*) has declined owing to climate change related reduced sea-ice (Stirling, 2005).

The effects of climate change on polar bear (*Ursus maritimus*) has been well studied, with the polar bear often used as the face of climate change campaigns. While the effects of climate change on polar bear populations is contentious, and differs by population, a number of studies from the southern extremes of the polar bear range (Wassman et al., 2010; Stirling & Derocher, 2012; Pilford et al., 2015) attribute unidirectional changes in sea-ice dynamics to reductions in polar bear population size, alterations in behaviors and ranges.

Diseases, and toxic effects may represent indirect effects of climate change on the health of arctic wildlife. Perturbations in pathogen transmission will have effects on the body condition of animals as their prey changes, changes in toxicant exposures, and factors associated with increased human habitation in the Arctic will further affect marine mammal health (Burek, et al. 2008). Scholarship in this field is somewhat limited owing to the lack of integrated long-term data on health, diseases, and toxicant effects in the Arctic. However, the research broadly concludes that impacts will vary among species, with some species more sensitive to changes than others (ibid).

2.4.2 Human Dimensions of Climate Change in the Arctic

Early studies regarding the human dimensions of climate change in the Arctic were conducted with an 'end point' approach to vulnerability, as outlined earlier in the chapter. These studies, conducted by government agencies and as captured in early assessment reports of the Intergovernmental Panel on Climate Change (IPCC) (Third Assessment Report) and the Arctic Council's ACIA (Maxwell, 1997; Anisimov and Fitzharris, 2001; ACIA, 2004), largely focused on the implications of changes for certain biophysical systems (Shaw et al., 1998; Nelson et al., 2002), predicting how systems are and will be affected by climate change.

These studies identified human populations in the Arctic as highly vulnerable to climate change, a function of the magnitude of climate change and associated impacts projected. While contributing to an increased understanding of how climate change will affect biophysical processes, however, these studies developed limited understanding of how communities would actually experience and respond to climate change impacts (Duerden, 2004, Ford and Smit, 2004). Responding to this, the last decade has seen the emergence, and rapid growth, of research that considers the way in which society experiences environmental change within the context of social, cultural, economic processes and change (Berkes & Jolly, 2002; Ford et al. 2006a, 2006b; Laidler et al. 2009; Hovelsrud and Smit 2010; Pearce et al. 2010; Prno et al. 2011, and in Alaska: Alessa et al., 2008a, 2008b; Kofinas et al. 2010). Conceptually, these studies draw upon the 'starting point' or Type II conceptual framing in seeking to understand the dynamic interaction between climatic change and social, economic,

and cultural processes. Much of this research focused on documenting climate change impacts, vulnerability and adaptive capacity, primarily investigating the risks posed by climate change to harvesting and subsistence activities (Ford et al. 2012, 2014).

Methodologically, some of these vulnerability assessments were guided by the principles proposed in the International Polar Year Project: Community Adaptation and Vulnerability in Arctic Regions project as outlined by Smit et al. (2008). Building on Ford & Smit (2004), this approach involved the documentation of current climatic exposures, sensitivity, and adaptive capacity; from this, broad characterizations of current vulnerability are made and extrapolated into projections or storylines of 'future vulnerability' using climate- and socio-economic projection data. In doing so, these studies have retained a primarily qualitative research approach, employing interviews, participant observation and focus groups to document how communities are experiencing and responding to climate change, in the context of multi-scalar socio-economic-political conditions and change. This scholarship has provided an important baseline for characterizing how vulnerability is experienced in Arctic communities.

Climate change vulnerability and Inuit

The implications of a changing climate are particularly pronounced for Inuit communities, whose close association with the land, sea and ice creates unique sensitivities to environmental change. Marine mammal harvesting is extremely important for Inuit, and wildlife still contributes significantly to livelihoods, wellbeing and food economies (Ford, 2009; Wenzel, 2009, 2013; Egeland et al. 2009; 2011).

Research documenting the Inuit experience with and adaptation to climatic conditions has a long history. In the late nineteenth century, anthropologist Franz Boas (1888) wrote about the ability of the Inuit to adapt in such an extreme climate. A few decades later, Rasmussen (1927) would make similar observations during his Fifth Thule Expedition in the 1920s. Since these seminal works, much of the literature regarding Inuit-environment interactions has maintained a focus on the subsistence system. Here research can be categorized into two perspectives: acculturation and adaptation. The acculturation perspective, dominant in the 1960s, became the conceptual framework

through which Inuit culture was understood for that period (Wenzel, 2013). Proponents of the acculturation perspective (Murphy & Steward, 1956; VanStone, 1960; Hughes, 1965) described acculturation as a transformational process that would affect the entirety of Inuit society, transforming 'subsistence' and thus the way in which Inuit engage with the land. A transition from this paradigm occurred in the following decades, as researchers began to conclude that change wasn't as pervasive or transformational as previously understood. This adaptation perspective focused on the technological and environmental aspects of Inuit adaptation to change; what was hunted, how and why (Balikci 1970). One example of this is Kemp's (1971) depiction of the snowmobile, and its greater utility over a dog sled and team. Kemp (ibid) concluded that the snowmobile became a tool adapted to the goals of Inuit subsistence, becoming as defining of a characteristic to Inuit as the dog sled teams once were, linking technological change with traditional culture. Much of the HDCC literature in the Arctic emerges from the aforementioned two research contexts (physical and human) and, interestingly, combines elements from both acculturation and adaptation perspectives regarding Inuit subsistence.

Arctic climate change vulnerability studies have broadly found that a combination of changing climatic conditions and changes in livelihoods contributes to community vulnerability to climatic risks (Ford et al. 2006a, 2006b; Laidler et al. 2009; O'Brien et al. 2004; Hovelsrud and Smit 2010; Pearce et al. 2010; Prno et al. 2011).

The vulnerabilities examined in these studies are largely associated with hunting and harvesting activities, which are documented to have become more dangerous, difficult and expensive in the face of changing climatic and socioeconomic changes. The literature identifies three key components of vulnerability as described below.

- *Augmentation and increased frequency of risk:* Inuit across the Canadian Arctic have been shown to be both perceiving and experiencing changing climatic conditions. These changes have been found to be amplifying and increasing the frequency of hazards faced by hunters as they travel and hunt (Ford et al. 2013; Pearce et al. 2010). The most pronounced climatic changes in a number of communities are recorded changes in strength, direction and predictability of wind as well as changing ice and snow conditions (Hovelstrud et al. 2011; Pearce et al. 2012; Ford et al. 2013). Prediction is essential to hunters who would use such

environmental indicators alongside traditional knowledge to forecast, anticipate and respond to dangers and opportunities for safe travel. In the face of climatic changes this traditional knowledge, once reliably used to predict safe hunting and travel conditions, has become less dependable and hunting has become more hazardous in some instances as a result (Ford et al. 2013; Pearce et al. 2010). Community access to resources has also been found to be sensitive to climatic change. Studies have found that access to caribou and seal hunting areas are increasingly being restricted by sea, ice and snow conditions. As these resources have significant social, cultural and economic importance changes in accessibility have great implications for the food security, culture, well-being and economies of communities (Ford et al., 2006a, 2006b; Prno et al. 2011; Andrachuk and Smit, 2012).

- *Changing Livelihoods and the erosion of traditional knowledge:* A number of studies suggest that socio-economic transformations including compulsory schooling, emergence of the wage-based economy and the increased cost of living are significantly reducing the time spent engaging in traditional activities, and thus are creating an erosion of traditional skills and networks that once conferred significant adaptive capacity (Ford et al. 2013; Pearce et al. 2010). Many studies find that as a result of these changes, Inuit youth are engaging less with the land sufficiently enough to harness the skills required for safe ice travel and hunting (Takano, 2005; Pearce et al., 2010; Laidler et al. 2011; Ford et al., 2013;

- *Differential vulnerability:* The majority of assessments show vulnerability as heterogeneous within communities. Different groups are differentially exposed and sensitive to risk and thus experience vulnerability differently; experienced hunters and active elders experience high level of exposure given their regular use of ice to hunt throughout the year. However, through this continued use of the land and using their intimate understanding of sea-ice processes and hazard identification, they also demonstrate significant adaptive capacity. Meanwhile, youth or lesser experienced hunters have limited experience with environmental change and thus poses a reduced adaptive capacity and increased vulnerability (Ford et al. 2008; Pearce et al. 2010). The interactions between young and old,

experienced and novice that facilitate reduced vulnerability are yet to be fully explored.

Beyond these impacts on the subsistence sector, a changing climate has implications for travel and transportation, municipal and industrial infrastructure, the prevalence and incidence of waterborne, foodborne and vector borne diseases in Arctic regions (Fussel, 2009; Lemmen; 2008; Ford et al. 2015). However much of this falls outside the scope of this research as these issues have not been noted as pertinent to the community of Ikpiarjuk.

CHAPTER THREE: RESEARCH DESIGN

3.1 CHAPTER OVERVIEW

This chapter presents the research methodology used to conduct the vulnerability assessment. It outlines the methods employed to operationalize the assessment and analysis, noting that the methodology and methods presented here parallel those used in the first study (Ford et al. 2006a). The chapter begins by reviewing both the conceptual and analytical approaches utilized, building upon much of the work cited in chapter two. The chapter then provides a rationale for the use of case studies and provides an overview of the case study community. Finally, the chapter concludes with an overview of the methods, data collection protocols and the approach used to analyze data obtained.

3.2 CONCEPTUAL FRAMEWORK: A MODEL OF VULNERABILITY

Building upon a contextual framing, this paper conceptualizes vulnerability as a function of exposure-sensitivity to the effects of climate change and adaptive capacity to manage them. The model recognizes that both the exposure-sensitivity and adaptive capacity of a community are continually affected by dynamic and multi-scale social and biophysical processes. The model used here is consistent with that of Ford and Smit (2004), used in the initial study (Ford et al. 2006a), builds upon Smit and Pilifosova (2001), and can be expressed as:

$$V_{ist} = f(E_{ist}, A_{ist})$$

Where:

V_{ist} = Vulnerability of community i to stimulus s in time t
E_{ist} = Exposure-Sensitivity of i to s in t
A_{ist} = Adaptive capacity of i to deal with s in time t

The relationship between the two elements in this model is not specified, as it is context specific; however, the approach understands vulnerability as a positive function of a community's exposure-sensitivity and a negative or inverse function of a community's adaptive capacity (Smit and Pilifosova, 2003).

Exposure-sensitivity reflects the susceptibility of human systems (individual, households, communities) to climatic risks; it is dependent on both the nature of the climatic conditions experienced and the characteristics of the community experiencing them. The nature of climate-related risks may include the magnitude, frequency, temporal spacing, rapidity of onset, and spatial distribution of biophysical risks. The characterization of the community is mostly concerned with livelihoods strategies and the location and structure of the community in relation to the risk, though also encompasses wider socio-political factors (Turner, 2003; Smit and Pilifosova, 2003; Ford and Smit; 2004). As an example, an Inuit community with a greater proportion of its population dependent on hunting and harvesting activities for food is more sensitive to changing sea-ice dynamics than an inland community.

Adaptive capacity refers to the potential or ability of human systems to address, plan for, or adapt to these risks. It is influenced by, among other factors, livelihoods, financial resources, social networks, infrastructure, social institutions, experience with risk, the range of technological adaptation available, as well as the equity of access to resources across the community (Ford & Smit, 2004; Smit & Wandel, 2006; Keskitalo, 2008).

It is further recognized that vulnerability is determined by interactions between exposure, sensitivity, and adaptive capacity. The influence of these interactions, as well as other determinants operating over multiple spatial-temporal scales may operate to create or moderate new or existing vulnerabilities (Smit and Wandel, 2006; Ford et al., 2010, 2013). For instance, some adaptive strategies may increase long term vulnerability through system response to change over time, creating what Fazey et al. (2011) and Ford et al. (2013) term ‘trajectories of maladaptation’.

3.3 ANALYTICAL FRAMEWORK

The analytical framework used to apply the conceptual model to characterize vulnerability is based on that of Ford and Smit (2004), and is consistent with other vulnerability studies (Ford et al, 2006a; 2006b; Pearce et al. 2010). The approach begins with the assessment of current vulnerability, through documenting current exposure-sensitivities and adaptive capacity. It progresses to assess future vulnerability by estimating directional changes in exposure-sensitivity and predicting

future adaptive capacity on the basis of past behavior (Ford et al. 2010). The approach of focusing on the current vulnerability to derive insights for the future is common in the HDCC literature, where the analysis of historical context from both interview data and literature allows for the characterization of how human systems manage and experience change while identifying processes and conditions that lead to adaptation and/or mal-adaptation. Such methodologies have significantly increased our understanding of human-environment interactions and have helped to identify and characterize determinants of vulnerability and sources of adaptive capacity.

Alongside this approach, the adaptation pathways approach, a new approach to future-oriented analyses, conceptualizing adaptation as pathways or route maps to assist planning, implementation, and adaptation, is used to anticipate future trajectories and responses to change (Fazey et al., 2015). The pathways approach can be both prospective and retrospective, understanding change as dynamic, ubiquitous, and constantly occurring through time rather than specific occurrences (ibid). Noting the challenges, complexity and uncertainty associated with assessing future vulnerability, and given that the focus of this research is to characterize the dynamics of vulnerability over the past decade, this thesis focuses on identifying and characterizing current vulnerability. This is consistent with other studies (Ford et al., 2006a; 2006b; Pearce et al., 2009; Hofmeijer et al., 2013), specifically drawing upon a longitudinal assessment of how vulnerability has evolved over the last decade.

3.4 PLACE-BASED RESEARCH

This study utilizes a place-based case study in the analysis and characterization of vulnerability. Case study methodologies are widely used in climate change vulnerability assessments in Arctic regions and globally, providing methodological value through a focus on depth, enabling a deep understanding of phenomenon, outcome or problem (Andrade, 2009; Klein & Myers, 1999).

3.4.1 Case study selection

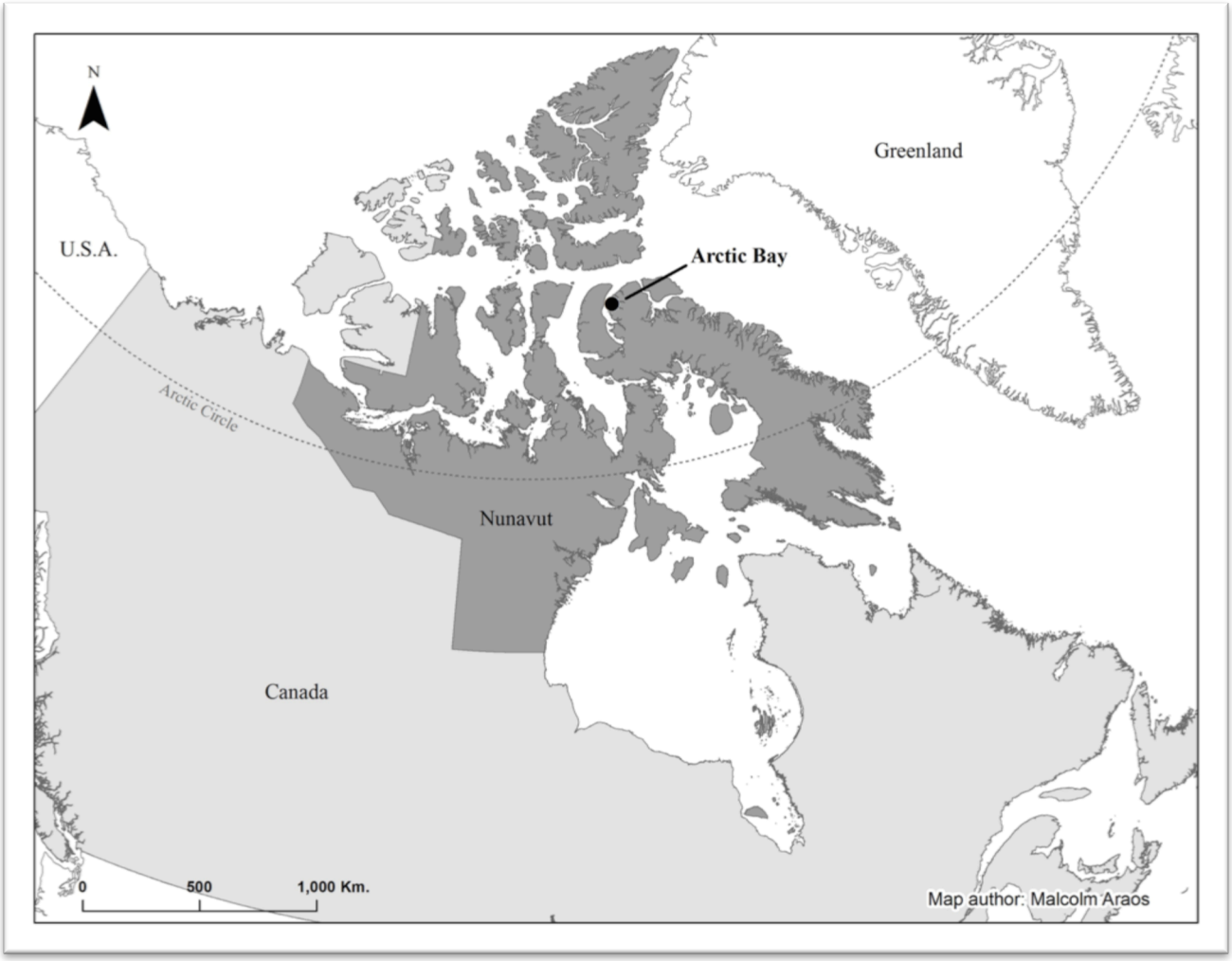
This research replicates the previously conducted vulnerability assessment conducted in Ikpiarjuk, Nunavut, one decade since the original fieldwork, using an identical approach and methodology (Ford et al. 2006a). This underpins the study aim to examine the dynamic nature of climate change vulnerability; seeking to understand

the continually evolving process of how human systems experience and respond to change.

3.4.2 Ikpiarjuk

Ikpiarjuk (Arctic Bay) is an Inuit Hamlet found on the Borden Peninsula on Baffin Island, in the Qikiqtaaluk Region of Nunavut, Canada, almost 700 miles north of the Arctic Circle (73° 02' N, 85° 10' W) (see Figure 1.1).

FIGURE 1.1 A MAP OF NUNAVUT WITH ARCTIC BAY (IKPIARJUK) HIGHLIGHTED.



As of the 2011 census, Ikpiarjuk had a population of 823 people (Stats Canada, 2012). The figure cited in the 2011 census represents a population growth of 19.3% from the 2006 census, and 27.3% growth since the 2001 census (StatsCanada, 2001) that

was cited in the initial vulnerability assessment (Ford et al, 2006a), this is further illustrated in table 1.1.

TABLE 1.1. IKPIARJUK DEMOGRAPHIC CHANGE OVER A TEN-YEAR PERIOD

	2001	**2006**	**2011**
Characteristics			
Population (total)	645	690	823
Aged 0 to 14 years	240	235	300
Aged 15 to 64 years	400	445	485
Aged 65 and over	10	15	35
Inuit Population	610	640	795
Employment rate %	49.4%	42.0%	39.8%
Unemployment rate %	21.6%	26.0%	25.9%
Average Individual Income	$21,270	No data	$28,813

Sources: StatsCanada, (2001; 2006; 2013)

Over the last sixty years the economy of Ikpiarjuk has shifted from one based entirely on subsistence activities to a mixed economy in which both the informal and formal economic sectors assume an important role (Damas, 2002). The building of a lead, zinc and silver mine 20 miles away in the community of Nanisivik began in 1976. The Nanisivik mine, which closed in 2006, provided not only employment for the community, but accelerated the transition of the local economy (Damas, 2002; Ford et al. 2006).

Today, key informant and participant interviews suggest that approximately 50% of the population of Ikpiarjuk are currently unemployed, while there is a paucity of recent data to support this, unemployment in 2011 was at 25.9%. However the participation rate, referring to the number of people who are employed or actively looking for work (those who are unable to work or are retired are not included), stood at 52.4% (StatsCanada, 2013). Table 1.1 also demonstrates a significant population increase over the ten year period with an overall increase of 27%, though, importantly, a 250% increase in the population aged 65 and older.

Traditional hunting and trapping activities remain of economic, cultural and social importance. Hunting and associated activities (food sharing, learning of traditional

skills) have been found to be integral in maintaining cultural identity, strengthening social relationships and contributing to food security in the community (Ford et al., 2006a). The initial study (ibid) however, suggested that despite the importance of hunting, fewer younger generation Inuit are participating in the subsistence economy.

In 2004, the Nunavut Wildlife Management Board described ringed seals, caribou and arctic char as the mainstays of the wildlife harvest in Ikpiarjuk, all of which are hunted year round. The report (NWMB, 2004) also documents a small amount of harvesting of ptarmigan, snow goose, beluga whale and arctic fox, though the quantities were insignificant. In the spring-time, Ikpiarjuk residents engage in the narwhal hunt, though narwhal harvesting is limited to this brief timeframe, it is of great economic and cultural importance (*ibid*).

No similar recent reports exist, however data from this study suggests that other than the substantial loss of caribou, hunting patterns remain similar. Polar bear and narwhal hunting is regulated by quotas set by the Nunavut Wildlife Management Board.

3.5 METHODS

3.5.1 Longitudinal assessment

Recent years have seen a dramatic increase in the use of longitudinal methods, particularly within the social sciences. The shift towards longitudinal design and analysis signifies a critical shift in research methods that enables a more comprehensive understanding of the processes thought to underlie many human behaviours and anthropogenic phenomena (Harring & Hancock, 2012). Despite this, few HDCC studies are based on a longitudinal study design (Erikson et al. 2005; Ford and Pearce, 2012).

Repeated observation of human-environment interactions over extended periods of time is essential for understanding the dynamics of vulnerability, recognizing that exposure, adaptive capacity, experience with risk, and changing socioeconomic context are continually evolving, shaping and re-shaping how climate risks are experienced and responded to. Furthermore, adaptive learning, experience with risk

and restructuring play an important role in influencing vulnerability, through repeated observation we may be able to answer questions such as how quickly does learning take place, and how much change can be adapted to?

To capture this dynamic nature of vulnerability, this study employs a longitudinal approach in both design and analysis. This provides an important historical dimension to the study, facilitating the analysis of continuity and change over a decade. Furthermore, the nature of longitudinal research allows for explanations and analyses of change that are complex, holistic and multifaceted. It is recognized that change is multi-faceted, involving political, cultural, incremental, environmental and structural dimensions. It is also recognized that micro-phenomenon such as chance, opportunism and accident are as influential in results as the wider context of change that they exist within (Saldana, 2003).

Epstein (2002) and Young et al. (1991) classify longitudinal studies into three formats of research design: (i) continuous research in the same geography over a number of years, (ii) periodic restudies at regular or irregular intervals, and (iii) returning to a study area after a lengthy interval of time has elapsed since the original research. This research project fits within the third classification, as the research involves returning to Ikpiarjuk to examine the same themes ten years after the original study. However, continued research over the ten-year period (format 1) would be preferable as it provides continuity, consistency and a greater accuracy and level of detail to the data. Though this type of research requires significant resources, time and appropriate funding.

3.5.2 Mixed methods approach

A 'mixed methods' approach is employed here consistent with the methods used in the previous study. Data collection techniques included: in-depth semi-structured interviews, key informant interviews, participant observation and the analysis of instrumental data (e.g. CIS sea-ice data). By combining multiple methods, biases, weakness and limitations of single methods can be limited (Rothbauer, 2008).

Semi-structured interviews

Semi-structured interviews are a standard method used to collect in-depth qualitative data in an open-ended format, where the participant is guided through the discussion by the interviewer. The method is widely used in climate change vulnerability research, particularly in projects engaging Indigenous communities (Ford et al. 2006a, Ford et al. 2006b; 2006b; Krupnik & Jolly, 2002; Pearce et al., 2010), and has been used in various northern research contexts (Laidler 2006; Krupnik & Ray 2007; Carmack and Macdonald 2009; Laidler and Ikummaq 2008; Ford 2009; Beaumier and Ford, 2010).

In this research, and consistent with the original study, a fixed list of questions was avoided in favour of an interview guide, which identified key themes to be covered in the interview. The interview guide used was consistent with the guide used in the first study, with elements of change explored as the participants led discussions. The interview guides used in both studies are available in Tables 1.2 and 1.3. The sections regarding future vulnerabilities and policy found in the 2004 guide were replaced with sections exploring change over time in line with the objectives of this study. This format prevented the interviewer from predetermining what conditions were relevant and important to people and rather allowed informants to identify relevant conditions in their own words and interpretations. Leading questions were avoided and particular effort was given to asking questions as open as possible as research has suggested that Inuit will not disagree with an opinion out of respect, even if they do not share it (Collings, 2009). Instead, broad and open questions were used to facilitate a discussion.

TABLE 1.2 INTERVIEW GUIDE USED IN 2015 STUDY

Section	**Questions**
Introduction and context - Background information - Hunting patterns	Where were you born? How long have you lived in Ikpiarjuk? Do you have family? Do you work? Do you hunt? What do you hunt, and when/where?
Current Climate Change exposures - Climate related - Social, Economic and Cultural	What problems do you face when hunting? What affects your ability to hunt? Have you experienced any difficulties in hunting? How do environmental conditions affect your hunting and community? Describe the demand for the animals you hunt.
Management Strategies - Strategies	How do you manage risks in hunting? Has this changed since you were younger? Why? What

- Constraints - Opportunities	constrains your ability to manage risk? Are things more difficult today than when you were younger?
Change over time - Climatic change - Economic change - Change in skills, behaviours or strategies	Have climatic conditions changed in recent years? Has this affected your ability to hunt? Has the local economy changed in recent years, what does this mean for your trade/livelihood? Have you developed new strategies, behaviours or skills in recent years?

TABLE 1.3 INTERVIEW GUIDE USED IN 2004 STUDY

Section	**Questions**
Introduction / context - Life history - Family - Seasonal cycle of activities	Where were you born? How long have you lived in Ikpiarjuk? Do you have family? Do you work? Do you hunt? What do you hunt and where?
Important conditions (current exposure) - Climate related - Social, cultural, economic, political - Change over time	What problems do you face? What affects your ability to hunt? Have you experienced any difficulties when hunting? Why do they pose a problem? Have they changed over time? How and why? How do environmental conditions affect you / your community? Is this different today?
Management strategies (current adaptive capacity) - Strategies - Constraints - Opportunities	How do you manage hunting risks? Has this changed since when you were younger? Why? What constrains your ability to manage risks? Are things more difficult today than when you were younger? Why? What can be done to make things easier?
Future challenges (future exposure and adaptive capacity) - Climate - Social, economic, political - Response	Have climatic conditions changed in recent years? Has this affected your ability to hunt? Has the local economy changed in recent years, what does this mean for your trade/livelihood? Have you developed new strategies, behaviours or skills in recent years?
Climate change policy response	What can done to help you better deal with these problems?

3.5.4 Interviewee selection

Interviewees were selected using a purposeful sampling strategy, allowing for repeat interviews with participants from the 2004 study as well as the recruitment of new participants to address issues of attrition. Of the 50 participants in the 2004 study, 24 were available for a repeat interview in 2015. The remaining 26 of the original

participants had either passed away (n = 8), had permanently relocated (n = 11) or either declined, were unavailable, or were deemed inappropriate for inclusion in the study (n = 7). Those excluded from the study were done so based upon the RAs guidance, these individuals may have ceased engaging land-based activities or community life or in some instances were alcoholics or drug-users, association with whom may have damaged the researchers reputation elsewhere in the community. This represents an attrition rate of 52%. To account for this, 16 new participants were recruited. The local research assistant (RA) with the intention of sufficiently representing all groups within the community and replacing the kind of individuals originally interviewed, identified these participants. Individuals were approached based on their similarities, either socio-economically or gender and age, with the participants in the initial sample. The RA, Mishak Allurut, was the same individual who worked on the 2004 study. The initial 2004 sample was intended to provide an accurate cross-section of the community, including different age groups, genders and occupations.

In total, 40 interviews were conducted in Ikpiarjuk in February and March of 2015, 22 of which were male and 18 female. A breakdown of the sample group is available in table 1.4.

TABLE 1.4 COHORT DEMOGRAPHICS

COHORT 1 (2004) *n* = 50	
Descriptor	**Sample %**
Sex	
Male	63%
Female	37%
Age group	
20-30	14%
31-40	12%
41-50	12%
51-60	8%
61-70	20%
70-80	29%
81+	4%
Employment	
Unemployed	39%
Part-time	4%
Full-time	35%
Retired	22%
Hunting frequency	
Never	18%
Rarely	18%
Spring-time only	20%
Weekends only	20%
All year round	22%

COHORT 2 (2015) n = 40	
Descriptor	**Sample %**
Sex	
Male	55%
Female	45%
Age group	
20-30	3%
31-40	20%
41-50	15%
51-60	15%
61-70	5%
70-80	30%
81+	13%
Employment	
Unemployed	40%
Part-time	5%
Full-time	33%
Retired	23%
Hunting frequency	
Never	13%
Rarely	18%
Spring-time only	8%
Weekends only	28%
All year round	35%

3.5.5 Interview protocol

Interviews took place at locations chosen by the interviewees, this resulted in half of the interviews taking place in the interviewees' homes, and other half being conducted at the researcher's rented accommodation in the center of town. It was common that the researcher would visit the homes of community elders, while the younger interviewees would come to the researcher's house. Mishak Allurut (research assistant) was present for the interviews requiring translation, otherwise interviews were conducted alone, with just the researcher and participant.

Each interviewee was paid $60 per interview, an amount suggested by local research assistants and the Nunavut Research Institute. Small gifts such as packs of tea, coffee

or soft drinks were also given to elder interviewees as a token of gratitude in line with cultural norms and upon recommendation of the research assistant. This protocol is consistent with the 2004 study.

Before interviews began, each participant was briefed on the purpose of the study, asked if the interview could be recorded (audio) and if they would like their data to remain confidential. These briefings took place in either English or Inuktitut, through a translator. Consent forms, available in both English and Inuktitut were then signed as required by both the McGill Ethics Review Board and the Nunavut Research Institute. Consent forms are provided in the appendix.

Interviews in English were conducted by the researcher, often alone, while interviews in Inuktitut were led by Mishak Allurut (RA). Of the 40 interviews, 21 (52%) were conducted in English and 19 (47%) in Inuktitut, with translation most commonly being used with community elders. This compares to 28 (56%) in English and 32 (64%) in Inuktitut in the 2004 study. A consecutive translation approach was utilized; an experienced interpreter, translated questions into Inuktitut followed with the response translated back to English simultaneously.

Key informant interviews

Key informant interviews provide in-depth information from a wide range of people—including community leaders, professionals, or residents. Key informants are purposefully selected as being those with knowledge about the community or issue being examined (Parsons, 2008).

In Ikpiarjuk, key-informant interviews were conducted with the Community Justice Outreach Worker, a Health Committee Member, the Search and Rescue coordinator and 4 active HTO (Hunters and Trappers Organization) members. These community members were selected given their knowledge regarding harvesting activities as well as the wider nature of the community. The HTO members were approached given their experience, both past and present, with harvesting activities. The search and rescue coordinator was able to provide information regarding changing exposure-sensitivity and the local and political response to this. While the health committee member and community justice outreach worker were both instrumental in the

management of hunting training camps for young people, which, in other studies (Pearce et al. 2009; 2010) have been shown to have potential to confer adaptive capacity.

The structure and content of these interviews varied depending on the subject matter and interviewee; however each interview maintained a consistent focus on the drivers and determinants of vulnerability, as determined by research participants, in the community. Interviews were not recorded at the request of the participants; however they were transcribed on the same day from notes taken. Interviewees were paid $60, consistent with payments to other participants.

Participant observation

Participant observation involves paying close attention to, and participating in 'everyday geographies' in order to understand both social spaces and the lived, experienced and emotional realities within them (Crang and Cook, 2007). Participant observation is an observational method whereby the researcher becomes an active agent in the group being studied. It is a common qualitative method used when conducting research on a particular population in a particular locality.

The method is of particular utility in both the western Arctic with Yup'ik populations (an ethnic group of western Alaska) (Fienup-Riordan; 2001; Morrow 1996) and with the Inuit of Baffin Island and Nunavut, sometime perceiving direct questions to be coercive acts and thus met with evasion (Collings, 2009). Only through observation over an extended time period does the researcher slowly discover and understand cultural competencies, in turn build trust, rapport and acceptance before eventually being able to ask questions in a culturally appropriate manner (ibid).

Application of this method included walks around Ikpiarjuk with Inuit elders or experienced hunters, participating in seal, polar bear and ptarmigan hunting trips to observe and experience concepts discussed in interviews, and generally experiencing and observing community life (over a 2 month period). Elders and experienced hunters were often those most willing to engage in these activities with the researcher

and were able to provide the most useful data for the study. Activities varied in duration and frequency, from a few hours to a whole day (with a total of four days spent outside the community). The purpose of the trips and experiences were made explicit while engaging in activities.

These trips involved three seal hunts and one polar bear hunt, questions were asked throughout to confirm previous data from interviews or to tease out nuances. This was particularly useful in observing the safety precautions taken on modern trips and asking how contemporary practices (GPS, online weather, additional supplies etc.) compare to those of ten years ago.

The fieldwork took place at the same time of year as the original study (January-March) and involved comparable field time. Observations were noted after the trip had taken place and compared with findings from other methods.

Instrumental data

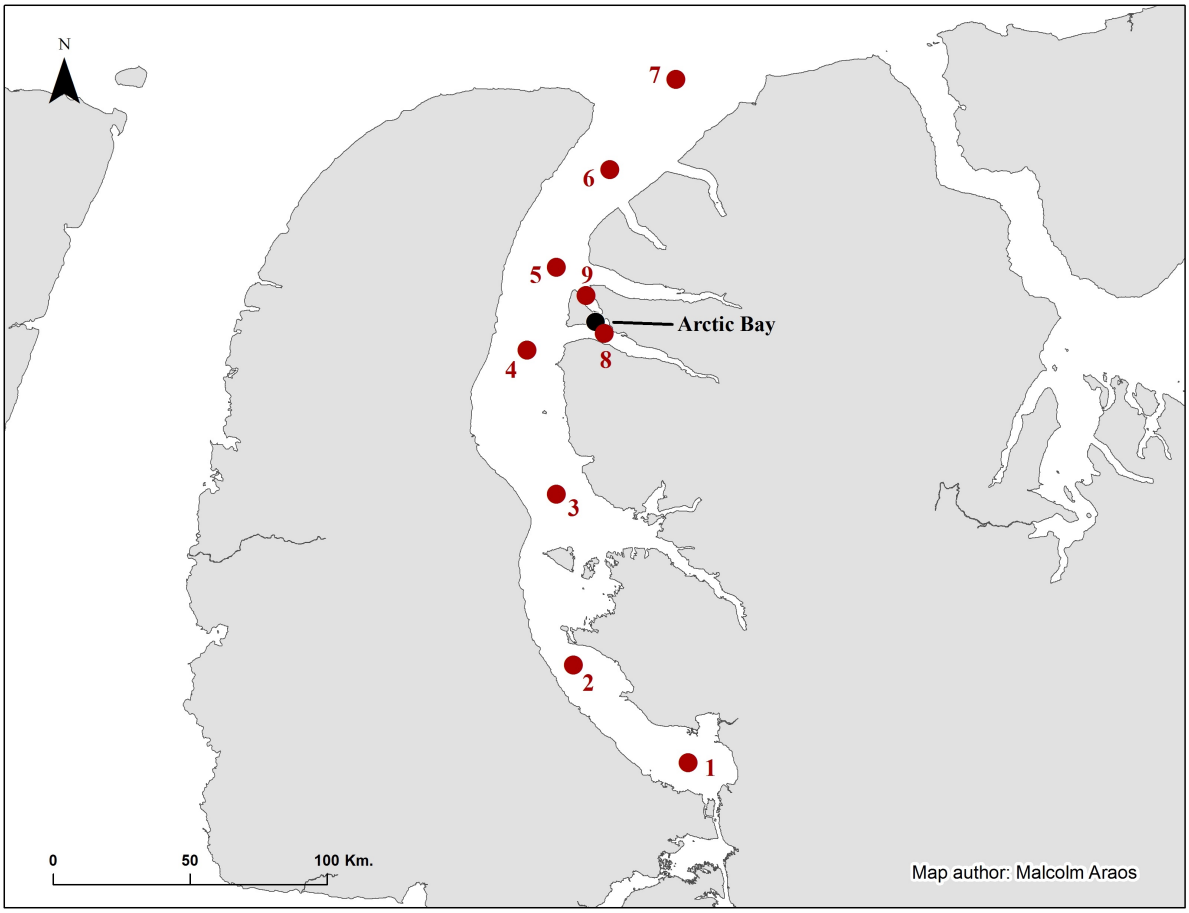
Instrumental data has been provided by the Climate Lab at the University of Toronto to inform analysis on biophysical change in and around Ikpiarjuk. Data provided and used in this study includes areal extent of sea-ice, changes in sea-ice freeze-up and break-up, temperature and precipitation extremes and snow accumulation. Data has been provided for the entire time period for which it is available (this differs depending on the process) and is used to frame the change experienced by the community and characterize biophysical change over the ten-year period.

Sea ice data were obtained in chart form from the Canadian Ice Service (CIS), which are derived from both surface observation and satellite imagery, with ice information relayed in the form of fractional ice coverage of the ocean surface (on a value of 10, which can be equated to a percentage of surface ice cover) (Gagnon and Gough, 2005). Sea ice concentration data were obtained for 9 sampling points surrounding the community of Ikpiarjuk (Figure 1.2), and were chosen on the basis importance for trail usage of Ikpiarjuk land harvesters: Point 1 is an area in which spring-time seal hunting takes place; points 2, 3 and 4 are points along well-used hunting trails; while points 6 and 7 represent the floe-edge from which narwhal hunting takes place. Ice charts were also used to estimate ice break-up and freeze-up dates and conditions

from 1968 to 2014. The ice breakup date is defined as the first date when the ice concentration was 5/10 or less during the summer months, while the ice freeze-up date was determined to be the earliest date when the ice concentration reached 5/10 or more between October and December (Gough et al, 2004; Gagnon and Gough, 2005). These thresholds are in accordance with the terminology utilized by both the Canadian Sea Ice Service and the World Meteorological Organization (WMO) (Gagnon and Gough, 2005). Dates were expressed numerically as the ordinal day of the year, where January 1st was the 1st day and December 31st was the 365th day, unless there was a leap year in which case December 31st would be the 366th day of the year (Gagnon and Gough, 2005; Kowal et al., 2014). As a result, the data is structured in such a fashion that for each year (from 1968 to 2014) there are 9 breakup and 9 separate freeze-up dates pertaining to each of the 9 superimposed sampling points (Gagnon and Gough, 2005; Kowal et al., 2015). One derived metric is included, the ice free season duration, which is the difference between freeze-up date and breakup date and as a result there are 9 separate ice free dates (Kowal et al., 2014).

Analysis of CIS data involved the calculation of the average date of break-up/freeze-up across each of the nine data points for the year, from here these figures were input into graphs for the identification of trends. Graphs were further drawn up for individual data from each point to identify trends and anomalies at each point.

FIGURE 1.2 MAP OF SEA ICE DATA POINTS



3.6 DATA ANALYSIS

Data analysis formed a two-part process: the first of which was the analysis of data pertaining the current nature of climate change vulnerability in Ikpiarjuk in 2015 (documented in chapter four). This was conducted in a manner consistent with the 2004 study. Second, a longitudinal analysis was conducted in which data from both studies, past and present, were compared and contrasted to extract information regarding the nature and drivers of change (documented in chapter five). Throughout both parts of the process, verification of the analysis and feedback was sought from community members.

3.6.1 Current Vulnerability

A coding scheme, identical to that used in the 2004 study, provided a framework for the analysis and extraction of data in a systematic manner, see table 1.5. Each

interview transcript was read and coded, whereby particular words, phrases and sections of text were assigned the appropriate theme code. Each interview was also assigned an attribute value relating to hunting habits (never, rarely, frequently, spring-time only etc.), sex (male, female) and age of the interviewee. This allowed investigation of the relationship between groups in the sample and reported risks and adaptations.

Analysis was an iterative process. Initially, latent content analysis was performed using the coding scheme to develop an understanding of the content of the interview data. This allowed for the identification of key exposure-sensitivities, adaptive strategies and determinants of adaptive capacity. Throughout this process, particular attention was given to how these themes have or have not changed over time. Next, data was analyzed with the intent of explaining and characterizing the processes shaping vulnerability. This involved comparing and contrasting interviews for explanations with regards to determinants of exposure and adaptive capacity; identifying trends and patterns; looking for differences based on age, occupation, sex, and harvesting behaviour; checking data for consistency to ensure credibility; comparing with other data sources including personal observations, key informant interviews, and secondary sources.

3.6.2 Longitudinal analysis

Through longitudinal analysis, this research seeks to understand and characterize the processes that drive vulnerability. Process, as defined by Strauss and Corbin (1998; 165) is "a series of evolving sequences of action/interaction that occur through time and space, changing or sometimes remaining the same in response to the situation or context". The authors advise that change has dimensional properties such as rate, and degree and may occur in stages or sequences.

To analyze change through time, interview data from the 2015 cohort was compared with that of the 2004 cohort. For those individuals that were interviewed in both studies, the two transcripts were compared and contrasted, identifying and characterizing the changes in exposure-sensitivity and adaptive responses over the ten-year period. Changes in exposure-sensitivity and harvesting-related behaviors

were coded, as were contextual changes such changes in the employment, retirement, health of the individual. This allowed for the chronological assembly of data, organizing or restorying (Ollerernshaw and Creswell, 2002) to develop an understanding of what happened first, next and then what is currently taking place. In practice, this involved the chronological ordering of all passages of participant data that have been similarly coded, creating a narrative with a clear beginning, middle and end. This often represented the most significant methodological challenge as participants were often not able to provide specific dates or years when describing observations or experiences.

When analyzing interview data from participants that did not take part in the initial study, change over time was analyzed through a series of framing questions, as follows;

1. When do changes occur in time?
2. What contextual and intervening conditions appear to influence change?
3. What is cumulative through time?
4. What remains constant and consistent through time?
5. What decreases or ceases through time?

A lack of published research conducted in Ikpiarjuk since the mid-2000s offers limited contextual information to frame or triangulate the responses of the participants. As a result, grey literature (predominantly news outlets) was used to contextualize findings and provide further explanation as to the changing nature of the community.

This process identified and developed the characteristics of current vulnerability and how it has changed that are discussed in chapters four and five.

TABLE. 1.5 – CODING SCHEME DEVELOPED TO ANALYZE THE INTERVIEW DATA

Current Exposure

- Harvesting related
  - Changing exposure
    - Harvesting behaviour
      - Social drivers
      - Economic drivers
      - Political drivers
      - Biophysical drivers
    - Climate change
  - Unchanging exposure
- Non harvesting related (leisure or professional)
  - Changing exposure
    - Nature of community
    - Climate change
  - Unchanging exposure

Current adaptive capacity

- Adaptive Response
  - Change over time
    - Social drivers
    - Economic drivers
    - Political drivers
    - Biophysical drivers
  - Constant over time
- Adaptation constraints
  - Change over time
    - Social drivers
    - Economic drivers
    - Political drivers
    - Biophysical drivers
  - Constant over time
- Adaptation facilitators
  - Change over time
    - Social drivers
    - Economic drivers
    - Political drivers
  - Constant over time

CHAPTER FOUR: CHARACTERIZING CURRENT VULNERABILITY IN IKPIARJUK IN 2015.

4.1 CHAPTER OVERVIEW

This chapter empirically applies the vulnerability framework to identify and characterize vulnerability to climate change in Ikpiarjuk, in terms of who is vulnerable, to what stresses, and why, based on the 2015 fieldwork. Focusing largely on vulnerabilities associated with subsistence harvesting, the chapter demonstrates that vulnerabilities emerge through a combination of changing climatic conditions and an increasingly challenging socio-economic context. However, in the face of these changes, Ikpiarjuk demonstrates significant adaptive capacity underpinned by sharing networks, traditional knowledge and use of new technologies. The chapter provides the basis for the longitudinal assessment of change in vulnerability over time in chapter 5.

4.2 EXPOSURE-SENSITIVITY

4.2.1 Biophysical drivers

The community of Ikpiarjuk is experiencing changing climatic conditions that are amplifying the frequency and magnitude of risks faced by the community. Some of the more pertinent biophysical changes have occurred in sea ice dynamics, the strength, direction, and predictability of the wind and changes in the abundance, migration patterns and health of some wildlife species important for subsistence.

Changing sea ice dynamics

The sea ice surrounding Ikpiarjuk is the platform for the community's wildlife harvesting activities, an activity that contributes significantly to the community's food supply. Except for a period of open water from mid-July and early October, travel and harvesting is largely performed on sea ice, where narwhal, ringed seal, arctic char and polar bear are harvested. Research participants reported spending considerable time on the ice: the 18 full-time hunters reported spending between approximately 20 and 30 hours on the ice per week, equating to three to four trips per week, with a higher frequency in the spring-time. The 10 weekend hunters would typically spend 5-10 hours per week on the ice, usually just one trip per week, again with higher frequency

in the spring-time. Spring-time hunting is popular in Ikpiarjuk, and indeed across the High Arctic, as young (3-4 month old) seals are harvested at this time, as well as the arrival of narwhal. Other participants stated that they hunted infrequently, or on an ad-hoc basis in the springtime.

Changes in sea ice dynamics were identified by every participant in the 2015 study cohort (n=40). Most of the community-identified changes were related to the timing of ice break-up and freeze-up, though more experienced hunters were able to provide more nuanced descriptions of changes in *how* the ice breaks-up, such as thickness, consistency of the ice, as well as its abrupt breaking up.

All research participants observed changes in the timing of sea-ice break up and freezing, and participants noted that sea-ice now melts earlier, in June, when in previous decades it would melt in late July. The timing of the re-freeze in the fall and winter months was also noted to have changed in recent years, now occurring in late October or November as opposed to September, as noted by participants and in instrumental data. In 1977, for example, Lindsay (1977) recorded that the fjords and sounds in the region freeze each year in October and remain frozen until early July.

> "The ice doesn't freeze as early as before. I used to freeze in September but now it's November" - Adrian Arnauyumayq, 2015

> "In springtime, there used to be camping [on the ice] until the end of July. Now we stop early June" - Jooeli Qamanirq, 2015

Instrumental data, as demonstrated in figures 1.3 and 1.4, demonstrates that for all data points, break-up has steadily occurred earlier in the year and freeze-up steadily occurring later over a 40-year period. The most pronounced changes appear to take place closer to the floe-edge. Instrumental data regarding these changes over time is outlined in the following chapter.

Participants further noted the changing nature of the break-up and freeze-up, providing location specific information more difficult to detect through instrumental data. These changes included the increasing rapidity with which the ice thins and

breaks, how it now melts from the bottom-up, instead of from the surface to sea, and how, around break-up time, the ice is softer and slushier than it used to be. A number of participants attribute the rapidity of break-up to warming sea temperatures. This is consistent with warming temperatures in the Arctic Ocean, as documented in the scientific literature (Steele et al., 2008; Holland et al., 2008).

> "It's water temperatures. The lakes have thick ice, but the ocean ice is thin. So the oceans must be warmer now and making these bad conditions." - Sakiasee Qauniq, 2015

Ten (25%), all of which were experienced hunters, interviewees identified the changes in sea ice dynamics as representing significant risk to safe travel and hunting in the spring-time.

> "We're not used to seeing [the ice] abruptly break up, there are no signs [of break-up] any more." -Koonark Enoogoo, 2015

The ability to predict, to anticipate and respond to dangers, opportunities, and change is essential for safe harvesting in the Arctic. Both traditional knowledge and experience are used to make predictions; however, both were described as being less dependable as ice dynamic change in ways not previously experienced (see section 4.3.1 for further description).

Changing thickness of sea ice featured prominently in interviewee responses. The Ikpiarjuk region was described to be experiencing thinner ice all year round, though with most notable consequence in the spring and fall, when the ice becomes too thin and dangerous for travel.

> "I have noticed that the ice is very thin today. In all seasons, it is much thinner than it once was." - Qaumayuq Oyukuluk, 2015

> "Ice thickness has changed, in 2003 or 2004 it was about eight or nine feet thick and now it is only up to six. I used to do the drilling for the ships in Nanisivik so I know the numbers." - Lisha Qavavauq, 2015

These changes in sea ice dynamics have significant implications for the subsistence sector of Ikpiarjuk. The community is experiencing reduced access to traditional hunting areas as a result of the thinner ice and increased ice-free open-water period in the summer.

> "Traditional hunting grounds can't be accessed anymore, the ice is too dangerous to travel on now. So they have to get there earlier and leave earlier" - Sakiasee Qauniq, 2015

In the spring and early winter months, hunters experience reduced access to traditional hunting grounds on Admiralty Inlet, a body of water to the west of Ikpiarjuk that runs south from Lancaster Sound along the western shore of Baffin Island's Borden Peninsula (see Figure 1.2). Admiralty Inlet has traditionally represented an abundant hunting area, sustaining large populations of narwhal (Dietz et al. 2008, Laidre et al. 2015), polar bear (Laidre et al. 2015), and seal.

Thinner ice in the spring and fall, however, makes travel to Admiralty Inlet too dangerous; consequently, almost all research participants (both fulltime and part-time hunters) report avoiding travel in the area in the late spring and fall months, meaning they lose 2-3 months of hunting activity. Interviewees suggested that reduced access to hunting grounds has significant implications for food and income security for the community.

> "In spring time, there used to be camping until the end of July. Now we stop in June. So people get less food and income" - Jooeli Qamanirq, 2015

However, the extended ice-free open-water period in the summer and fall months increases the opportunity for using boats for fishing and access to hunting areas, and suggests increasing potential to hunt narwhal by boat. However, due to a limited number of community members owning boats (approximately 20 were counted during fieldwork), perhaps also owing to increasingly strong winds present dangerous conditions for boating, open-water narwhal hunting was not commonly reported.

These responses are consistent with much of the scientific literature regarding sea-ice

outlined in chapter two.

Wind

Changing wind characteristics are also proving problematic for the community. The community identified changes in the direction, strength, and frequency of wind, all of which present risks for hunters. The most commonly cited risk being experienced with observed changes in climatic conditions was the sudden and unanticipated changes in wind strength and direction that cause sea ice to unexpectedly disintegrate in the springtime, leading to increased incidences of hunters being stranded on drifting ice. This has significant implication for the springtime narwhal hunt.

In Ikpiarjuk, narwhal hunting is a highly valued cultural activity with important economic dimensions (Furgal et al., 1996; Ford et al., 2006a). The products of the hunt are also of great importance to the community: maktaq (narwhal skin with fat attached) is considered an important seasonal food and is in high demand in the community and across Nunavut. With the rise of internet use, maktaq is now sold within and between communities, with interview data indicating that Iqaluit is the main community where the maktaq is sold. Furthermore, narwhal ivory tusk represents a rare but profitable source of income from traditional hunting activities. A decade ago, tusks sold internationally for US$80-150 per foot (Armitage, 2005; Ford et al., 2006a); however, interviews reported that today a tusk commands between $250-$400 per foot. The community engages in the narwhal hunt in June and July, with many in the community involved in the hunt, either actively hunting, preparing the meat, sharing the catch, or producing carvings from the tusks. As a result, the activity is much anticipated, contributing to local cultural identity and strengthening community sharing networks and relationships.

Hunting of narwhal takes place at the floe-edge. Here, hunters take up position along the ice edge, they watch and wait for narwhals to surface for air near enough to shoot them with a rifle and retrieve them with a grappling hook, or boat. A strong southerly wind, for example, which is now described as being more frequent and more severe can detach the floe-edge from the ice that is anchored to the shore thereby stranding hunters. Many hunters in the study have lost equipment and have occasionally been rescued on floating ice. It is noteworthy that narwhal hunting at this time has always

entailed risks, but the community identified the changing wind and ice conditions as making the activity even more hazardous.

> "Last year on the narwhal hunt seven or eight people got stuck on the same day, drifting on the ice. They lost their skidoos" – Valarie Qaunaq, 2015

Moreover, changes in wind strength and direction has implications beyond the narwhal hunt. It makes boating, typically used to catch seal or fish in the summer months, more dangerous.

> "The wind might shift without warning and [my] boat would be blown off route, perhaps into dangerous areas or conditions" – Anonymous, 2015

Participants also reported that changing wind dynamics make travel on the land and ice in wintertime more challenging and expensive. Traditional tents, used on longer hunting trips in the spring and summer time, can no longer stand up to the stronger winds that are being experienced, while interview data suggests that strong winds are experienced year-round, implications for camping are most acutely felt in the spring.

> "The wind is stronger now. The tents used to be able to withstand winds, not anymore. The stronger winds make tents useless." – Anonymous, 2015

Wildlife

The community has also observed changes in the health, abundance, and migration timing of a variety of wildlife species in the land and ocean surrounding Ikpiarjuk. In turn, this has affected both harvesting-related risks, and the subsistence based-livelihoods common among Ikpiarjuk's population.

Changes in polar bear (Ursus maritimus) abundance across the Arctic are well documented within the scientific literature (see Wassman et al., 2010; Stirling & Derocher, 2012; Pilford et al., 2015), though there appears to be no recent studies conducted regarding the subpopulations of Lancaster Sound, the body of water concerning the community of Ikpiarjuk. The current and projected impacts of climate change on polar bears remains contested; interviewees in Ikpiarjuk, however, have observed an increase in polar bear activity in areas surrounding the community, citing

a greater number of polar bears in the vicinity owing to changes in when and where they hunt. With the increased polar bear presence, community members describe experiencing an increased risk of attack while hunting.

> "There are more polar bear now too. My husband was attacked when hunting. There are many attacks now. There was one in town just last year" – Victoria Pauloosie, 2015

Five interviewees reported being attacked by, or encountering a polar bear within a year of the research trip, noting how incidences like these are more frequent in recent years. Bears have been spotted in the community and the surrounding hills;

> "There are so many near the community. Even walking close to the community looking for ptarmigan, you are at risk now. There didn't used to be so many polar bear." – Anonymous, 2015

Hunters and trappers do not seem to be deterred by the increased risk of polar bear attack; however, observations suggest that few hunters carry a rifle of a high enough calibre to effectively defend themselves in the event of an attack. Similar observations have been made in Clyde River, whereby Gearheard et al. (2006) noted that changing sea-ice dynamics significantly influence the health and distribution of polar bears; later freeze-up and earlier break-up leads to bears coming closer to the community in search of food.

Some research participants (n=2) also noted killer whale (*Orcinus orca*) sightings in the open water months of recent years. Both participants cited recent sightings of the whales, while noting that they had never previously seen killer whales in the waters surrounding Ikpiarjuk. There was no suggestion that killer whales were hunted, nor were there plans to do so. The implications of the arrival of the species in the area remain unclear. One participant noted that orcas make the narwhal hunt more difficult as they disperse the group, while the other claimed that orcas make narwhal hunting easier as narwhals are now found closer to the floe-edge, avoiding predation.

The observations of participants in Ikpiarjuk reflect wider research on the topic. Noting that there has been little directed scientific research regarding killer whale advancement in the Canadian Arctic, a comprehensive review by Higdon and colleagues (2011) found that reported sightings of killer whales has increased considerably over the past decade across the region. While there have been sightings throughout the Canadian Arctic, studies suggest that the most frequent sightings occur in the Hudson Bay, southern Baffin Island and Lancaster Sound, with few observations in the central Arctic or the Canadian Beaufort Sea (ibid). Advancement in killer whale distribution within the eastern Canadian Arctic has been attributed to the opening of areas that have historically been blocked by ice (Higdon and Ferguson, 2009), these waters are ice-free for longer periods, with killer whale presence increasing exponentially over the past 50 years (Higdon et al, 2009). Changing climatic conditions and sea ice dynamics are expected to result in the redistribution of a number of both arctic and temperate species (Tynan and Demaster 1997, Laidre et al. 2008; Moore and Huntington 2008, Higdon and Ferguson 2011), though the increasing abundance of mammal-eating killer whales may further impact existing and future marine ecology dynamics, the extent of this remains unclear (Ferguson et al. 2010a).

The ringed seal (*Phoca hispida*) is one of the most important animals used by Ikpiarjuk Inuit. Its uses, as reported by research participants and in the literature, are vast and of particular utility to hunters. Today, seal is widely used for clothing, food, tarp, kayak skins, and dog packs, while in the past it has been used to make rope and fuel. Four participants identified the increasing difficulty in seal hunting, and reported that there are fewer seals in traditional hunting areas in Strathcona Sound and Adams Sound (see Figure 1.2), attributing this to a changing ecosystem;

> "Seals used to be abundant, they were feeding on cod, which fed on krill. We don't have krill anymore, so fewer cods and fewer seals" – Anonymous, 2015

> "There are less seals now, I think that is because of ice formations. Foxes are probably eating them, too" – Anonymous, 2015

One participant also noted that seals are 'thinner' now than they were a decade ago. Furgal et al. (2002) made similar observations in Ikpiarjuk, with all participants (*n*= 17) in Furgal el al.'s study observing that ringed seals in the surrounding area had changed since they began to hunt them. Specifically, research participants reported an increase in the number of ringed seals with abnormal livers (*ibid*).

Caribou (*Rangifer tarandus*) is of significant physical and cultural importance to Inuit and is traditionally hunted year round (Miller and Gunn, 2003). However, there were conflicting views among participants on the state of caribou in the Ikpiarjuk region. Around half of interviewees referenced the disappearance of caribou in the areas that surround Ikpiarjuk over the past two decades, all of whom cited the animal's cultural importance to the community and its prior abundance in the early 1990s. Interviewees suggested that the lack of caribou extends beyond the loss of a well-loved food source; caribou hides provide highly insulated clothing necessary to endure the cold of the winter months. Five participants reported not hunting on the coldest days as their clothing was insufficient, suggesting that if caribou were more abundant, they would use caribou parkas and pants and be able to hunt. It remains unclear the extent to which climate change has affected this population decline.

The lack of caribou also appears to have stimulated a number of new activities in the community. Research participants (n=4) reported having started to travel by snowmobile to hunting grounds near Igloolik (approximately 500km away) to hunt caribou, a long journey in which adverse weather or ice conditions present risks. These participants began taking these trips approximately five years ago. Other participants reported buying whole caribous (skinned and butchered) for $300 from Iqaluit, Igloolik or Resolute Bay; however, the cost of the meat as well as shipping costs prohibits trade for many community members.

While an increase in fox populations were identified by the community, decreases in, ptarmigan and other bird populations were also noted. A decrease in Ivory Gulls is documented by Mallory et al. (2003) in the Ikpiarjuk area, while other ecosystem changes are yet to be fully examined.

4.2.2 Socio-economic drivers

> "Climate change has no effect [on Inuit]. It just means people go hunting earlier or later in the year. That's all. Just changing hunting times. Now, only a few can afford to go out and hunt… hunters need [financial] support to be able to go out. But it's not just the affordability, it's also knowledge. Some people have the equipment but they don't know how to hunt"
> - Sakiasee Qauniq, 2015

There have been significant changes to the characteristics of Inuit livelihoods since the 1950s. Traditional subsistence Inuit lifestyle has transitioned into a 'mixed economy' characterized by the co-existence of both a market economy and traditional sector (Wenzel, 1991, 2013; Condon et al., 1995; Damas, 2002; Chabot, 2003). These changes have, and continue to shape the way in which Ikpiarjuk Inuit interact with the environment, both exacerbating and abating sensitivities to changes in climate.

The physical changes outlined in the previous section were described by interviewees (n = 18) as being of limited concern relative to the socio-economic changes in Ikpiarjuk. Hunters, and the community more broadly, stressed that Inuit have long since lived with difficult and changing climatic conditions and have adapted accordingly. However, a changing socio-economic context brings new constraints on how Inuit are able to use time, and the increased monetary investment required to hunt is creating new sensitivities and exacerbating existing sensitivities.

The increasing monetary cost of hunting in Nunavut is well documented (Chabot, 2003; Wenzel, 2013). Traditionally, Inuit hunters financially supported themselves almost exclusively through hunting and trapping activities; trading skins, furs and ivory tusks (from narwhal) for equipment or financial gain (Wilkinson, 1955; Damas, 2002). A dependence on money relates to the profound changes in Inuit society associated with the centralization of Inuit communities in fixed settlements in the 1950s and 1960s (Damas, 2002). In the 1960s, with the provision of healthcare, education and housing for the Inuit, government policy promoted the settlement of semi-nomadic Inuit groups in centralized permanent villages (ibid). Associated with this process was the development of a wage-based economy and an increased integration with national and global markets (Wenzel, 1991; Reeves, 1977).

The shift from many semi-nomadic communities to few permanent settlements had significant consequences for Inuit subsistence: the new settlements were often located far from hunting areas which increased the use of, and dependence on snowmobiles and motorized boats to access hunting areas (Wenzel, 1991; 2009). Thus the increasing importance of money for Inuit hunters, who must now have sufficient monetary income to own, operate and maintain (and occasionally renew) snowmobiles, firearms, boat motors, appropriate clothing and other equipment. However, rising prices since the 1990s, combined with declining seal skin markets have resulted in hunters seeking to secure an income from different sources to facilitate their harvesting activities (Wenzel, 1991; 2013).

The rising financial cost of hunting reflects the wider trends occurring in Nunavut's economy. Increasing food prices in Nunavut have been widely documented (CCA, 2014). Recent figures from Statistics Canada (2014) demonstrate an unemployment rate in Nunavut almost twice that of the national average (11.7% and 6.6%, respectively), 49.1% of the territory's population receives welfare, and as noted by Egeland et al. (2010) 70% of households are considered food insecure. Recent statistical analysis concluded that the proportion of Inuit children living in poverty is two to three times the Canadian average (44% vs. 18%)(MacDonald & Wilson, 2013; Duhaime & Edouard, 2015). These studies, among others, found a high prevalence of food insecurity, high prices for commodities, insufficient income to support hunting and fishing, and a high rate of dependence on social assistance across Nunavut (Chan et al., 2006; Duhaime et al., 2008; Rosol et al., 2011).

> "Everything gets so expensive that it changes our whole livelihoods. Now people go on the radio to get food, people can't afford food. They can't afford gas" – Moses Koonoo, 2015

The above quote illustrates how the economy and food security of Ikpiarjuk reflects the broader context of Nunavut. Over 80% of research participants cited rising prices of food, gas and equipment as a factor that affected their hunting habits or the food security of their household. Participants suggested that the prices of goods in the community have increased by up to 50% over the past ten years, and with increasing

food prices and limited employment opportunities, many households within the community have difficulty affording store-bought food.

> "There are more people hungry now, with the demand for food and more people. Also the lack of income – people can't afford food."
>
> – Adrian Arnauyumayq, 2015

Interviewees described a strong link between traditional food consumption and food security. The households or families of active hunters were described to be more likely to be food secure, with significantly higher proportions of their diet obtained from traditional sources as opposed to store-bought food. The link between traditional food consumption and food security has been well documented in scientific literature (CCA, 2014). A cross-sectional survey of 1901 Inuit families (Huet et al. 2012), for example, documented that food insecure households were less likely to have an active hunter in the household than those that are food secure. While other studies have attributed the rising costs and thus inaccessibility of hunted and store food, as an additional stressor identified as affecting food security (Power 2007; Ford 2009; Beaumier and Ford 2010). Furthermore, the increase in consumption of store-bought foods, often high in trans-fat, sugar and salt has been observed to have negative implications for food security and Inuit health (Kuhnlein et al. 2008; Sharma et al. 2010).

Increasing food insecurity and high commodity prices, along with population growth is creating an usually high demand for traditional foods; however, many hunters receive insufficient income to support their hunting and fishing activities.

The cost of hunting

The snowmobile is an integral part of everyday life in Ikpiarjuk. An essential piece of equipment for the modern hunter, the snowmobile replaced the traditional dog teams, making engagement in traditional activities both easier and more efficient. "If a snowmobile is perceived to have greater utility than a dog sled, then the ownership of a snowmobile will become one of the criteria defining the traditional Eskimo hunter" (Kemp, 1971: 115). Hunters are entirely dependent on snowmobiles to access hunting areas in the winter months and to transport their harvests back to the community. The

ownership and maintenance of a snowmobile, however, is increasingly expensive and inaccessible for many of the individuals interviewed.

> "Snowmobiles [once cost] $5,000 and we could afford that. Now they are $16,000 to $20,000 and we cannot afford that. They are also electronic now, so we are unable to fix them – it makes it more expensive to fix them." – Mishak Allurut, 2015

Observations suggest that there are approximately 75 functioning snowmobiles within the community, with approximately 100 more that are in a state of disrepair or are irreparable. It is in this regard, that many research participants no longer actively hunt; their snowmobile had broken down and they are unable to afford the parts for repairs, parts must be ordered from the south or bought online from eBay, often at significant cost and with substantial delivery times. Those who are in full-time, wage-based employment demonstrated the ability to buy new snowmobiles every year or so, or were easily able to repair their machines. However, those without work, or those who depend on traditional activities as a source of income (arts and crafts or hunting and trapping) would often have to wait months to be able to afford the necessary repairs, contributing to a vicious circle.

Beyond the cost of owning and maintaining a snowmobile, almost all participants referenced the rising price of gas in changing their hunting behaviours. Hunters find themselves unable to travel the distances needed to access traditional hunting areas, or hunting with reduced frequency, resulting in increased food insecurity and reduced income.

Participants suggested that the 'typical' hunting trip, a day trip usually spanning up to ten hours, would cost approximately $110, including gas, oil and food. The retired research participants (n=17 or 43%) receive $500 per month in pension payments, limiting their hunting activity to once a month unless they are able to secure alternative sources of income.

In the context of multiple stressors, the financial inaccessibility of hunting has significant implications. Hunters are often unable to purchase safety equipment to cope with changing climatic conditions, thus technological adaptations are available only to those who can afford them. Furthermore, as sea-ice conditions become

increasingly dangerous during the shoulder months, safe hunting often requires travelling greater distances to access safer, more stable ice. A lack of monetary resources limits the ability of the hunters to purchase the gas required to travel these distance.

Changing risk taking behavior

Interviews with elders and experienced hunters suggest that younger, or more inexperienced hunters, in the economic context of limited opportunities, are taking greater risks in the hope of financial return, and thus frequently find themselves getting into difficulties. This is particularly evident during the springtime narwhal hunt. Ikpiarjuk's Search and Rescue services are increasingly busy at this time of year responding to emergencies and accidents that take place at the floe edge. The Search and Rescue coordinator and experienced hunters attribute the increased incidence of accidents at the floe-edge not to changing environmental conditions per se, but to hunters taking greater risks to obtain the valuable ivory tusks. In this context, climatic changes are increasingly dangerous as hunters pay less attention to the risks in the pursuit of economic gain.

> "It's because people want to catch narwhals. The tusks are so valuable so more and more people, even inexperienced hunters go out after them and get in trouble." - Valerie Qaunaq, 2015

The study found that some hunters, in attempting to earn an income from narwhal tusks, begin hunting the animals from the floe-edge as soon as they migrate to the region in June and July. Traditionally, however, hunting narwhal was avoided at this time due to the inherent dangers of floe-edge hunting. Instead, hunters would wait for narwhal to migrate closer to the community where they could be hunted from the shore or from a boat (Wilkinson, 1955; Ford et al. 2006a).

This risk taking behavior only appears evident with younger, less experienced hunters who tend to be those with the most limited employment opportunities. Older hunters and those engaging in wage-based employment demonstrate opposite risk taking behaviors; they are becoming more cautious and hunting narwhal less.

> "I limit my narwhal hunting now, I'm wary of the dangerous ice conditions, I try to stay away from it now. Almost all elder narwhal hunters go out less now because of the fast break up of ice" – Anonymous , 2015

There was very little mention in the interview data of hunters switching to hunting from boats as the floe-edge becomes dangerous; this might be owing to the small number of boats in the community and the general inability to afford to purchase one. The ownership of a boat was reported as desirable, with interviewees without a boat often citing plans to save for one, fix a broken boat or a sentiment of disappointment that they were unable to purchase one.

Finally, while there is a quota of 130 narwhals that the community is permitted to hunt (NWMB, 2012), no research participants cited this as a challenge in the context of climate change or otherwise.

Weakening of Inuit Traditional Ecological Knowledge (TEK)

The relationship between climate and Inuit traditional skills and knowledge is well-documented (Boas, 1888; Jenness, 1917; Stefansson, 1922; Condon et al., 1995; Wenzel, 2009; Collings, 2011; and Pearce et al. 2015). Inuit traditional ecological knowledge (TEK), can be broadly understood as a body of knowledge, practice, or set of values acquired through experience, observation, and spiritual teachings or passed orally through generations (Huntington, 1998; Berkes, 1999). With regards to subsistence hunting in the Arctic, TEK enables hunters to manage risks posed by environmental conditions and change through the use of land-based skills. TEK, however, is not static.

Knowledge is dynamic, adaptable and cumulative - constantly updated with new experiences and technologies (Wenzel, 1991; Ford et al., 2009). TEK, meanwhile, must not be conflated with IQ, which "encompasses all aspects of traditional Inuit culture including values, world-view, language, social organization, knowledge, life skills, perceptions, and expectations." (Anonymous, 1998:1). IQ refers not only to hunting behaviours and practices, but also the allocation of resources, spiritual dimensions of hunting and the sharing of the catch.

A weakening of TEK in arctic communities has been documented to increase the sensitivity of hunters to climatic change (Pearce et al. 2011; 2015 Berkes and Jolly, 2001). TEK is essential for a successful and safe hunting trip, it encompasses;

- The ability to predict, understand and avoid danger through taking necessary precaution.
- Understanding precursors to certain hazardous conditions; understanding survival techniques and strategies when stranded in bad weather.
- Knowing what equipment to take along and what preparations to make
- Understanding the landscape and knowing how to navigate using traditional means.

These skills have historically been acquired from an early age through observation and apprenticeship (Pearce et al., 2010, 2015).

However, as a result of disengagement of younger generations from the land, owing to both compulsory schooling and changing livelihoods (Pearce, 2010; Ford et al, 2013), Ikpiarjuk and other communities are experiencing a weakening of TEK. Unlike previous generations, and due to both economic and wider societal factors, young Inuit today are generally spending less time involved in subsistence activities (Ford et al. 2013; Pearce et al. 2010). Thus, some have fewer opportunities to learn the knowledge and skills necessary for safe and successful travel and hunting under changing climatic conditions. This is evident in Ikpiarjuk:

> "Back then, more young people were trained to be hunters and providers. But not anymore. That knowledge isn't passed on. Because there's less incentive. [young people] can eat store bought food , they also have school. They are preoccupied." – Anonymous, 2015

Hunting is less safe for inexperienced individuals, but they also experience diminishing returns on their hunting trips, this is particularly pertinent given the rising cost of hunting:

> "Young hunters are not paying attention to traditional knowledge They hunt regardless of moon-cycles and don't listen to elders. As a result they lose equipment and get stuck at the floe-edge." – Qaumayuq Oyukuluk, 2015

A number of participants further mentioned how traditional knowledge is no longer as reliable as it used to be. Changing, unpredictable environmental conditions appear to be lessening the efficacy of traditional knowledge; elders are unable to predict wind or ice conditions based on cloud conditions or wind speeds and temperatures.

> "We used to be able to rely on elders to tell us about the weather conditions, but we stopped asking four years ago or so. The cloud formations are now different, they can't predict the weather anymore." – Jobie Attitaq, 2015

In the context of the observed changing climatic conditions, the weakening of TEK is particularly problematic as it undermines the flexibility, hazard avoidance ability and emergency preparedness of hunters. Inuit have long since adapted their hunting techniques and timing to environmental stressors, doing so with a wealth of experience, oral traditions, and a collective memory of past situations to respond to fluctuations in the environment and extreme events. For example, in the context of changing sea-ice dynamics, without an understanding of traditional hunting routes, younger or less experienced hunters have difficulty in identifying safe routes over broken ice, or struggle finding alternate routes when conditions become too hazardous for travel.

As such extremes and environmental stresses become more prevalent and persistent, the weakening of TEK threatens the Inuit's ability to safely and successfully engage in harvesting activities (Pearce et al. 2015).

Sharing networks

In the context of environmental change, complex networks of resource sharing, reciprocity, collective action, and exchange have traditionally characterized Inuit communities (Boas, 1888; Stefanson, 1913; Damas, 1963; Balikci, 1968). Much scholarship, suggests that resource-sharing networks, among other factors, have

historically contributed to adaptability in the face of external stress (Balikci, 1970; Callaway, 1995).

A sharing network refers to the relations of trust and reciprocity that enable people to act collectively (Adger, 2003), and have been found to represent a component of adaptive capacity, reducing risk for those engaged (Pearce et al. 2015). However, 'Social economy' is perhaps a more appropriate descriptor of the Inuit sharing system in that it refers to a complex set of behaviours, structured principally by kinship, that frame economic and social decision-making (Wenzel, 1991; Wenzel et al., 2000; Natcher, 2009). While Inuit social economy has been well researched within the literature, studies are most often concerned with the sharing, transfer or redistribution of traditional resources such as food (Harding & Wenzel, 2012). Increasingly non-traditional resources such as money, equipment and store foods are becoming an important part of the social economy, though there are fewer studies addressing the function non-traditional resources in this economy (Harder &Wenzel, 2012).

In Ikpiarjuk this social economy is still evident and there remains a level of interdependence within extended family units, with sharing and reciprocity still integral to the community's cultural identity. Almost all interviewees stated that their catches are shared first with the extended nuclear family, and then sometimes shared with the wider community:

> "When I catch enough, I share with the community, otherwise, I keep it within the family" – Lisha Qavavauq, 2015

Today, in Ikpiarjuk, the extended family unit is central to the sharing network, helping to maintain food security during periods of environmental stress, limited resource availability and accessibility. As an example, as fewer hunters can afford to go out and catch seal, sharing networks ensure that those in need (elders, those who cannot afford to hunt or buy store foods) have some access to country foods when it is available. However, as a result of changing livelihoods, traditional sharing practices have been significantly altered in recent years. Many participants stated that increasingly fewer people share their catches:

> "Less people share now. There used to be many people offering food on the

> radio, now there are only two. However close families still share between themselves" - Quamayug Oyukuluk, 2015

The reasons for this were left ambiguous and often seemed too much of a sensitive subject to warrant further questioning. It does, however, seem that the changes in sharing behavior is most evident within younger generations, while community elders maintain traditional sharing patterns, perhaps owing to a dependence on these networks rooted in their reduced mobility and ability to hunt. This is consistent with studies elsewhere observing a weakening of sharing practices that, in the context of a changing climate, have created food insecurity (Beaumier and Ford 2010).

Furthermore, it seems a greater individualistic attitude is altering traditional sharing practices:

> "It used to be that everything was shared equally, though now it is more of a first come, first served attitude. People now take the biggest pieces, people seem more selfish now." - Ikey Kigutukarjuk, 2015

This change in the way in which the community shares resources is also evident in the introduction of money in traditional sharing systems. Amongst elders, both in Ikpiarjuk and Nunavut more broadly, there is a widespread reluctance to exchange traditional foods directly for money (Gombay, 2007), although there is growing evidence that this is becoming more common (Beaumier and Ford, 2010). This is the case in Ikpiarjuk, where many young hunters receive payment in exchange for seal, narwhal or fish.

> "There is money involved now. It used to be shared for free, people have to purchase food now. People offer to buy it, though. We used to share with no expectation of getting anything back" - Mary Atagutaluk, 2015

As such, these changes within the Ikpiarjuk food sharing systems may increase the sensitivities of Ikpiarjuk hunters and families to the observed changing climatic conditions. Access to traditional foods underpins food security in Ikpiarjuk and other Arctic communities. A changing climate has implications for both marine and terrestrial ecological dynamics, affecting the health, abundance, and migration

patterns of a number of species in the Arctic which in turn influences food availability, accessibility, and quality, is therefore believed that traditional food systems are susceptible to climate change (Beaumier and Ford, 2012).

During periods of scarcity or environmental stress, sharing networks facilitate the distribution of food through extended family units, this is particularly important as changing climatic conditions limit access to hunting areas, or a lack of money, equipment, money or time makes hunting inaccessible to some segments of the community.

The introduction of trade in traditional sharing activities, through the reallocation of a scarce resource (money), may confer adaptive capacity, which will be discussed in the following section. However, it is evident in Ikpiarjuk that a weakening of traditional ecological knowledge is increasing sensitivity to climatic risks.

4.3 DETERMINANTS OF ADAPTIVE CAPACITY

In vulnerability studies, adaptive capacity is understood as a function of certain components of human systems that influence the propensity or ability to adapt to a changing climate, take advantage of opportunities, or cope with adverse consequences (Adger, 2006; Smit and Wandel, 2006). Increased adaptive capacity therefore results in decreased vulnerability, all else equal.

The ability of those engaged in the harvesting economy in Ikpiarjuk to cope or respond to the documented changes in climate-related exposure-sensitivities is indicative of a high level of adaptive capacity, underpinned by traditional knowledge and skills, technology and sharing networks. However, as noted above, certain components of adaptive capacity are being constrained or undermined, resulting in emerging vulnerabilities in certain sections of the community.

4.3.1 Traditional skills and knowledge (TEK)

Traditional skills and knowledge are contributing to adaptive capacity in the context of changing climatic conditions in Ikpiarjuk. Across the Canadian Arctic, TEK has been documented as a determinant of contemporary Inuit capacity to adapt to climate

change, particularly within the subsistence sector (see Berkes and Jolly, 2002; Furgal et al. 2002; Ford et al., 2006a; 2006b; 2010; Pearce et al., 2010a; 2015; Ford and Pearce, 2012).

Pearce et al. (2015) note that TEK is of particular significance for the Inuit subsistence sector as adaptations (the manifestation of adaptive capacity) are often synergies of several elements of adaptive capacity operating at different scales (Ford et al., 2010). TEK often acts as an antecedent causal factor in many other adaptive strategies (Pearce et al. 2015). For example, hunters are able to navigate changing and dangerous sea-ice conditions as a result of accumulated experience, observation and practice, and use alternative trail routes and locations to harvest. This is evident in Ikpiarjuk whereby interview data suggests that elder and more experienced research participants (those who hunt weekly) cited hazard avoidance as a response made possible only through their knowledge of the local environment and understanding of ecosystem processes;

> "[I] now pay more attention to the moon-cycles, the tides and strength of the ocean current. [I] time [my] hunting according to these factors more now to avoid the risks." –Anonymous, 2015

> "I pay more attention to the currents now [in response to recent environmental changes], I am more careful where I know that the [ocean] currents are stronger." – Anonymous, 2015

The most common responses to environmental change were related to the strength of currents in the waters and the strength of the wind, both of which can create dangerous conditions on the ice in the springtime hunting season. Almost all hunters reported changing the timing and frequency of their hunting trips to avoid such hazards;

> "In early spring, [I] would go home earlier in the day because [I] know the ice gets thinner and less stable later in the day. This would affect the number of animals caught." – Koonoo Oyukuluk, 2015

> "I limit my hunting now, I'm wary of the dangerous ice conditions so try to stay away from it now. Almost all narwhal hunters go out less now because of the fast break up of ice." – Koonark Enoogoo, 2015

As demonstrated in the above quotes, hazard avoidance involves a reduced amount of time spent hunting, and as previously noted, interview data suggests that this may have implications for household food security and income through the sale of skins, hides or ivory.

Another documented response to changing climatic conditions was the greater levels of preparedness for emergency situations. This has been well documented elsewhere in the Arctic, whereby hunters are increasingly anticipating encountering a hazard and planning for this. Snowmobiles or motors on boats may break, as might radios, GPS devices or bad weather might leave hunters stranded on the land, sea or ice. Hunters have been documented taking extra precautions to be prepared for such hazards (Ford et al., 2006a; 2006b; Pearce et al., 2010). Almost all frequent hunters referenced an increased preparedness in the face of changing and unpredictable environmental conditions, and also reported packing extra supplies, including gas, naphtha fuel, a tent, extra clothing and a GPS device or high frequency radio. Again, traditional skills and knowledge are essential for the hunter to understand what to prepare for, how to prepare, and what to do should an emergency arise.

However, younger generations, for reasons outlined below, appear to demonstrate a lower level of adaptive capacity given their relative lack of traditional knowledge and skills. The majority of younger hunters, on the occasions that they are able to hunt, appear to prefer hunting alone, later in the day, when elders are unwilling to accompany them for reasons outlined in the following quotes.

> "[local environmental change] is only a problem for the younger generation. Us older folk have some knowledge about the land, about the weather. I make sure I know the moon cycle, for example, before I hunt. This affects currents, floe edge hunting. I'd never go the floe edge at full moon. My grandfathers taught me this." – Anonymous, 2015

The aforementioned changes in timing and frequency of hunting trips to avoid hazards do not seem to take place for many younger hunters;

> "Young people also don't stick to traditional hunting ways. We go early, and we always get animals. Now, young people go late, whenever they want and they don't catch animals and put themselves in danger." – Anonymous, 2015

This was validated with observations of younger hunters leaving on hunting trips later in the day and younger hunters also referencing this trend in interview data. The younger interviewees, when describing this trend, expressed a lack of urgency in the need to hunt, explaining that they will hunt when convenient to them, again, suggesting an erosion of TEK.

Disparities in the traditional skills and knowledge possessed between the generations suggests differential levels of adaptive capacity within the community, as elder, experienced hunters know how to manage risks, while the younger generations appear to lack the experience and knowledge required. Pearce et al (2015) suggests that the ability of an individual to draw on traditional knowledge and skills depends on whether, and the extent to which these skills have been transmitted. Historically, traditional skills and knowledge have been transmitted through hands-on experience with hunting and listening to and learning from elders and other experienced hunters (Wenzel, 1987; Condon, 1996; Pearce et al., 2011b). However, constraints to knowledge transmission appear to be the primary cause of the differential levels of adaptive capacity within the community. Various perspectives on what is preventing the transmission of knowledge emerged in the interviews; community elders, for instance, stated that young people are uninterested in the traditional ways and are not willing to learn;

> "Fewer young people hunt. Like my sons don't want to come, but you need more than one person to hunt. My children would rather sleep." - Qaumayuq Oyukuluk, 2015

Meanwhile, younger interviewees were more likely to report that elders are unwilling to share their knowledge;

> "Elders are not teaching young people now. People think that the young people are not interested, but it's not true. For some reason, elders are not willing to teach anymore" – Ina Allurut Tunraq, 2015

Another barrier to the transmission of traditional knowledge and skills is the gradual disengagement of younger generations from the land and subsistence activities, in part owing to engagement in the waged economy, schooling and changing livelihoods as outlined previously in this chapter.

> "Traditional knowledge is not being passed on. Schools have taken over the up bringing and childcare. So there's less connection between the parent and child in terms of passing on Inuit knowledge."
>
> – Sakiasee Qauniq, 2015

Finally, interview data suggests that there are economic barriers to the transmission of traditional knowledge. Younger people tend to be unemployed, or have very limited capital, as a result, very few own a snowmobile or can afford gas or equipment;

> "Young people are anxious to go out, they want to. But they don't have the equipment or the warm clothes to be able to go out. Locally there are no jobs, so they cannot afford the equipment" – Anonymous, 2015

These economic constraints to adaptive capacity are also pertinent for the elder, experienced hunters, many of whom noted the rising price of supplies and equipment as constraining their ability to prepare for and manage risk.

> "We need gas, oil and food. Now they need to buy this over a long time. We used to buy three barrels of gas at once with the supplies. Now we have to buy gas one month, oil the next, supplies the next." – Ikey Kigutikajuk, 2015

The above quote also demonstrates a response to both changing environmental conditions and the rising costs of hunting. Almost all research participants reported

that in the past five years they have begun carefully planning and budgeting for their hunting trips, ensuring that they can afford all the necessary items to hunt as well as basic living costs;

> "Money affects my hunting – I need to save and plan ahead to buy gas, food, supplies and skidoo parts" – Anonymous, 2015

However, research participants indicated that within the past ten years there has been an increasing number of projects strengthening traditional knowledge and encouraging participation in traditional activities in the community. In Ikpiarjuk there have been kamik (traditional Inuit footwear) making workshops, sewing classes, traditional Inuit dance classes as well as a number of spring-time seal hunting workshops. Publically available information on these workshops is sparse, though both interview data and a review of the Government of Nunavut website indicates that such programmes are currently funded and run by the Justice Committee, the Health Committee and Qikiqtani Inuit Association.

Interviewee data indicate that these workshops are well attended, providing the opportunity for young people to engage in traditional activities while learning the skills necessary to hunt safely and effectively;

> "It gives people something to do. It gives young people traditional skills not passed on from the older generations. It allows those without snowmobiles to go out hunting. It brings money to the community as we pay elders to be the instructors" - Ina Allurut Tunraq, 2015

4.3.2 Sharing networks

As outlined in the previous section, the traditional sharing networks of Ikpiarjuk remain important to the community. All research participants referenced the sharing of food or resources, which has traditionally ensured that elders and others 'in need' of food do not go hungry. However, in the past decade, the way in which resources are shared within the community appears to have changed. Sharing has typically referred to the transfer, allocation, and redistribution of traditional resources, such as

country food. Increasingly in Ikpiarjuk non-traditional resources such as money, equipment, and store foods have now become a component of the socio-economic environment of the community. Interview data suggests that the sharing of non-traditional resources facilitates significant adaptive capacity for those interviewed.

Few studies have examined the sharing of non-traditional resources, particularly money in the support of harvesting of harvesting. As a result, the specific ways in which the flow of money and other non-traditional resources function in a sharing economy are not well understood (Wenzel, 2000). However, in Ikpiarjuk, the sharing of financial resources support and facilitate hunting in times of scarcity, both contributing to food security and building the adaptive capacity of the community to respond to change. As hunters begin to travel greater distances to access safe hunting grounds or areas of resource abundance, hunting trips become more expensive through gas consumption. The sharing of money, often from those in full-time employment or retired with fulltime hunters negates these financials barriers to hunting. Similarly, Gombay (2009) found, that an institution that both mimics and breaks with tradition through the inclusion of a market in traditional activities may help Inuit subsistence.

Interview data regarding the sentiment of the community towards the influence of non-traditional resources in the sharing economy were mixed, inconsistent and often conflicting, even with similar demographics:

> "I'm both supportive and concerned. One on hand, it is good because it provides income for hunters to feed their families when they have no other money. On the other, I am concerned because this is not the traditional way, Inuit have never sold country foods in the past." – Anonymous, 2015

> "I've never heard any complaints it. In fact, I hear elders offering to buy seal meat these days" – Anonymous, 2015

Generally, research participants saw the increased use of money in sharing networks as a benefit as it facilitates more hunting, redistributes wealth and ensures that people

are fed. However, elders in particular, appear to be concerned about the cultural implications of this, citing the deviation from the traditional Inuit way of sharing.

Hunters confirmed that the exchange of money, gas or equipment allows them to hunt more frequently and provide greater food security for the community;

> "So that I can hunt more, sometimes I go on the radio and request gas, and people give me gas in exchange for a seal" – Anonymous, 2015

As a result of these changes, hunters are able to continue providing food for family units and the wider community despite the high and rising price of hunting. This facilitates adaptive capacity as it ensures food security in times of environmental change, changing migration patterns and changing availability and accessibility of wildlife resources. While non-traditional resources are increasingly shared, sharing networks still operate on the same principles that they did historically, underpinning the well-being of the community through collective action and reciprocity;

> "[the exchange of money for country food] allows us to help people. Sometimes we want to buy food from people who have no job, to give them an income. People often pay hunters as a contribution to the cost of hunting" – Anonymous, 2015

4.3.4 Technology

The use of technology appears to be facilitating adaptive capacity amongst research participants. The majority of interviewees reported having used the Internet, GPS or Spot GPS messenger. The experience with and influence of these technologies differs between the equipment used and the user. Over half of the hunters interviewed cited consulting various websites to check floe-edge conditions (with participants using noetix.ca & c-core.ca/fem), as well as gather general weather information regarding wind strength and direction and temperatures.

> "Google tells me if the weather conditions are safe, I now check every time before I hunt" – Anonymous, 2015

While it remains unclear exactly which websites were used (participants often couldn't name the site from memory) the information accessed online allowed hunters to calculate whether a hunting trip was safe, or what supplies they might need to take with them. Several participants noted that the use of online weather and ice forecasts allows them to manage recent environmental change;

> "I use the Internet to check where to weather is coming from it helps manage the unpredictability of the weather these days." - Anonymous, 2015

Facebook was also recorded to be of importance to the hunters and their families. In some instances GPS devices were linked to Facebook accounts, allowing for the monitoring of the location of the hunter. Others would use Facebook to buy and sell hunting equipment (snowmobile parts, firearms) and share country foods. Observations of the community Facebook group further demonstrated that Facebook is used to ensure the safety of hunters. On numerous occasions in the two month research periods, posts were made referencing hunters who were stuck on the ice in need of rescue, or flashing lights spotted on the horizon, those able, having seen these alerts, would go and rescue the hunters in need of assistance.

Almost all research participants reported using or having used a GPS device when hunting. They are most often used on longer hunting trips, or when hunting from the floe-edge;

> "I use the GPS now near the floe-edge. I check the coordinates before bed, if they have changed by the time I wake up I know I need to get out of there before I drift away." – Simeone Olayuk, 2015

In response to both a changing climate and the risk-taking behavior evident in the younger hunters, the Hamlet Office began loaning GPS devices (free of charge) to residents of Ikpiarjuk. The Search and Rescue Officer reported that this program began in 2010, funded by the Department for Emergency Management. It was reported that the program is highly popular with hunters with GPS devices loaned year-round. The benefits of this are two-fold; first, the devices help hunters with

navigation, and second, the devices facilitate quick and effective search and rescue operations for stranded hunters.

The Search and Rescue Officer commented that, due to the GPS programme:

> "Hunting is safer now. For example, last year, 7 or 8 people got stuck on the same day, drifting on the ice. They lost their skidoos. With GPS and sat phones we could get a helicopter to them" – Valerie Quanaq, 2015

Potential hindrances to technology as a facilitator of adaptive capacity include the lack of financial resources to purchase the technologies necessary for safe hunting. For many interviewees, the cost of new technologies was shown to be prohibitive, particularly for full-time and younger hunters without employment opportunities.

> "Equipment – spot devices, life jackets, satellite phones are all so expensive. We can't afford them. I have a satellite phone, but I don't have money to be able to buy minutes" – Anonymous, 2015

Furthermore, a number of elder hunters feel that technology represents too much of a deviance from the traditional hunting techniques and thus refuse to use GPS devices or take into account weather and ice forecasts, choosing instead to depend on their traditional knowledge.

> "Real Inuit don't use GPS or Internet. No, we are more traditional, we just look at the skies" - Leata Olayuk, 2015

Studies elsewhere in the Arctic have demonstrated that with an increased use of technology comes increasing risk-taking behaviors and an erosion in TEK, as an example, some hunters may travel without sufficient land or navigational skills given their dependence on GPS devices (Aporta & Higgs, 2005; Ford et al. 2006b; Hovelstrud & Smit, 2010). Concern regarding the link between technology use, risk-taking behavior and an erosion of TEK was not apparent for younger hunters, while some elder hunters expressed concern regarding how an over reliance on technology could degrade TEK and cause dangerous situations when technology fails, explored more in the following chapter.

4.4 CHAPTER CONCLUSION

This chapter identifies and characterizes both the exposure-sensitivities and adaptive capacity of present-day Ikpiarjuk, finding that a changing and challenging socio-economic context (rising prices, limited opportunity to earn an income) exacerbates the risks associated with climatic change. Many hunters are unable to purchase the supplies, equipment or technologies necessary for a safe hunting, while others find that waged work prevents time being spent on the land and thus prohibits the acquisition of skills and experience needed to manage risk. The next chapter compares and contrasts the nature of current vulnerability documented in 2015 with that documented in 2004 (Ford et al. 2006), identifying the processes and drivers of vulnerability over time.

CHAPTER FIVE: THE DRIVERS OF CHANGE—COMPARING VULNERABILITY IN 2015 AND 2004

5.1 CHAPTER OVERVIEW

This chapter compares and contrasts the findings from the 2015 research with the initial vulnerability study as conducted in 2004. Comparing the characteristics of vulnerability in 2004 against those experienced in 2015 allows for the broad characterization of the changing nature of vulnerability, its drivers, determinants and influencing factors. Consistent with the previous chapter and initial study, the dynamic nature of vulnerability is characterized through the analysis of changes of its constituent parts: exposure-sensitivity and adaptive capacity.

The chapter shows that over the last ten years, changes in biophysical exposures have continued and even accelerated in some instances. It is the socio-economic conditions and changes however, that are shaping how these changes are affecting the community, driving the emergence of some vulnerabilities and moderating others. The high cost of living, in the context of environmental change, is changing people's risk taking behaviors when engaging in hunting activities as people become increasingly opportunistic.

However, it is also found that the increased availability and accessibility of new technologies (predominantly Internet connection and GPS devices) contribute adaptive capacity in the community, though not without risk. Furthermore, the changes in nature of traditional sharing networks which were previously thought to have been detrimental to adaptive capacity, are found to have evolved in ways that facilitate adaptation to both environmental and economic stress.

5.2 CHANGES IN EXPOSURE-SENSITIVITY: 2004-2015

5.2.1 Biophysical change

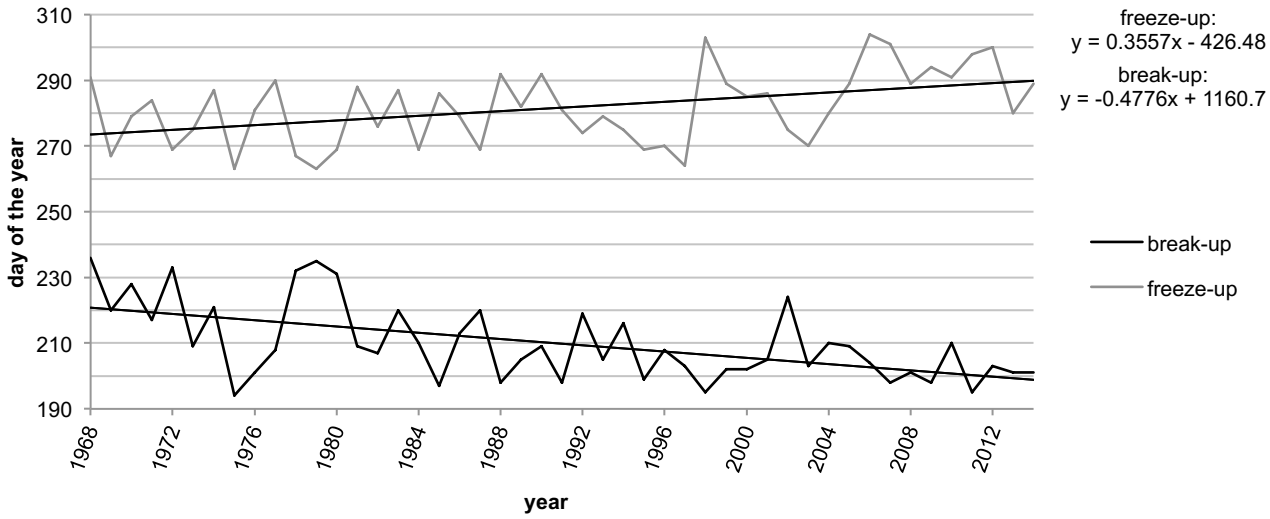
Changes in sea-ice dynamics

Instrumental data collected from the sea-ice surrounding Ikpiarjuk shows continuing change in sea-ice break-up and freeze-up dates between 2004 and 2014. As shown in

figure 1.3, over the ten-year period, at all data points, break-up is continuing to occur earlier while freeze-up is occurring later in the year. Figure 1.3 also demonstrates that this is consistent with the longer-term trends over a forty-six year period. The earlier break-up and later freeze-up dates have resulted in an average 26% increase in ice-free (open water) days between 2004 and 2014, an increase of 18 days (figure 1.4).

The data does not indicate that climate extremes, at least with regard to ice break-up dates are becoming more common. For example, the latest break-up date recorded the '04-'14 decade was July 29th in 2010, 2007 and 2004. By comparison, this extreme was also recorded three times in the '94-'03 decade (2002, 1998 and 1994) and, four times in the previous decadal chunk (1992, 1990, 1986 and 1984). However, extremes in late freeze-ups appear to becoming more frequent, with three recordings of November freeze-ups in the most recent decade (2012, 2007 and 2006). There is only one other recording of a November freeze-up prior to this decade, documented in 1993.

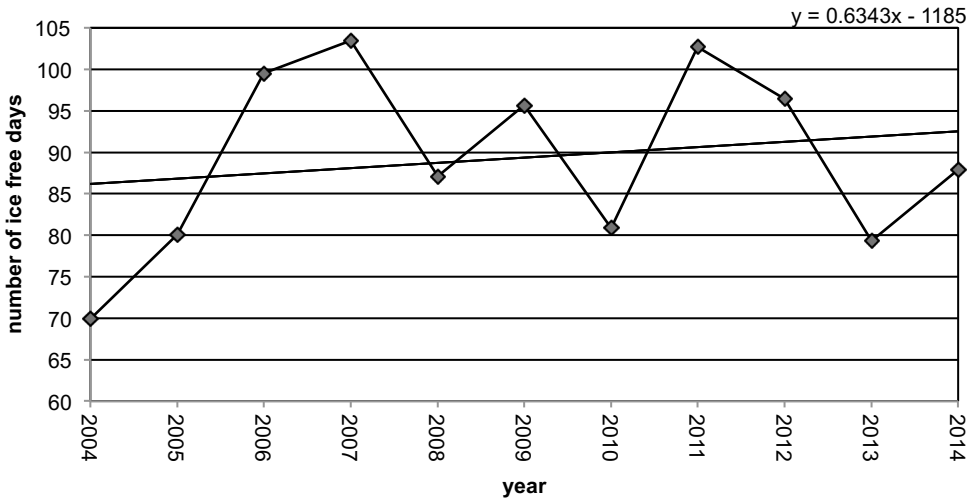
FIGURE 1.3 CHANGES IN SEA-ICE BREAK-UP AND FREEZE-UP DATES OVER A 46-YEAR PERIOD



The changes in sea-ice dynamics over the past decade have affected the community. Five of the research participants in the 2015 study identified changes in sea-ice dynamics as the overall biggest change (of all changes, including socio-economic) affecting the community over the ten-year period. The 2004 (Ford et al. 2006a) study found that accessibility of resources is sensitive to sea-ice change. Later ice freeze-up

and later break-up had changed the timing at which hunters could access wildlife resources, and hunters were waiting longer in the fall months before the ice was safe enough to travel on. The study concluded that reduced community accessibility to harvested animals had important ramifications for the community given the significant social, cultural, and economic importance of hunting. As outlined in Chapter 4, reduced accessibility to wildlife resources remains one the most pertinent climate change impacts experienced by the community in this study. With almost all research participants reporting reduced access to hunting areas in the late spring and fall months, interviewees suggested that reduced access has significant implications for food and income security for the community. The increasingly later ice freeze-up and increasingly earlier break-up has continued to constrain accessibility to resources and indicates that exposure to sea-ice changes has been exacerbated over the last decade.

FIGURE 1.4 CHANGE IN NUMBER OF ICE-FREE DAYS BETWEEN 2004 & 2014



Changes in wind strength and direction

The 2004 study found that the aforementioned changes in ice conditions, combined with the modification of wind direction, speed, and predictability created new sensitivities for narwhal hunters. That study found that changing environmental conditions challenged Inuit knowledge and ability to evaluate risks of hunting at the floe-edge, resulting in a number of incidents of hunters being stranded on drifting ice

or losing equipment (ibid). Data from 2015 demonstrate the continuation of these challenges suggesting that the associated sensitivities have been exacerbated over the ten years. An increase in the frequency of search and rescue missions, as suggested in the following quotes, may be indicative of increasing vulnerability in the face of continued change in climatic conditions.

> "We were floating on the ice for a couple of days, a helicopter was flying around, it managed to rescue us, got RCMP and asked for help. But that was really uncommon" - Levi Barnabas, 2004

> "Last year 7 or 8 people got stuck on the same day, drifting on the ice. They lost their skidoos. With GPS and sat phones we could get a helicopter to them. Search and Rescue is busier now than in the past. Especially in the spring and summer, it's because people want to catch narwhals. The tusks are so valuable so more and more people, even inexperienced hunters, go out after them and get in trouble" - Valerie Quanaq (Search and Rescue Coordinator), 2015

The second quote reflects findings across much of the interview data of the 2015 study, suggesting that one of the drivers of the increasing sensitivity of narwhal hunters is increasing risk-taking behavior in the face of challenging economic conditions (see section 5.1.2), intensified by unpredictable and changing sea-ice and wind conditions.

Wildlife

The most commonly cited change in wildlife dynamics over the ten-year period was the loss of caribou near Ikpiarjuk. In the 2004 study, a significant portion of the active hunters reported frequently hunting caribou close to the community, or within a day's travel:

> "I hunt caribou here when the ice is still not formed (…) very soon these people will be traveling by four wheeler, ATVs and going over there to hunt caribou. In winter and summer we have caribou here, sometimes it's bad now because you can't get caribou in winter here" - Levi Barnabas, 2004.

> "There used to be caribou here in abundance. We got used to caribou meat, when populations depleted, we suffered as we liked it. So we started ordering it in from other communities but it is expensive. I first noticed the caribou moving away 10 years ago, we have to travel to Igloolik now which made it more expensive" - Levi Barnabas, 2015

However, in 2015 the majority of participants reported the complete loss of caribou in the local area. Three research participants cited this change as the biggest change (of all environmental and socio-economic changes) in the community in the last decade. Today, to hunt caribou, research participants reported travelling to Igloolik or Resolute Bay, though given the costly and increasingly dangerous nature of these journeys; some of the community now purchases caribou meat online, paying in excess of $300 per animal.

On Baffin Island caribou numbers have declined from 180,000 to 12,000 since the 1980s (Struzik, 2015). The extent to which climate change is affecting caribou populations remains uncertain (Gunn et al. 2011). Overhunting and caribou migatory patterns may be a reason caribou have declined in some geographies, but alone does not account for the rapid decrease. It is suggested that warming in the Arctic that is contributing to the stress that caribou already face, including deep snow, predation, pathogens, insects, and overgrazing (Struzik, 2015). The climate-induced stressors may include extreme weather and ice storms, changes freeze-up and breakup dates of large bodies of water, affecting migration and new parasitic diseases (ibid).

However, for the residents of Ikpiarjuk, the loss of caribou may represent a new vulnerability to climate change for the community of Ikpiarjuk. Not only is caribou a much loved food source for the community, but it also provides warm clothing that is needed on the coldest of winter days. The absence of caribou in the vicinity of Ikpiarjuk bears significant economic cost, four or five caribou may save a family living in Ikpiarjuk between $2,000 and $4,000 annually in food costs (Struzik, 2015). In the 2015 study, a small number of participants reported not having warm enough clothes to be able to hunt in what they described as increasingly cold winters, stating that the loss of caribou has led to a shortage of caribou hide garments.

An increase in killer whale and polar bear activity and attacks (polar bear only) in and around Ikpiarjuk was a common observation (n=7) in 2015, with many sightings reported in and around the town, some hunters (n=2) reported being attacked by polar bears in recent years. Interview data from the 2004 study contains very few references to polar bear and killer whale activity in the local area. Reported changes in the migration patterns and abundance of other species were inconsistent across interviews and of limited concern to the community.

Community perceptions of climate change

Interview data from the 2004 study shows that few participants, though experiencing environmental change, had heard of the term 'climate change' and thus had limited opinions on the issue. Furthermore, not all participants in the 2004 study reported observing or experiencing changing climatic conditions in Ikpiarjuk, and for those who did, it was commonly reported that they were part of natural variability and would return back to 'normal' in the near future. By 2015, however, reportedly owing to increased internet access in the community and climate change's increasing presence in Canadian and global media, all participants had heard of the term and had well developed opinions regarding its validity and pertinence to the community. Not surprisingly, while all interviewees reported observing environmental change, those that engaged with the land less (spring-time only hunters, for example) were less able to describe the change in detail and reported smaller amounts of change. Meanwhile, frequent hunters described environmental change in detail and often described the changes in sea-ice and wind conditions, as well as changes in the local ecosystems as large-scale and of importance to their livelihoods and community.

This difference in the perceptions of environmental change between the two groups may suggest differential levels of vulnerability. Given that frequent hunters can provide more detailed and nuanced descriptions of change, it is likely that they are more aware of the risks and opportunities that they present and are thus able to adapt accordingly. Whereas those who perceive less change, or less able to describe change in detail, may be increasingly vulnerable as they may be unaware of the nature and frequency of the risks associated with change and thus may not take the necessary precautions.

5.2.3 Socio-economic change

The initial study characterized climate change vulnerability in Ikpiarjuk as arising from, alongside biophysical factors, changing Inuit livelihoods which were found to undermine certain aspects of adaptive capacity in the community, enhance sensitivity, resulting in emerging vulnerabilities (Ford et al. 2006a). However, since 2004 there have been many changes in the local economic context, which may be further affecting adaptive capacities in negative ways. These livelihood changes, which include a rising cost of living, limited employment opportunities, the increased financial cost of hunting, and weakened traditional practices around the sharing of resources, were cited by all research participants, and noted as the biggest change in the community since 2004 by 18 of the participants.

Resource Development

One of the most notable changes in Ikpiarjuk since 2004 is the closure of Nanisivik mine and the opening of the Mary River mine. These two events are frequently mentioned in both interview data and grey literature. The Nanisivik mine, a lead, zinc and silver mine 20 miles outside of Ikpiarjuk, closed in 2006. The mine provided significant employment opportunities for the community, contributing over $1 million to the economy in wages over the 25 years of operation (DSD, 2002). It is unclear how many jobs were provided in the community in that time (ibid). Interviewees suggested that the employment provided by Nanisivk, predominantly to younger males, facilitated more and safer hunting as the fixed income allowed them to cover associated costs. While workers were only able to hunt on weekends due to commitments at the mine, they were able to afford gas, skidoo parts and the supplies necessary for safe and successful hunting trips when not at work. Nanisivik, however, also brought negative social impacts, the influx of disposable income in the community increased alcohol consumption, which in turn has been linked to increased incidence of domestic abuse and violent crime (ibid). The closure of the mine in 2006 represented a loss of income for many families, as a result some of the research participants reported hunting less frequently or without proper provisions as they could not afford gas or equipment.

In 2014 the Mary River iron-ore mining site opened, providing approximately 30 jobs within the community, with more projected in coming years. Interviewees spoke highly of the Mary River mine, hopeful of the employment opportunities provided and aware that the influx of new money within the community will help hunters to buy new snowmobiles, safety equipment and the supplies necessary for hunting.

A small number of the hunters interviewed (n = 2) expressed concern regarding how resource development has affected wildlife dynamics, and may continue to do so as Mary River expands. One elder, when describing the decline of caribou populations in the area recounted stories of helicopters, potentially investigating mining sites, would fly low near caribou herds and "scare them away", the research participant suggested that the continual disruption of the caribou's habitat had caused them to migrate elsewhere;

> "I also noticed helicopters flying very low, dropping stakes for construction of Mary River – this scared the caribou away. I have been seeing this for many years, since the Mary River project was started. Maybe around 2006." - Lisha Qavavauq, 2015

Similarly, during the research trip, Baffinland, the Canadian mining company behind Mary River, held a community consultation in Ikpiarjuk. During this discussion a number of community members expressed concern about the ice-breaker ships disrupting polar bear migration patterns through the breaking of the ice. The routes of the ships however appeared to be outside of traditional hunting routes so posed little danger to those using the sea-ice as a harvesting platform.

Finally, community members who worked at Nanisivik mining site told of lead and zinc contamination in the waters surrounding the mining site. At the time, hunting near the mine was prohibited due to potential toxicity of the animals, again, concerns have been raised regarding the development of the Mary River mining site.

Though research is sparse, these concerns are found in academic literature. A study taking place elsewhere in the Canadian Arctic found mining and resource exploration activities to have a large negative affects on species occurrence, in particular bears,

wolves and caribou (Johnson et al. 2005). Similarly, conservation groups are increasingly aware of threats to species in the Arctic due to mining, shipping, oil and gas development and overfishing in key areas (WWF, 2015). For the vulnerability of Ikpiarjuk, this represents a compounding issue; wildlife around Ikpiarjuk has already been recorded to change as a result of a changing climate. Further disruption from resource development projects may contribute to the scarcity of some species, species such as polar bear, narwhal or seal, for which the community is dependant upon for livelihoods and food security. Further concern exists in the community regarding potential societal impacts, some participants recalled issues that Nanisivik mine brought with the increased money in the community, recounting issues of alcohol and drug consumption, sometimes leading to conflict in the community. It is possible that Mary-River, with the increased investment, may bring societal impacts of a similar nature.

Risk taking behavior & cost of living

The 2004 study found the high financial costs of new technology to be prohibitive for responding to changing environmental conditions, especially for full time hunters and youth with limited income opportunities (Ford et al. 2006a). The purchase of safety equipment to cope with changing climate conditions was found to be expensive, and although institutional support through Nunavut Tunngavik and Government of Nunavut played an important role, this support was insufficient to cover all the additional costs of hunting. In 2004, the Ford et al. (2006a) study found that the ability of hunters to make extra preparations before hunting was conditional upon the ability to purchase those extra supplies, thus the lack of financial resources was suggested as a major factor constraining the ability of hunters to adapt to dangerous sea-ice or wind conditions. By comparison, in 2015, the rising cost of living in Ikpiarjuk was referenced by over 80% of research participants, most of whom cited rising prices of food, gas and equipment as a factor that affected their hunting habits or the food security of their household. Though lacking official data to support these observations, many research participants suggested that prices of goods in the community have risen by up to 50% over the ten-year study period. As noted previously, this has had significant impact on both food security and the ability of Ikpiarjuk hunters to harvest resources.

The increased cost of living and cost of hunting appears to have exacerbated vulnerabilities in the community since 2004 by changing the way in which hunters take risks, particularly when engaging in the narwhal hunt. The 2004 study found that risk-taking behavior was changing due to the loss of traditional knowledge needed to assess risk when making decisions regarding hunting, timing or location. Risk-taking behavior was also noted to have changed with the technological developments. Interview data in 2004 indicated that with the use of GPS or radios, participants demonstrated less caution and overconfidence in dangerous conditions, placing confidence in the 'safety net' provided by technology. However, data from the 2015 study suggests that today changes in risk-taking behavior are more pronounced in that a greater number of people are taking risks when engaging in the narwhal. The primary driver of this change in behavior appears to be the need for money. Narwhal tusks, which have become significantly more valuable over the ten years, can be sold and then the profits used to purchase hunting equipment, household items or support families with limited income opportunities.

Harvesters Support Programme

The Harvesters Support Programme, provided by the Government of Nunavut, launched in 1993 and provided financial assistance to hunters and harvesters in order to make expensive equipment, such as boats or snowmobiles, more accessible. Hunters who received the equipment were often selected by lottery or at the recommendation of local Hunters and Trappers Organizations.

In the 2004 study, a number of hunters (n = 4) referenced purchasing new hunting equipment through the support programme, easing the cost of hunting and ensuring that their vehicles or safety equipment were in working order. While the 2004 study found the Harvesters Support Programme to enhance the adaptive capacity of its recipients, it was also suggested to have heightened inequalities and contributed to the emergence of conflict and social tension in the community with negative implications for adaptive capacity. Conflict arose from the disagreements regarding the allocation of money, with many residents perceiving that financial support was given to those not 'in need' (i.e. those with adequate financial resources) at the expense of those who most needed support (i.e. those without an income or financial resources). However, by 2014 Nunavut Tunngavik had suspended the program to review its efficacy (CBC,

2014). The loss of this institutional support was not explicitly mentioned in any of the 2015 interviews, though the prohibitive cost of hunting was a significant theme in all interviews. While the loss of this support may have limited the adaptive capacity of a small number of individuals in the community, the loss of a source of conflict may provide a net benefit to the community's wider adaptive capacity.

5.3 CHANGES IN DETERMINANTS OF ADAPTIVE CAPACITY

5.3.1 Technology

One of the most pronounced changes in the determinants of adaptive capacity over the ten years is a significant increase in the use of technology in responding to change. In 2015, hunters reported using a variety of digital tools from accessing Facebook to share equipment, information on hazards or request help, checking online weather forecasts and sea-ice reports, to using GPS devices that relay information to websites. In 2004, these technologies were in their infancy. New technology in the original study mostly concerned the use of satellite phones and VHF radios, and for a few early adopters the use of GPS, with such technologies described as a 'double-edged sword'; while helping to buffer certain risks, new technology was also reported to create new risks, exacerbate others, and generate emerging vulnerabilities. GPS, for example, was described to replace the need for traditional navigational knowledge and understanding of the land. It allowed for safe and easy access to hunting grounds and provided guidance when visibility is poor but also altered risk taking behavior through instilling a sense of security in the technology, and if GPS were to fail, it was a concern that hunters would not possess the traditional skills required to travel safely. Moreover, GPS units were expensive and available only to those with adequate income. Such sentiments while documented in the 2015 interviews, were not widely reported. In 2015, almost all research participants reported using or having used a GPS device when hunting. They are most often used on longer hunting trips, or when hunting from the floe-edge, as demonstrated in Chapter 4. GPS and other digital tools were also described to be of use not only in hazard avoidance, but in the navigation of already dangerous situations.

> "I am now able to travel safely. GPS helped me travel safely from Pond Inlet to Arctic Bay in a snowstorm. Another time I was using a GPS but it ran out

> of power so I used an iPad with a map and coordinates – using that I found my way back." – Simeone Olayuk, 2015.

The below sentiment proved to be common one in the 2004 interview data. In 2015, however, fewer people expressed this concern, though it is still of importance.

> "If everybody is using GPS traditional skills will be lost" - Jobie Issigaituk, 2004

> "I don't use GPS or satellite phone. My brother did once - it saved us when we got stuck in fog and had to camp out on an island. I'm still learning to hunt, so I want to learn the traditional way without the gadgets" - Anonymous, 2015

As demonstrated in the above quotes, noted in the initial study (Ford et al. 2006a) and elsewhere (Aporta and Higgs, 2005, Pearce et al. 2011), new technologies such as GPS can also increase sensitivity to hazards by encouraging risk-taking behavior and a disassociation with traditional navigational skills and place names. Moreover, both in this study and in the wider literature (Pearce et al. 2011), older particpants typically stress the importance of traditional navigation and weather forecasting skills for safe travel despite new technologies. For instance, when new technologies fail (e.g., a weather report is incorrect, the GPS battery dies) a hunter must depend on traditional skills.

The 2004 study documented limited use of Internet services in Ikpiarjuk. By 2015 Internet use was widespread however, with almost all active hunters reporting using online weather or sea-ice reports as important to their preparations. For those that were unable to read English or did not have Internet access, they would have a relative check the online forecasts and feed this information back to them. In 2015, technology was also used to supplement traditional knowledge, with many hunters reporting consulting elders and experienced hunters prior to travel. Regardless of online weather forecasts, elders would be consulted for confirmation and further guidance, consistent with findings in 2004. Beyond the use of online weather and ice reports, the use of digital social networks such as Facebook appear to confer adaptive capacity. The active community Facebook group allows for the identification of those

in need, for the coordination of unofficial search and rescue trips and facilitates the sharing both food, equipment and traditional knowledge of dangerous/safe hunting routes on the given day. The use of the Internet by the community of Ikpiarjuk signifies perhaps the largest change in adaptive capacity over the ten-year period.

It is unclear from the interview data exactly many participants used GPS devices in 2004, though interview data and anecdotal evidence from the 2015 study suggests that their use is more widespread now. This may, in part, be due to the provision of GPS devices at the local Hamlet office.

5.3.2 Sharing networks

In 2004, a high level of interdependence within the extended family unit, a sense of collective responsibility and mutual aid, and sharing were documented (Ford et al., 2006). These networks of reciprocity and sharing were found to facilitate the sharing of food, equipment, and knowledge and ensured a quick response when a member of the community was in need (ibid). The study concluded that it was unclear whether these networks that facilitated adaptive capacity will remain functional in the context of continuing social and cultural changes, and documented evidence of a weakening of sharing networks, resulting in the emergence of social conflict. The 2015 restudy suggests that sharing networks have not broken down but adapted to a new context. The changes in the dynamics of the sharing networks in some ways facilitate significant adaptive capacity for the wider community. For example, the inclusion of money in the sharing economy, facilitates the distribution of a scarce resource (money) and facilitates hunting activities.

The inclusion of money in sharing networks, which participants reported to have only begun in the past five years, was of perceived benefit to the community. As a result, hunters are able to afford to hunt and continue to provide food for family units and the wider community despite the high and rising price of hunting. Money is exchanged in a variety of ways, in some instances community members may pay hunters for a percentage of their catch, others would often purchase gas for the hunter in exchange for food. These practices are most prevalent within family networks, though extend beyond these in the case of elders. In turn, this contributes to food security in times of

environmental change, changing migration patterns and changing availability and accessibility of wildlife resources.

5.3.4 Experience with risk

It is widely recognized that adaptive learning and experience with risk influence how climate risks are experienced and responded to, shaping and reshaping how vulnerability evolves over time (Gearheard et al. 2006; Ford et al. 2009). Interview data from the 2004 study suggests that the climate perturbations experienced at the time were perceived as both recent and unusual.

> "[these changes were] unusual because the ice doesn't normally start moving until the wind is blowing it away but it was unusual because although it was calm the ice start cracking." – Lisha Levi, 2004

Owing to this, research participants would often find themselves unprepared to respond to, or minimize the risks associated with the changing climatic conditions.

> "The ice that we were standing on started floating away, we weren't prepared for this. The new southerly wind [pushed us] towards open water."- Lisha Levi, 2004

The 2015 interview data shows that the community now perceives the climatic changes as directional. Very few participants describe the changes as unusual or recent, having observed them for over a decade. It has been suggested that experience with risk over a longer time period may facilitate adaptive or social learning, as through experience people learn how to manage or minimize risks (Gearheard et al. 2006; Ford et al. 2009). Furthermore, Alessa and colleagues (2008) suggest that when no change is perceived, particularly by youth, this may be indicative of low adaptive capacity.

However, participants reported no changes in their hunting patterns, activities or behaviors as a result of experience with change suggesting lows levels of social learning are taking place. In response to the question "In recent years have you

developed any ways of managing these changes, economic or environmental?" the following response was ubiquitous:

"Not really, I do about the same" - Moses Koonoo, 2015

Conversely, through participant observation and responses to other questions, it became apparent that a number of changes have occurred in the community's hunting and risk taking behavior. Though the extent to which the increased use of technology (GPS, online weather reports) can be attributed to environmental change is unclear, most hunters now use a form of technology to prepare for, manage and mitigate risk. While the Hamlet office describes it's offering of GPS devices to hunters devices as a response to environmental change, technologies have also become more accessible in both cost and abundance in the community.

Secondly, though not apparent in questioning regarding how people are learning to adapt, it is evident that most hunters are now better prepared when embarking on a hunting trip. Many participants cited checking weather conditions online or seeking additional guidance from elders before leaving, furthermore, participants appear to be packing a greater number of supplies (gas, food, parts, clothes) to ensure their ability to cope with getting stranded, a machine breaking down or a fall through the ice.

5.4 CHAPTER OVERVIEW

This chapter has outlined the key differences and drivers of change between the two vulnerability assessments in 2004 and 2015. It was described that environmental changes continue to occur, with break-up and freeze-up dates occurring progressively later over the ten-year period. In some regards, it was also apparent that climate extremes (with regard to freeze-up timing) are becoming more commonplace. The loss of caribou in the local area appears to represent a significant change for the community, with a popular source of food and clothing becoming prohibitively expensive or requiring distant, often dangerous travel. The increased occurrence of killer whales in local waters was also noted, though the consequences of this for the community's sensitivity to climate change are not yet understood.

Both the increased use of technology such as GPS devices, online weather reports and Facebook and changes in the nature of sharing networks appear to be facilitating adaptive capacity. Hunters are increasingly prepared for climatic risk as a result of checking online weather reports, while GPS devices and Facebook use allow for quick and effective rescue and community mobilization in times of emergency. As suggested in the early study (Ford et al. 2006), dependence on technology may create new vulnerabilities as peoples' risk taking behavior alters with the 'safety net' technology provides, though no data was collected that indicates this in the recent study. Changes in sharing networks, while perceived as detrimental to traditional Inuit culture by some, also appear to facilitate adaptive capacity in the reallocation of financial resources which allow hunters to buy the necessary equipment, gas and supplies to be fully prepared for hunting trips. Finally, though there are multiple influencing factors, experience with risk appears to be facilitating learning and changing hunting behaviors. While participants reported that they are not learning or changing, observational data and responses to other lines of questioning suggest that people are in fact, adapting. The community perception that social learning is not taking place warrants further study. The next and final chapter reflects on what this study has contributed in relation to the research questions and situates the research within the larger HDCC scholarship.

CHAPTER SIX: DISCUSSION AND CONCLUSION

6.1 CHAPTER OVERVIEW

This research identifies and characterizes the vulnerability and adaptive capacity of the community of Ikpiarjuk to climate change in 2015, comparing it to previous work conducted in 2004 to better understand the temporal dynamics of how the community experiences and responds to climate change. The research finds non-climatic factors to be central in shaping vulnerability to changing climatic conditions during both studies. Only through the understanding of these socio-economic stressors, such as a rising cost of living or reduced time spent on the land and how they interact with climatic stressors, are we able to fully understand and characterize the dynamic nature of how communities interact with a changing climate and how livelihoods are affected.

This chapter critically examines the findings of this research in the context of the broader scholarship. The chapter begins with reflections upon a decade of climate change research and how this work contributes. It then progresses to discuss the insights the work brings to ongoing discussions in the literature, such as limits to adaptation, the importance of scale, and what the findings might mean in the context of projected climatic change in coming years. The conclusion summarizes the main findings and identifies entry points for further research.

6.2 A DECADE OF CLIMATE CHANGE RESEARCH

This research builds on the findings of over a decade of studies assessing the vulnerability of arctic communities to climatic change (Berkes & Jolly, 2001; Ford et al. 2006a, 2006b; Laidler et al. 2009; Smit and Hovelsrud, 2010; Pearce et al. 2010; Prno et al. 2011). These earlier studies examined how climate change interacts with Inuit society, and provided a general understanding of the factors that create vulnerability or underpin resilience for Arctic communities. This study builds upon this knowledge by examining the dynamic interactions between human and non-human stressors across multiple temporal scales, an area of examination largely absent in the human dimensions literature. In this way, this work has aided in the development a better understanding of the dynamic nature climate change

vulnerability over a longer-term, understanding how broad trends (both human and non-human) affect climate change vulnerability.

As such, with the longer-term perspective utilized in this study, we are able to better characterize and understand processes and conditions identified in previous assessments in the Arctic that did not employ a longitudinal study design. For instance, many studies have shown that the adaptability of Inuit harvesters in context of variable and unpredictable climates is underpinned by flexibility in resource use to diversify, innovate and take advantage of different hunting options (Ford et al. 2006a; 2006;b; Wenzel, 2009; Pearce et al. 2011). Some of these studies further demonstrated that changing non-climatic factors such as engagement in the waged economy, harvesting quotas and developments in extractive industries have constrained this adaptability in some instances and enabled it in others. This thesis concludes with findings that mirror this work; however, the longitudinal aspect offers additional insight into the directional nature of these constraints. It has shown that hunters' flexibility to respond to changing conditions in Ikpiarjuk is increasingly constrained, first by the necessity of waged employment and also by the rapid development of a nearby mining site. Conversely, the mine provides employment does that facilitates the purchase of hunting equipment. It further posits that as prohibitive as employment in affecting resource use flexibility is unemployment; a large percentage of hunters in Ikpiarjuk reported that their flexibility was constrained by their ability to afford gas and supplies to make hunting trips.

Second, a decade of vulnerability and resilience studies in northern Canada (Pearce et al. 2015; Berkes and Jolly, 2002; Furgal and Seguin, 2006; Budreau and McBean, 2007; Ford et al., 2010) and major international climate change reports (IPCC, 2007, 2010; UNFCC, 2010) have demonstrated the critical role that TEK plays in underpinning adaptive capacity in Arctic communities. In several instances, studies have acknowledged that TEK underpins many adaptations including the aforementioned flexibility with regard to seasonal cycles of hunting and resource use (Pearce at al. 2015); for instance, the ability to use new trails to access harvesting areas or hunt new species depends upon a detailed knowledge of the land and animals. Both the longitudinal nature of this study and growth in TEK scholarship indicate that that TEK continues to be important in enabling flexibility in hunting, hazard

avoidance, and preparedness, especially in the context of continuing and pervasive climatic and socio-economic changes. The increased use of technology in Ikpiarjuk in some ways further challenges the transmission and use of TEK. As some hunters become increasingly reliant upon GPS, for example, their knowledge of traditional routes may degrade and not be passed on to others. Evidence from Ikpiarjuk mirrors other findings in the scholarship, noting that as human-stressors become more pronounced, the transmission of TEK between generations is strained, thus hindering adaptive capacity.

Third, a number of studies, both in the Arctic (Ford et al. 2008; Ford et al 2013; Pearce et al. 2010) and elsewhere (Davidson-Hunt & Berkes. 2003; Reed at al. 2010; Fazey, Fazey and Fazey, 2005; Fazey et al. 2007) have suggested that continued climatic change may stimulate adaptive learning at an individual level. These works posit that learning in response to change takes place through observation, iterative experimentation, and practical engagement with the land and oral transmission of knowledge from elders (Ford et al. 2009; Ford et al. 2006; Pearce et al. 2010). In this way, adaptive learning is strongly connected to TEK. While the literature provides us with the context within which learning is taking place in the Canadian Arctic, and in response to which stimuli, there is no indication as to how much change communities and individuals can learn to respond to, and how quickly it is possible to learn and thus change moderate vulnerability. In Ikpiarjuk, in interviews participants reported that they have not changed their hunting habits or behaviours over the ten year period.

However, comparing both interview and observational data from both the 2004/5 and 2015 study indicate that adaptive learning is apparent. Recognizing that weather conditions are less predictable, participants were found to be more prepared in 2015, packing extra supplies (gas, food and shelter, for example) and taking greater precautions in checking weather conditions through either new technologies or traditional means. Today, the Inuit of Ikpiarjuk understand the environmental changes experienced as directional, whereas in 2004 interviewees conceptualized environmental change as part of a cycle and commonly noted that they would soon normalize. This study has shown that as climate change continues, people are recognizing this and are preparing according, whether taking greater precautions or altering their risk-taking behaviors as outlined in chapter four.

6.3 BROADER SCHOLARLY CONTRIBUTIONS

Beyond these contributions to understanding the dynamics of the human dimensions of Arctic change, the thesis also holds broader insights pertinent to key areas of discussion in the vulnerability and adaptation literature.

6.3.1 Limits and barriers to adaptation

While scholarship to date has widely recognized the need for adaptation in the context of changing climatic conditions, there is a growing body of literature discussing the limits and barriers to adaptation (Adger et al. 2007; Dow et al. 2013). While limits and barriers to adaptation may be clearly identified in the physical sciences, in social-systems little is known of these limits (Adger et al. 2009). Key areas for enquiry include the determinants of social limits, their likelihood, who and what these limits affect, and what the consequences of them might be (Dow et al. 2013).

Nomenclature within limits to adaptation literature is diverse and often ambiguous. Terms such as 'thresholds', 'limits', 'barriers' and constraints are used interchangeably, though have different meanings. Broadly, a barrier or constraint is understood as a stressor or an impediment to adaptation that can, theoretically, be overcome (Moser, 2010). Whereas an adaptation limit is understood as a level of risk that cannot be surpassed owing to internal or external system dynamics (Dow et al. 2013).

In the Arctic, a number of studies have found social stressors, such as the loss of cultural activities (sharing networks or garment making practices) and the financial costs of adaptive measures, to represent significant barriers to adaptation (Crate, 2008; Ford, 2009; 2011 Adger et al. 2011; Cunsolo-Willox et al. 2012). These works have done much to demonstrate the adaptability of Inuit, showing that while a number of barriers may exist there are very few limits to adaptation (Ford, 2009; Ford et al., 2015).

The findings of this thesis parallel those of the broader scholarship. In Ikpiarjuk, social stressors, often cultural or socio-economic in nature, determine barriers to adaptation. Culturally, reduced engagement in traditional practices such as food

sharing and hunting was found to represent a barrier to adaptation. As discussed in chapters four and five, Inuit food sharing networks have long since contributed to food security in the context of environmental stress. As sea-ice dynamics change and traditional foods become less available and accessible, the degradation of sharing practices appears to be hindering adaptation. Equally, as members of the community, often for economic reasons, spend less time hunting, they are less able to respond to change and identify and prepare for environmental risks given reduced TEK. The barrier to adaptation is widely documented elsewhere in the literature (Gearheard et al., 2006; Laidler et al., 2009; Pearce et al. 2011; 2015). Economically, the rising cost of hunting and the often-prohibitive cost of technology are further found to be prohibitive of adaptive capacity for members of the community without access to financial resources.

In this regard, the longitudinal nature of this study has provided insights that demonstrate how barriers to adaptation have become greater over the past decade. Economic stressors such as a rising cost of living and limited employment opportunities have worsened since 2004, while cultural changes including a reduced engagement with the land and degraded sharing networks appear more pronounced. Furthermore, in 2015 the lack of access to technology such as GPS, Internet or radio appears to limit adaptation for individuals who do not have the financial resources to purchase them. No strict limits to adaptation were evident in the study. It will be interesting herein to examine how reduced costs of gasoline, occurring since the fieldwork was conducted, might affect community engagement with the land and responses to changing conditions.

In many instances, northern institutions active in the community have done much to respond to the growing barriers. The provision of free GPS devices for daily loans, for example help overcome the limits to technologically based adaptation. Furthermore, the provision of traditional activity workshops, ranging from sewing classes to seal hunting workshops have been acknowledged by the community as building TEK and thus adaptive capacity in the face of multiple-stressors. On a wider scale, however, these institutions and regulatory systems have been criticized for a poor response to climate change (Berkes and Jolly, 2002).

6.3.2 Issues of scale

It is understood that the way in which climate change is experienced and responded to is conditioned by social, cultural, economic, and political influences and processes operating at different spatial and temporal scales (Blaikie et al., 1994; Ford and Pearce, 2012). The identification of these cross-scale linkages is essential in understanding the dynamic nature of climate change vulnerability.

The analysis of current exposure-sensitivity in Ikpiarjuk demonstrated that the way in which people hunt is influenced by processes operating at different spatial and temporal scales. For instance, the closure of Nanisivik and opening of Mary River mining sites drastically affected both hunters ability to pay for hunting equipment through the provision of employment and the timing and length of their hunting trips as they conformed to working hours. The operation of mining sites also appears to have had impacts on local wildlife as well as contribute to a number of social difficulties, all of which affect the community's response to a changing climate. Wider processes such as globalization are also evident in the exposure-sensitivities of the community. The recent proliferation of the use of the Internet and other technologies in the community appear to be abating a number of vulnerabilities, while other aspects of the community's global integration, such as rising food and gas costs, limit adaptation. In 2004, the exposure-sensitivities documented in Ikpiarjuk were largely influenced by Nanisivik mining site, the imposition of government quotas on narwhal hunting and the global growth in the knowledge economy, bringing more of the community's population into desk-based work and limiting engagement with the land.

In this regard, the scales at which many of the determinants of vulnerability in Ikpiarjuk remain consistent over the ten-year period. Regional trends such as resource development continue to influence vulnerability, bringing much needed income opportunities that may abate some climate risks, while simultaneously reducing hunter's engagement with the land and perhaps placing further stress on ecosystem dynamics. The barriers presented by government-imposed quotas appear to be significantly less pertinent in 2015 interview data than in 2005, though it is unclear as

to why this might be. A recent shift towards a co-management approach to natural resource management may have influenced this (see Armitage et al. 2011). Finally, the opportunities for adaptation provided by the increased availability and accessibility of technology have grown over the past decade.

6.3.3 Future vulnerability of Ikpiarjuk

The future vulnerability of a system is determined through estimating directional changes in exposure-sensitivity and future adaptive capacity on the basis of past behavior and future expectations. Some of these themes are addressed briefly in chapters four and five. The future climate change vulnerability of Ikpiarjuk is inherently difficult to project and remains unclear, though this thesis has identified a number of processes, mostly relating to the subsistence sector, which will have significant implications for the exposure-sensitivities and adaptive capacity of the community in the face of continuing environmental change.

Changing sea-ice dynamics are projected to continue into the future (Comiso & Hall, 2014), and the community appears to be responding to the associated risks with a combination of changing hunting timings and use of technology. This study suggests that the resultant implications for Arctic ecosystems may, however, be a key driver of future vulnerability. Climate change has already had an impact on Arctic terrestrial, freshwater and marine ecosystems (Larsen and Anisimov, 2014; Post et al., 2013), with the loss of caribou already having had a profound affect on the food supply of the community of Ikpiarjuk. A lack of research means it is unclear how the observed increase in polar bear and killer whale populations in the area will affect ecosystem dynamics and the availability of food if they continue.

Another key determinant of future vulnerability in Ikpiarjuk will be the continuation and legacy of resource extraction projects such as Nanisivik and Mary River. Over the coming decade, Baffinland, the mining company behind Mary River, has plans to turn the site into the Arctic's largest open-pit mine, transporting between 18 million and 20 million metric tons of iron ore along a rail line that it plans to build across 100 miles of tundra; although this depends on the price of global traded commodities, which at the time of writing had decrease precipitously since the site was developed and the current operability of the mine significantly scaled back. With the impacts of

mining sites on local ecosystems already observed by the community, the strain that a development of this scale will place on ecosystems already stressed by a changing climate may be profound. The site will, however, provide much needed employment opportunities for the community, which may facilitate a greater engagement with hunting activities as they become more financially accessible. Though employment will severely limit the flexibility that hunters require in timing their trips in accordance with safe conditions.

Should the trend of increasing accessibility of technology continue into the future, findings from this study suggest that it should help to abate risks associated with a changing climate. Weather and sea-ice forecasting services and GPS devices should continue to assist both planning and risk-taking behavior, while Facebook and other digital communication platforms may continue to facilitate the sharing of both traditional and non-traditional resources while ensuring the prompt rescue of hunters reported to be stranded on the community Facebook page.

6.4 CONCLUSION

This study replicated in 2015 a vulnerability assessment conducted in 2004 (Ford et al., 2006a) using a consistent approach and methodology, and interviewing the many of the same community members where possible. The decadal reanalysis broadly found that the exposure-sensitivities and adaptive capacity of present-day Ikpiarjuk have been modified and challenged by a changing socio-economic context. The simultaneous rise in the cost of living, limited employment opportunities, and restrictive hours for those in employment were found to exacerbate the risks associated with changing climatic conditions. Many community members reported to be unable to purchase the supplies, equipment or technologies necessary for a safe hunting trip, while others found that waged work prevented time being spent on the land and thus prohibited the acquisition of skills and experience needed to manage risk. However, the community demonstrated adaptive capacity through the use of technology, modifying traditional sharing networks and, to a lesser extent, a politicalrevival in the funding of traditional skills workshops. An overview of these changes is available in Table 1.6

TABLE 1.6 OVERVIEW OF AREAS OF CHANGES BETWEEN 2004 & 2015.

	2004	**2015**
Biophysical exposures *Reduced sea-ice*	Later freeze-ups and earlier break-ups recorded. New areas of open water, areas of unusually thin ice are documented to increase the dangers of travelling on sea ice. Reduced access to hunting areas has important ramifications for community	Continued decline of sea-ice extent and thickness with a 26% increase in open water since 2004. Associated risks continue, while reduced accessibility of traditional hunting grounds is exacerbated by further loss of sea-ice.
Changes in wind	Stronger, unpredictable winds create dangerous situations while boating on open water in the summer, whiteout conditions in the winter, and dangerous narwhal hunting conditions during the break-up.	Increased strength and unpredictability of winds persist causing a greater number of accidents during floe-edge hunting, reducing engagement in longer hunting trips as tents collapse in the wind.
Wildlife	No recordings of significant changes in wildlife abundance or migration patterns.	Loss of availability to caribou. Increase in polar bear and killer whale abundance.
Perception of change	Many report not experiencing environmental changes; those that have understand these changes as short-term fluctuations.	All participants report experiencing environmental changes, most understanding that these changes are directional and a part of wider climatic change.
Socio-economic exposures *Resource development*	Nanisivik mine provides significant employment for the community. The income facilitated more and safer hunting and hunters could afford gas and equipment, however hours of work were restrictive to flexibility in hunting patterns.	In 2014 Mary-River mine opens, providing 30 new jobs, with more projected in coming years. Interviewees suggested influx of new money within the community will help hunters to buy new snowmobiles
Cost of living	A high cost of living and hunting, combined with limited employment opportunities, limits the ability of hunters to make extra preparations before hunting. The lack of financial resources represents a major constraint to adaptation.	An increased cost of living and cost of hunting since 2004 has further exacerbated vulnerabilities. Rising food, gas and equipment prices limit hunting and threaten food security. Participants suggest that prices of have risen by up to 50% since 2004.

Technology	Frequent use of satellite phones and VHF radios, and for a few early adopters the use of GPS. Technologies described as a 'double-edged sword'; helping to buffer certain risks while exacerbating others.	Widespread use of satellite phones, GPS devices, spots. Recent internet access further provides tools such as online weather reports and social media to facilitate hunting and sharing practices.
Sharing networks	A high level of interdependence, a sense of collective responsibility and mutual aid, and sharing were documented. Though in context of continuing social and cultural changes there is evidence of a weakening of sharing networks, resulting in the emergence of social conflict.	Some evidence suggests a reduced engagement in sharing networks, despite these networks facilitating significant adaptive capacity for the wider community. The inclusion of money in the sharing economy facilitates the distribution of a scarce resource and facilitates hunting activities.
Experience with risk	Climate perturbations are perceived as both recent and unusual. Owing to this, hunters find themselves unprepared to respond to, or minimize the risks associated with the changing climatic conditions.	Climatic changes understood as directional. As such, participants are better prepared when embarking on hunting trips; either checking weather conditions online or seeking additional guidance from elders. Participants report packing a greater number of supplies (gas, food, parts, clothes) to ensure their ability to cope with adverse conditions.

Next, and addressing the second research question, the study progressed to examine the temporal dynamics of climate change vulnerability through the combined analysis of data from both this study and the antecedent (Ford et al. 2006a). As such, the study provided an empirical grounding from which to examine climate change vulnerability as a dynamic process. In this regard, it was found that environmental changes are continuing to occur, with break-up and freeze-up dates occurring progressively later over the ten-year period, along with a continuation of less predictable weather and changes in wildlife dynamics. However, the increased use of technology since 2004, and changes in the nature of sharing networks appear to have increased adaptive capacity over the ten years. In 2015, research participants were recorded as increasingly prepared for climatic risk as a result of checking online weather reports, while GPS devices and Facebook use allow for quick and effective rescue and community mobilization in times of emergency. These facilitators of adaptive capacity were not apparent in the initial study. Furthermore, changes in sharing networks through the inclusion of money in the past ten years, appears to have further

facilitated adaptive capacity, though perceived as detrimental to traditional Inuit culture by some.

The use of longitudinal design is novel in the Arctic, and thus far novel in the wider HDCC literature. Its application provides a key tool through which the drivers and characteristics of vulnerability over multiple temporal scales can be identified. Longitudinal assessment also offers the potential to identify maladaptations, as demonstrated in the changing of sharing networks.

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8.0 APPENDIX

8.1 CONSENT FORM

Department of Geography
McGill University
Burnside Hall
805 Sherbrooke Street West
Montreal, QC, Canada H3A 2K6

Informed Consent Form

Project Title: Revisiting Arctic Bay: The Dynamic Nature of Climate Change Vulnerability in the Canadian Arctic.

Project Description: The project aims to understand how environmental change may or not be affecting hunting and harvesting practices in Arctic Bay. Information gathered will be compared and contrasted with information from 2005 in an attempt to understand how the community has changed and what has caused this.

Use of information: Lewis Archer, is a student at McGill University, the information obtained from both interviews and observation will be used to produce a masters thesis, academic articles and community resources. All those taking part in the research, such as yourself, will be asked for suggestions as to how the results should be interpreted and shared.

Contact Address: Lewis Archer, Dept. of Geography, McGill University, 805 Sherbrooke St. W., Montreal, H3A 2T5, lewis.archer@mail.mcgill.ca

Supervisor Contact Address: Dr. James Ford, Dept. of Geography, McGill University, 805 Sherbrooke St. W., Montreal, H3A 2T5, james.ford@mcgill.ca

If you have any questions or concerns regarding your rights or welfare as a participant in this research study, please contact the McGill Ethics Officer at 514-398-6831 or [appropriate officer email address]

Medium of discussion: Both interview (approximately 45-60 minutes) and observation are to be conducted in a location chosen by you, the participant, and digitally recorded if permission granted. The data from your interview (including consent forms, participant ID code key, audio recordings and transcripts) will be deposited securely at McGill University in a locked cabinet or on a password encrypted computer to which only Lewis Archer, the principal investigator will have access.

I/we would also like to accompany you on a hunting trip to observe how you engage with the environment and resources.

Explanation of the study: I/we are interested in your views and experiences with hunting in the face of environmental change in Arctic Bay. I/we are seeking your consent to partake in a 45-60 minute interview within which I/we will ask you about your hunting practices, both past and present. Furthermore, I/we would like to accompany you on the land as you hunt. Please know that you can choose to not answer a specific question(s), deny the observation or withdraw from the study at any time without repercussions. Your participation in this study is voluntary.

I (the participant) give permission for audio recording: YES NO

I (the participant) desire that my identity and the information I provide be confidential: YES NO

I (the participant) agree to participate in the interview YES NO

I (the participant) agree to participate in the observation YES NO

I have been fully informed of the objectives of the project being conducted. I understand these objectives and consent to being interviewed for the project. I understand that steps will be undertaken to ensure that this interview will remain confidential unless I consent to being identified. I also understand that, if I wish to withdraw from the study, I may do so without any repercussions

Name (please print): _____

Signature: _____ Date: _____

Signature of witness: _____ Date: _____