CHAPTER 3

Rural and Remote Communities

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Table of contents

Key messages 107

3.1 Introduction 109

3.1.1 Rural and remote Canada 110

3.1.2 Approach to chapter development 111

3.2 Climate change is affecting rural and remote communities 114

3.2.1 Introduction 114

3.2.2 Knowledge-sharing and collaboration 115

3.3 Local and Indigenous Knowledge are key to adaptation and understanding climate impacts 117

3.3.1 Introduction 118

3.3.2 Monitoring and recording climate change impacts 119

3.3.3 Enhancing adaptive capacity and building resilience 120

3.3.4 Supporting sustainable risk reduction strategies 120

3.3.5 Informing place-based decision-making and policy on adaptation 121

Case Story 3.1: The Saugeen Ojibway Nation and tracking of climate change impacts on whitefish 121

3.4 Climate change is challenging livelihoods and economies 122

3.4.1 Introduction 122

3.4.2 Vulnerability and adaptation in the natural resource sectors 126

3.4.3 Adaptation responses and opportunities 131

Case Story 3.2: Government programming and partnerships in support of farm-level adaptation in Saskatchewan 134

3.5 Critical infrastructure and services are at risk 135

3.5.1 Introduction 136

3.5.2 Transportation and energy systems 136

3.5.3 Regional variation in climate change impacts to infrastructure 137

3.5.4 Adaptation responses and opportunities 138

Case Story 3.3: Adapting to transportation and service disruption in Nova Scotia's ageing communities 141

3.6 Individual and community health and well-being are being negatively affected 143

3.6.1 Introduction 143

3.6.2 Availability of nourishing, accessible and preferred food and water sources 145

3.6.3 Infectious disease and exacerbating existing chronic illnesses 146
3.6.4 Increased risk of injury and mortality 146
3.6.5 Impacts on mental health and well-being 146
3.6.6 Adaptation responses and opportunities 147
Case Story 3.4: Coping with the health impacts of wildfire in the Northwest Territories 150
3.7 Climate change is resulting in intangible losses and damages 150
3.7.1 Introduction 151
3.7.2 Shifting cultural practices and identity related to place 152
3.7.3 Changes to the social fabric of rural and remote communities 153
3.7.4 Loss and damage to landscapes and sites of cultural and social significance 154
3.7.5 Adaptation responses and opportunities 155
Case Story 3.5: Supporting Inuit wellness, strength, resilience and cultural continuity in Nunatsiavut, Labrador 158
3.8 Local participation in adaptation decision-making improves outcomes 159
3.8.1 Introduction 159
3.8.2 The need for a collaborative approach to governance 160
3.8.3 Responding to governance challenges 162
Case Story 3.6: Co-constructing and building rural adaptation capacity 164
3.9 Moving forward 166
3.9.1 Knowledge gaps and research needs 166
3.9.2 Emerging issues 167
3.10 Conclusion 168
3.11 References 175

Key messages

Climate change is affecting rural and remote communities (see Section 3.2)

Rural and remote communities often experience environmental, social, economic, cultural and health impacts from climate change disproportionately compared with urban centres. Despite these challenges, rural and remote communities display strong resilience and are often at the forefront of adaptation action in Canada.

Local and Indigenous Knowledge are key to adaptation and understanding climate impacts (see Section 3.3)

Residents of rural and remote communities have a strong connection to the environments that they depend on for their livelihood, sustenance, well-being and way of life. Place-based knowledge systems, including local and Indigenous Knowledge, and lived experience are key to understanding and adapting to climate change impacts in rural and remote communities and areas.

Climate change is challenging livelihoods and economies (see Section 3.4)

Climate change is already impacting many of the economic sectors and subsistence activities that rural and remote communities rely on for their livelihoods and economic well-being. Local adaptation strategies are helping to protect traditional economies through planning and capacity building, changing land practices and use of technology.

Critical infrastructure and services are at risk (see Section 3.5)

Critical infrastructure and related services, particularly in rural and remote coastal communities, are at risk of failure and disruption from increases in the number and severity of extreme weather events. In response, a growing number of these communities are mainstreaming climate change considerations into community planning and design, and are beginning to reimagine, reinforce and rebuild their built environments.

Individual and community health and well-being are being negatively affected (*see* Section 3.6)

In rural and remote communities, health and well-being are strongly influenced by social, cultural and physical environments. Climate change is negatively impacting the health and well-being of individuals and communities, both directly and indirectly. Reducing risk, adapting to climate change impacts and realizing co-benefits from GHG emissions reduction present important opportunities for the health sector.

Climate change is resulting in intangible losses and damages (*see* Section 3.7)

Climate change impacts are leading to a wide range of intangible losses and damages in many rural and remote communities and areas, including the loss of identity, cultural continuity and sense of place. These intangible losses and damages are expected to be widespread and cumulative, and are critical to consider in climate change adaptation and policy.

Local participation in adaptation decision-making improves outcomes (*see* Section 3.8)

Enhancing governance capacity and decision-making related to climate change adaptation in rural and remote communities requires access to additional resources, information and support. Decision-making processes related to adaptation programs and policy can be made more effective through greater participation of local residents and organizations, inclusion of local and Indigenous Knowledge, and consideration for the specific circumstances of rural and remote communities and areas.

3.1 Introduction

There are rural and remote areas in every province and territory across Canada, with many remote communities located in Arctic and Subarctic parts of the country. These areas, and the communities located within them, are home to residents, businesses and organizations that are often highly dependent on natural resources and ecosystems for cultural purposes, livelihoods, transportation and well-being. Compared to urban centres, rural and remote communities often experience greater impacts from climate change, particularly in the Arctic and Subarctic regions where changes in climate are occurring more rapidly than elsewhere in the country (Bush avnd Lemmen, 2019). These communities also tend to have fewer financial, human and formal institutional resources with which to respond to these changes. At the same time, however, rural and remote communities have access to important assets that support resilience and adaptation from which they can draw, such as strong informal economies, social networks and connections to place, community and culture.

The challenges and inequities in rural and remote regions (*see* Box 3.1) impact all people living in Canada. While Canada's 15 largest municipalities are home to 53% of Canada's population, the vast majority (79%) of Canadian municipalities and other settlements are located outside of major metropolitan areas (Minnes and Vodden, 2019; Statistics Canada, 2016). Furthermore, nearly 6 million Canadians (approximately 17% of the country's population) live in rural and remote areas[1] (Statistics Canada, 2016).

Box 3.1: Rural and remote communities

For the purpose of this chapter, rural and remote communities (including small towns) are defined as having a population of fewer than 10,000 people. In rural communities, less than 50% of the population commutes to an urban location for work. Remote communities either have no residents that commute to an urban location for work or are located in the Yukon, Northwest Territories, Nunavut, Nunavik or Nunatsiavut[1].

Rural and remote communities make critical contributions to Canadian society, culture and environmental stewardship. These regions provide natural resources such as food, energy and drinking water, as well as other ecological amenities (*see* Ecosystem Services chapter) that support all Canadians, while also generating approximately 30% of Canada's gross domestic product (Vodden et al., 2019). Despite these

1 A variety of definitions for rural and remote communities are used throughout the literature; the definition used in this chapter was selected to maintain consistency with the Cities and Towns chapter. Given the importance of rural-urban interactions and interdependencies for rural lives and livelihoods, this definition includes all settlements located outside of Statistics Canada Census Agglomeration and Census Metropolitan areas (e.g., outside of "urban" areas) (Statistics Canada, 2016). In contrast, Statistics Canada's current classification of population centres identifies small population centres as those with populations of 1,000–29,999 (Statistics Canada, 2016).

contributions, rural and remote communities in Canada remain comparatively under-researched and have not been prioritized in terms of policy development and funding (Canadian Rural Revitalization Foundation, 2015). This chapter discusses the gaps in research and policy from a climate change perspective by assessing the current knowledge of climate change impacts, adaptation strategies and potential future directions for climate change adaptation in rural and remote areas.

3.1.1 Rural and remote Canada

Despite the wide geographic distribution of rural and remote communities in Canada, they share similar characteristics that influence and mediate their experiences with climate change. For example, rural and remote communities are often geographically isolated; reliant on natural resources for sustenance, livelihoods, and ways of life; and have limited social and physical infrastructure and capacity (e.g., limited access to technology and communication systems, health and education services, supplies, and human resources). At the same time, rural and remote communities often have strong social capital and networks, extensive local and/or Indigenous Knowledge, and high rates of community involvement, which create resiliency and pride (Lemmen et al., 2008). It is important to note that while there are shared priorities, concerns and strengths, rural and remote communities across Canada display a wide diversity of important factors and attributes, including physical geography, culture, economy and demographics. Such factors differentially affect the experiences, responses and capacities of these communities related to climate change impacts and adaptation.

Climate-related changes are occurring alongside other social and economic changes in rural and remote communities, leading to social disruption. Compounding stressors include the adoption of labour-saving technologies to lower production costs in resource industries, and changes in market conditions and international competitiveness due to shifts in global economic policy, such as the expiration of the Softwood Lumber Agreement in 2015 or the 2010 European Union ban on seal skins (Schroth et al., 2015; Reed et al., 2014). New technologies, the rising cost of living, and a growing wage economy in some communities also intersect with climate-related changes and impacts on land-based subsistence activities (Clark et al., 2016b; Pearce et al., 2015).

Other changes compounding the ways in which climate change is experienced in rural and remote communities in Canada include demographic changes (e.g., ageing populations), population growth in many Indigenous communities, and the movement of young adults and retirees to amenity-rich locations. These changes can have negative implications on the rural labour force and available tax base, services and business opportunities, social dynamics, transmission of intergenerational knowledge, and virtually all aspects of community life. From an institutional perspective, rural and remote areas are often disproportionately affected by reductions in government funding for programs and services, and are subject to province- or territory-wide policies that are not well suited to their particular circumstances (Vodden et al., 2019; Dampier et al., 2016). For example, residents of these areas often experience disproportionately more job losses and negative economic consequences resulting from changes to province- or territory-wide energy policy (Dampier et al., 2016). These challenges, combined with frequently changing circumstances, require support at all levels (national, regional, local) to develop and implement strategies for coping, adaptation

and resilience in rural and remote areas. Figure 3.1 highlights assets and challenges for rural and remote communities related to climate change adaptation.

Figure 3.1: Summary of key assets and challenges for rural and remote communities and areas related to climate change adaptation.

3.1.2 Approach to chapter development

Building on past national assessments (Warren and Lemmen, 2014; Lemmen et al., 2008), this chapter synthesizes the state of knowledge on the impacts of climate change in rural and remote communities across Canada. Specifically, this chapter applies a social equity lens to climate and environmental changes, and emphasizes adaptation, strength and resilience in rural and remote communities. While responses at all levels are required, this chapter emphasizes the need for local strategies that are culturally and geographically relevant. Information and perspectives from all provinces and territories in Canada are

presented in this chapter. The information included was gathered through a systematic review of published peer-reviewed and broader literature related to climate change in rural and remote communities and areas across Canada; consultation with individuals living, working and undertaking research in these communities; and collaboration with other authors involved in this national assessment. Furthermore, this chapter explicitly incorporates the voices, expertise and knowledge of Indigenous individuals, Elders, organizations and communities, recognizing that many remote areas in Canada include Indigenous communities and First Nations, Inuit and Métis homelands. The chapter concludes with a discussion on knowledge gaps, research needs and emerging issues, and a synthesis of the state of adaptation to climate change in rural and remote communities.

This chapter presents seven key messages on the state of climate change impacts and adaptation across rural and regional communities and areas, as well as a number of short case stories from specific communities. These key messages reflect a series of priority themes that emerged from the literature review and consultations, and by drawing on the expertise of the author team. These priority themes include: enhancing adaptive capacity through knowledge-sharing, collaboration and co-creation; place-based knowledge systems; livelihoods and economy; infrastructure and transportation; health and well-being; identity, culture and society; and governance and institutions. Within these priority areas, it is important to consider how particular characteristics of rural and remote communities may support or hinder effective adaptation to climate change (*see* Box 3.2).

Box 3.2: Social factors influencing vulnerability to climate change in rural and remote communities

Vulnerability to climate change is influenced by a variety of determinants including social, cultural and political factors (e.g., access to resources, political representation and social networks), as well as individual characteristics and circumstances (Krawchenko et al., 2016). In the literature, indigeneity, gender, age and socioeconomic status are highlighted as key factors that influence individual- and community-level vulnerability to climate change impacts in Canada's rural and remote communities.

Indigeneity

First Nations, Inuit and Métis populations in Canada—especially those living in remote and/or coastal areas in the Arctic and Inuit Nunangat (Inuit Homelands)—are particularly affected by the negative social, economic and environmental impacts of climate change due to their often-close and enduring reliance on the land for sustenance, livelihoods, culture and well-being (Archer et al. 2017; Picketts et al., 2017; Government of Canada, 2016; Province of New Brunswick, 2016; Cunsolo Willox et al., 2015; Durkalec et al., 2015; Cunsolo Willox et al., 2012). It is also important to consider the ways in which current inequities experienced in Indigenous communities were created, as a result of historic and current government policies (Loring and Gerlach, 2015). At the same time, enduring connections to land and culture held by many Indigenous Peoples and communities in Canada are a source of strength, which fosters adaptive capacity.

Gendered experiences

Researchers have begun to explore the gendered dimensions of climate change in rural and remote areas, with gender being identified as a key determinant impacting individual experiences, specifically in Indigenous (Young et al., 2016; Hanrahan et al., 2014), forest-based (Reed et al., 2014), agricultural (Fletcher and Knuttila, 2016) and coastal communities (Williams et al., 2018; Women's Environment and Development Organization, 2018; Vasseur et al., 2015). In rural and remote communities, divisions of labour based on gender influence the ways in which individuals are impacted by climate change, as well as their ability to respond to these impacts. In agricultural communities in Saskatchewan, for example, environmental crises associated with climate change have been found to further entrench patriarchal gender roles that position men as "primary farmers" and women as supporters and caregivers. This positioning may lead men to be more negatively affected by the psychological impacts of climate extremes, due to their position as "primary farmers," or could make women more vulnerable due to the constant pressure to support others that are affected by climate extremes (Williams et al., 2018; Fletcher and Knuttila, 2016). In the Inuit community of Black Tickle, Labrador, men are often responsible for water retrieval. Consequently, as climate change affects water availability, single women may experience increased vulnerability to water insecurity (Hanrahan et al., 2014).

Ageing populations

Age influences the vulnerability of individuals and communities to climate change, particularly in rural and remote areas, where populations tend to be older. Specifically, many elderly people in rural, coastal communities are at higher risk due to challenges with accessing and responding to warnings related to environmental emergencies, greater reluctance to leave their homes and limited financial capabilities. These challenges are further compounded by often-limited services for older populations that are in need of both social and physical support (Krawchenko et al., 2016; Manuel et al., 2015; Rapaport et al., 2015).

Socioeconomic status

In many instances, socioeconomic factors such as high poverty rates, unemployment, food insecurity and lower levels of formal education can exacerbate and magnify climate change impacts in rural and remote communities (Loring and Gerlach, 2015; Vasseur et al., 2015; Reed et al., 2014). Residents in communities with lower average incomes are disproportionately affected by climate change impacts, in part as a result of an increasing trend in homeowner insurance costs related to property and infrastructure damage from extreme weather events (Drolet and Sampson, 2017). In addition, responses such as relocation or building protection walls to prevent or delay such damages are not affordable to all (Federation of Canadian Municipalities, 2018b; Vasseur et al., 2017). Further, options for wage earnings are limited in some rural and remote communities, and are often supplemented by activities such as hunting, fishing, trapping and gathering, which are also affected by climate change (Kornfeld, 2016; Statham et al., 2015).

3.2 Climate change is affecting rural and remote communities

Rural and remote communities often experience environmental, social, economic, cultural and health impacts from climate change disproportionately compared with urban centres. Despite these challenges, rural and remote communities display strong resilience and are often at the forefront of adaptation action in Canada.

Rural, remote and resource-dependent communities have a history of coping with socio-ecological change, which has created a culture of resilience. While uncertainty associated with climate change impacts and the speed of climate-related changes is challenging existing capacities, many communities have begun to develop and implement adaptation strategies to anticipate, prepare for and address impacts. Adaptation strategies employed by rural and remote communities across the country include gathering and sharing information related to climate change impacts and potential responses; building adaptive capacity; harnessing the use of innovative technologies; and working across jurisdictions to co-construct plans and policies that facilitate successful adaptation and ensure ongoing resilience.

3.2.1 Introduction

Canada's rural and remote communities are home to residents, businesses and organizations that typically depend on climate-sensitive natural resources and ecosystems for their culture, livelihood, transportation and well-being. At the same time, due in part to their geographic location, these communities are experiencing greater impacts from climate change than their urban, and often more southern, counterparts.

As such, rural and remote communities are often characterized as being more vulnerable to climate change than other communities in Canada (Reed et al., 2014). Many rural and remote communities, however, have in the past demonstrated high levels of adaptive capacity and resilience, including in the face of "boom and bust" cycles in market demand for natural resource products and resulting from a history of ongoing colonial legacies and other power relationships that adversely affected them. Inuit communities in Inuit Nunangat, for example, are accustomed to working within changing environments, adapting which species they hunt and when depending on availability, and relying on group memory, intergenerational knowledge-sharing, learned experiences, sharing and trade (*see* Section 3.4). Continued exposure to climate change over long periods can create "response with learning" capabilities that facilitate adaptation (Pearce et al., 2015). Adaptive capacity is challenged by uncertainty around how climate change will impact specific communities, but many have begun to develop and implement adaptation strategies, drawing on local and Indigenous Knowledge, social networks and practices of flexible resource use (Clark et al., 2016b; Young et al., 2016).

3.2.2 Knowledge-sharing and collaboration

Gathering and sharing information related to climate change impacts and potential responses is critical to adaptation efforts. Recent research highlights the importance of knowledge co-production, drawing from multiple knowledge systems and from knowledge that is experiential and place-based. For example, community-based monitoring programs and collaborative research have been used to inform decision-making on climate change adaptation. The use of local and Indigenous Knowledge has helped to support hazard avoidance, emergency preparedness, flexibility and innovation in hunting practices, as well as monitoring of pests, pathogens and weeds. Examples include the eNuk app from Nunatsiavut (eNuk, n.d.), the Northwest Territory's Knowledge Agenda (Government of Northwest Territories, 2017), and 4-H Ontario's Field Crops: Weeds, Insects, and Diseases project (4-H, n.d.). Similarly, climate change-related health monitoring has informed key adaptation strategies (*see* Table 3.4) for responding to impacts such as vectorborne and foodborne disease, reduced water quantity and quality, respiratory disease and mental health concerns.

Residents and organizations in rural and remote communities have also worked with partnering agencies at all levels of government, academia and non-government organizations to not only gather climate change-related data on risks and responses, but also communicate information related to this research (e.g., lists of safe spaces, pamphlets regarding disease outbreaks and best practices for public health related to adaptation) (Drolet and Sampson, 2017; Groulx, 2017; Pearce et al., 2012). This has included incorporating culturally relevant and locally appropriate materials into educational programming, and providing practical advice on adaptation to local homeowners, investors, businesses, governments and non-profit organizations (Groulx et al., 2014; Pearce et al., 2012).

Together, these knowledge creation and mobilization strategies have supported and enhanced adaptive capacity in rural and remote communities. For example, adaptation efforts draw from and build upon existing capacity within communities by enhancing social networks, connections to cultural practices and land-based learning, and intergenerational knowledge-sharing. Further efforts, however, are needed to reduce social barriers to adaptation (e.g., poverty, inequality, housing concerns, etc.) (Groulx, 2017). Adaptation initiatives have also contributed to building more livable and sustainable communities and local economies by incorporating a focus on local food production, alternative transportation options, age-friendly communities, clean energy practices and renewable energy project development into community planning and development efforts. Community members and concerned citizens in rural British Columbia, for example, are calling for integrated, holistic planning responses to environmental and social change (Drolet and Sampson, 2017).

Rural and remote communities are also harnessing innovative technologies in their adaptation initiatives, including the use of telehealth (i.e., the delivery of health information and services through information and communications technologies), satellite imagery to assess unpredictable conditions and social media to respond to emergencies (Taylor, 2019; Goodridge and Marciniuk, 2016). Digital reconstruction has also been used to mobilize knowledge and help to digitally preserve sites of cultural and social significance that are at risk of damage from climate change. For instance, 3D laser scanning technology was used to create a digital reconstruction of Fort Conger, Nunavut—a former settlement, military fortification and research post-dating back to 1881—an example of a polar heritage site that is at risk of destruction due to climate change (*see* Figure 3.2; Dawson and Levy, 2016; Science and Survival at Fort Conger, 2015). The digital reconstruction allows for public exploration of a site they may never see. Other technologies, such as GIS maps and 3D flood

animations, have been used to better communicate climate risks related to flooding and infrastructure failure to community members (Lieske, 2015; Lieske et al., 2014).

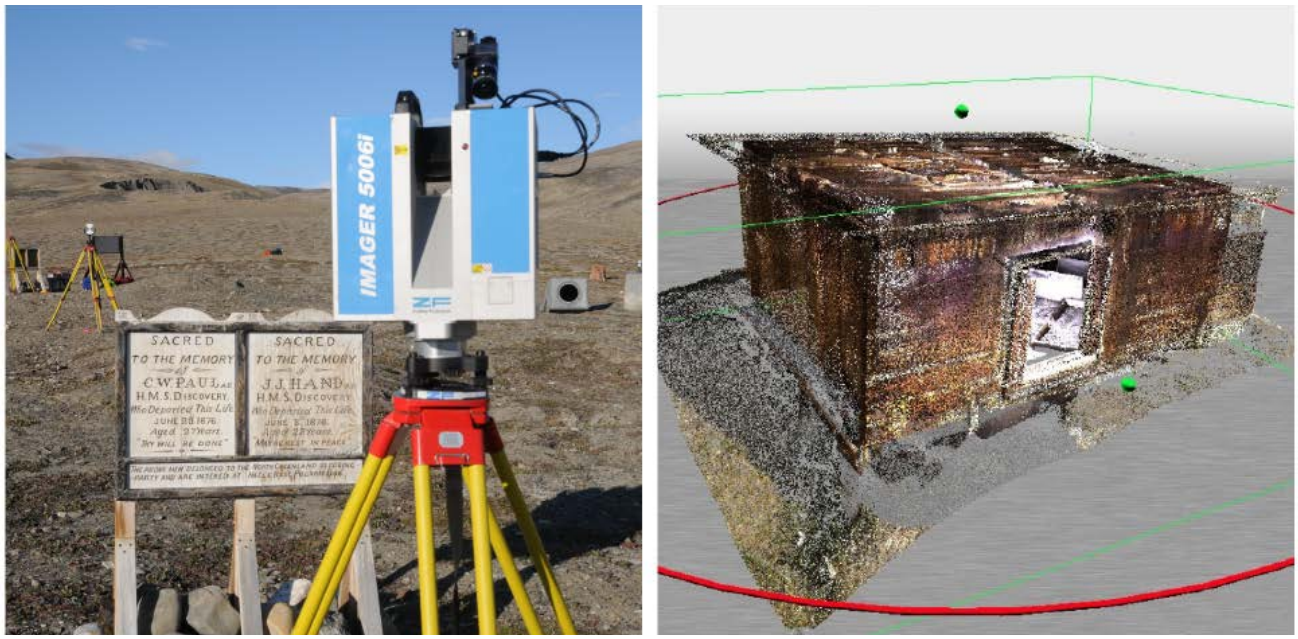

Figure 3.2: The Fort Conger historic site is being digitally preserved through the use of 3D laser scanning technology, which was used to create a digital reconstruction of the site. Source: Science and Survival at Fort Conger, 2015.

Residents of rural and remote communities have also actively participated in the development of national and provincial/territorial assessments, pilot projects, programs and policies pertaining to climate change impacts and adaptation, to ensure that their voices are heard and their circumstances are understood. Adaptation is also increasingly being supported by co-constructed planning and policy, although there is a clear and continuing need for greater local autonomy in adaptation-related decision-making, as well as for improved coordination and communication across different levels of government (*see* Section 3.8). Resilience has been enhanced in rural and remote communities through climate change action plans that are culturally relevant and that draw from social networks, experiences, diversity considerations, consensus building and place-specific emergency response plans. Specific examples of ways that rural and remote communities are leading adaptation actions across Canada are presented in Tables 3.1 to 3.6 and through various case stories included in this chapter (*see* Box 3.3).

Box 3.3: Examples of rural and remote communities across Canada leading adaptation actions

- The Bagida-Waad Alliance—a not-for-profit organization founded by the Saugeen Ojibway Nation and the Chippewas of Nawash—is documenting Indigenous Knowledge and experiences of fishers about climate change impacts on Lake Huron and in Georgian Bay, Ontario.
- Agricultural producers in rural Saskatchewan are responding to climate variability through a range of environmental management practices such as fallowing, creating windbreaks, installing farm water infrastructure and growing new crops with support from government programming and partnerships.
- Provincial officials in Nova Scotia are working with coastal planners and managers to develop strategies to reroute transportation lanes and update design standards. Also, municipal authorities in the province are using flood maps to warn future developers of projected risks, identify vulnerable key municipal infrastructure and adapt their emergency response plans and equipment accordingly.
- A number of community adaptation strategies in the Northwest Territories include educational workshops and physical activity programs to reduce health risks associated with wildfires.
- In the Nunatsiavut region of Labrador, community programs bring together youth and experienced harvesters serving as mentors to support social and cultural connections and to enhance skills, pride and food security.
- Within watershed governance structures in British Columbia, actors at multiple levels are working together to provide decision-makers and stakeholders with up-to-date information about changing water quality and flows, as well as other climate change impacts and potential responses.

3.3 Local and Indigenous Knowledge are key to adaptation and understanding climate impacts

Residents of rural and remote communities have a strong connection to the environments that they depend on for their livelihood, sustenance, well-being and way of life. Place-based knowledge systems, including local and Indigenous Knowledge, and lived experience are key to understanding and adapting to climate change impacts in rural and remote communities and areas.

Climate change impacts are dependent on a number of connected factors that are rooted in specific places. As a result, climate change is impacting individuals and communities in rural and remote areas across Canada in many different ways. It is important that place-based knowledge systems—including local and Indigenous Knowledge—be drawn upon in understanding and responding to climate change impacts. Both local knowledge and Indigenous Knowledge Systems are based on long-term, ongoing relationships between people and their natural environments. Such knowledge can provide useful insights on changing climatic conditions and on the lived experiences of those affected by climate change.

3.3.1 Introduction

In many rural and remote areas across Canada, knowledge about the environment is strongly rooted to place (Chapin et al., 2015). Place-based knowledge systems, which are critical for understanding and responding to the impacts of climate change, are a strength of rural and remote communities that is already being leveraged in many climate change governance, policy and research contexts (EPCCARR, 2018; Arnold and Fenech, 2017; Ellis and Albrecht, 2017; Government of Northwest Territories, 2017; Horning et al., 2016a, b; Cunsolo Willox et al., 2013a, b).

Indigenous Knowledge, local knowledge, and other place-based knowledge systems are commonly utilized in rural and remote Canada. Indigenous Knowledge, which is held by Indigenous Knowledge holders, has been defined as knowledge gained through cultural practices and lived experiences, including multi-generational observations, interactions with other community members, teachings and skills sharing (Pearce et al., 2015; Ford et al., 2014). Indigenous Knowledge is systematic, cumulative and continually changing as new observations and experiences occur (Pearce et al., 2015; Ford et al., 2014). At the foundation of Indigenous Knowledge Systems are generations of place-based observations and experiences; this knowledge is shared through stories, values and ways of knowing, which shape experiences, perceptions, understanding and responses to climate change (EPCCARR, 2018). Similarly, local knowledge—the knowledge that is gained from living and knowing in specific places and environments—is based on sustained interactions between people and the natural environments of which they are a part. In the context of climate change, local knowledge offers insight into human responses to changing environmental conditions (Chapin et al., 2015). Some research indicates that the rapid rate of climate change may challenge the capacity and applicability of some aspects of local and Indigenous Knowledge Systems (Pearce et al., 2015). However, due to their place-based nature, these forms of knowledge are robust, essential and have been highlighted as key to identifying and addressing the local impacts of climate change in rural and remote communities and areas (Ford et al., 2016; Chapin et al., 2015).

There are several important strengths of Indigenous and local knowledge systems in the context of understanding and responding to climate change, including: 1) understanding, monitoring and recording climate change impacts; 2) enhancing adaptive capacity and building resilience; 3) supporting sustainable risk reduction strategies; and 4) informing decision-making and policy change.

3.3.2 Monitoring and recording climate change impacts

In many rural and remote areas across Canada, place-based knowledge systems are being used to monitor the impacts of climate change (Arnold and Fenech, 2017; Savo et al., 2017; Statham et al., 2015; Gill and Lantz, 2014). For the Teetł'it Gwich'in in Fort McPherson, Northwest Territories, for example, Indigenous Knowledge is being used to monitor the environmental impacts of climate change and to provide place-based and context-specific information related to water security (Gill and Lantz, 2014). The data collected through this monitoring program has been used to create a web-based map that displays photos and videos provided by participants, ultimately producing descriptive and culturally relevant information about environmental changes (Gill and Lantz, 2014). In another example, communities throughout Nunavut used Indigenous Knowledge to provide insight into the climate changes observed in the region during the winter of 2010–2011, which included a range of climate extremes (e.g., extreme and unpredictable winds, warming temperatures), sea ice (e.g., later freeze-up, unpredictable thickness) and land conditions (e.g., icy land conditions) to inform future studies (Statham et al., 2015). In the Northwest Territories' Knowledge Agenda, the role of Indigenous and local knowledge is acknowledged as key to identifying and understanding climate change and its implications for the landscape, wildlife, traditional activities, and human health and well-being, and for informing government decision-making (Government of Northwest Territories, 2017). In Rigolet, Nunatsiavut, Labrador, Indigenous Knowledge is being used to monitor climatic changes through a community-led monitoring program, which allows community members to record environmental and health changes associated with climate change using the eNuk mobile phone application (*see* Figure 3.3; Kipp et al., 2019; Sawatzky et al., 2017). Information collected through the app is being used to promote safer travel through information-sharing, to inform policy-level decision-making and to preserve important Inuit knowledge. These examples illustrate the key role that Indigenous and local knowledge holders play in understanding the impacts and extent of climate change.

Figure 3.3: The eNuk app is a tool for ongoing and near-real-time monitoring of observations, patterns and trends in climate and environmental conditions and associated health implications. The app allows community members to record their environmental and health observations in the form of photos, videos, audio recordings and text descriptions while travelling, hunting, fishing and harvesting on the land. The app includes indicators of environmental change (e.g., thinning ice or unusual weather patterns) and elements of both physical health (e.g., unintentional injuries) and wellness (e.g., feelings and emotions associated with certain conditions or places) (eNuk, n.d.). Photos courtesy of Ashlee Cunsolo and Inez Shiwak.

3.3.3 Enhancing adaptive capacity and building resilience

Place-based knowledge systems have also been recognized as enhancing adaptive capacity and resilience to the adverse effects of climate change in rural and remote areas at both the individual and community level. For many Indigenous communities in Northern Canada, Indigenous Knowledge is based on knowledge and skills that are at the root of safe practices while out on the land (e.g., responding to environmental dangers such as changing snow, ice and weather conditions) (Ford et al., 2014). As a result, Indigenous Knowledge has contributed to the flexibility and adaptability of individuals and communities, as well as to successful hazard avoidance and emergency preparedness in the context of changing climatic conditions (Pearce et al., 2015). Place-based assessments can therefore be used not only as a way of accounting for local climatic conditions, but also as an avenue through which knowledge users can better understand adaptive capacity in specific contexts (Ford et al., 2015).

3.3.4 Supporting sustainable risk reduction strategies

The contextual nature of climate change has posed challenges for rural and remote communities in terms of creating and implementing sustainable and successful risk reduction strategies. Research examining rural and remote areas across Canada has found that incorporating place-based knowledge that is rooted in the lived experiences of local communities can positively contribute to sustainable development planning (Drolet and Sampson, 2017). For example, a study examining six rural communities in the interior and northern regions of British Columbia highlighted the ways in which each community experienced diverse climate change impacts. These communities expressed a need for adopting different approaches to sustainable development, which emphasize using a place-based approach rooted in local contexts and experiences (Drolet and Sampson, 2017). In a study examining best management practices for adapting to environmental impacts of climate change in agricultural communities in Alberta and Saskatchewan (located in the Swift Current Creek, Oldman River and Castle watersheds), community members highlighted the need to incorporate local knowledge and practices in sustainable social development planning. Agricultural producers acknowledged that, despite being subjected to changing weather stressors, they have been able to adapt by applying local knowledge from farmers, ranchers, watershed groups and irrigation districts to develop new technologies, practices and management strategies (McMartin and Merino, 2014).

3.3.5 Informing place-based decision-making and policy on adaptation

Place-based knowledge systems and the lived experiences of individuals and communities in rural and remote areas are being used to inform decision-making and policy. For example, a program examining environmental management practices for agriculture in rural Saskatchewan found that incorporating local knowledge into discussions about the uncertainties of climate change would increase the number of scenarios considered, thus helping to decrease policy concerns and ensure regional appropriateness (Hurlbert and Pittman, 2014). In areas where changes to permafrost alter existing structures, research has highlighted the role that local and Indigenous Knowledge can play in policy that relates to the built environment (Ford et al., 2015). Indigenous Knowledge Systems can also provide novel perspectives and options for action, which extend beyond scientific knowledge and help highlight priorities, build understanding and advance climate change adaptation (EPCCARR, 2018).

Despite the important knowledge highlighted in this chapter, there is a dearth of information focused on the place-based implications of climate change for those living in rural and remote communities in Canada (Rapaport et al., 2015). Although changes to the environment are affecting local peoples' relationships with and knowledge about the land (Durkalec et al., 2015; Harper et al., 2015, 2012; Cunsolo Willox et al., 2012), it is vital to continue supporting and drawing from Indigenous and local knowledge to effectively understand and respond to the context-specific nature of climate change impacts in rural and remote communities and areas (*see* Case Story 3.1).

Case Story 3.1: The Saugeen Ojibway Nation and tracking of climate change impacts on whitefish

Many families in the Saugeen Ojibway Nation and Chippewas of Nawash rely closely on whitefish populations in Lake Huron and Georgian Bay for their culture, sustenance and livelihoods. As wind speeds increase and temperatures rise due to climate change, fishers have begun to notice changes to the fish in these areas. The Bagida-Waad Alliance was founded by these fishing communities to serve as a local research organization, with the aim of establishing a baseline for fish populations, tracking climate change impacts on Lake Huron and Georgian Bay and documenting Indigenous Knowledge of fishers. Leveraging the stories and experiences of fishers and Elders is expected to help the community develop its climate change adaptation capacity, as well as preserve place-based knowledge systems for future generations (Johnson, 2019).

3.4 Climate change is challenging livelihoods and economies

Climate change is already impacting many of the economic sectors and subsistence activities that rural and remote communities rely on for their livelihoods and economic well-being. Local adaptation strategies are helping to protect traditional economies through planning and capacity building, changing land practices and use of technology.

Changing sea ice and ocean conditions, warmer temperatures and drought are already impacting economic sectors such as agriculture, forestry, fishing and tourism, as well as subsistence activities such as hunting and gathering. These industries and related activities are often dependent on climate-sensitive natural resources and are vital to livelihoods and economic well-being in rural and remote communities. Despite the significant intersecting challenges, individuals and organizations in many rural and remote communities have taken important steps to protect and adapt their livelihoods, while also encouraging new development options such as alternative energy projects. Many residents that rely on land-based subsistence economic activities have also adopted coping and adaptation strategies, which include changing travel times and routes, shifting to other target species, using new digital technologies and drawing on strong social networks to share food, equipment and knowledge. These strategies often come at a financial and personal cost, however, and require support and care to avoid maladaptation (i.e., adaptation actions that inadvertently increase the risk of adverse outcomes).

3.4.1 Introduction

Many rural and remote communities in Canada have mixed economies with both formal (cash or wage-based) and informal (primarily non-cash) sectors playing important roles. Further, many rural and remote communities depend on natural resource industries—including agriculture, forestry, fisheries, energy and mining—for their economic base and to support livelihoods (*see* Figure 3.4; Drolet and Sampson, 2017). In turn, these communities and their residents make vital contributions to provincial and national economies (Dampier et al., 2016). In more than 1,800 rural and remote communities in Canada—the majority with populations of 10,000 or less—an average of 30% of the local labour force is dependent on natural resource sectors for employment (*see* Figures 3.5 and 3.6). Current and potential climate change impacts on natural resource sectors, particularly those that have yet to develop or implement adaptation strategies, therefore make many rural and remote communities economically vulnerable.

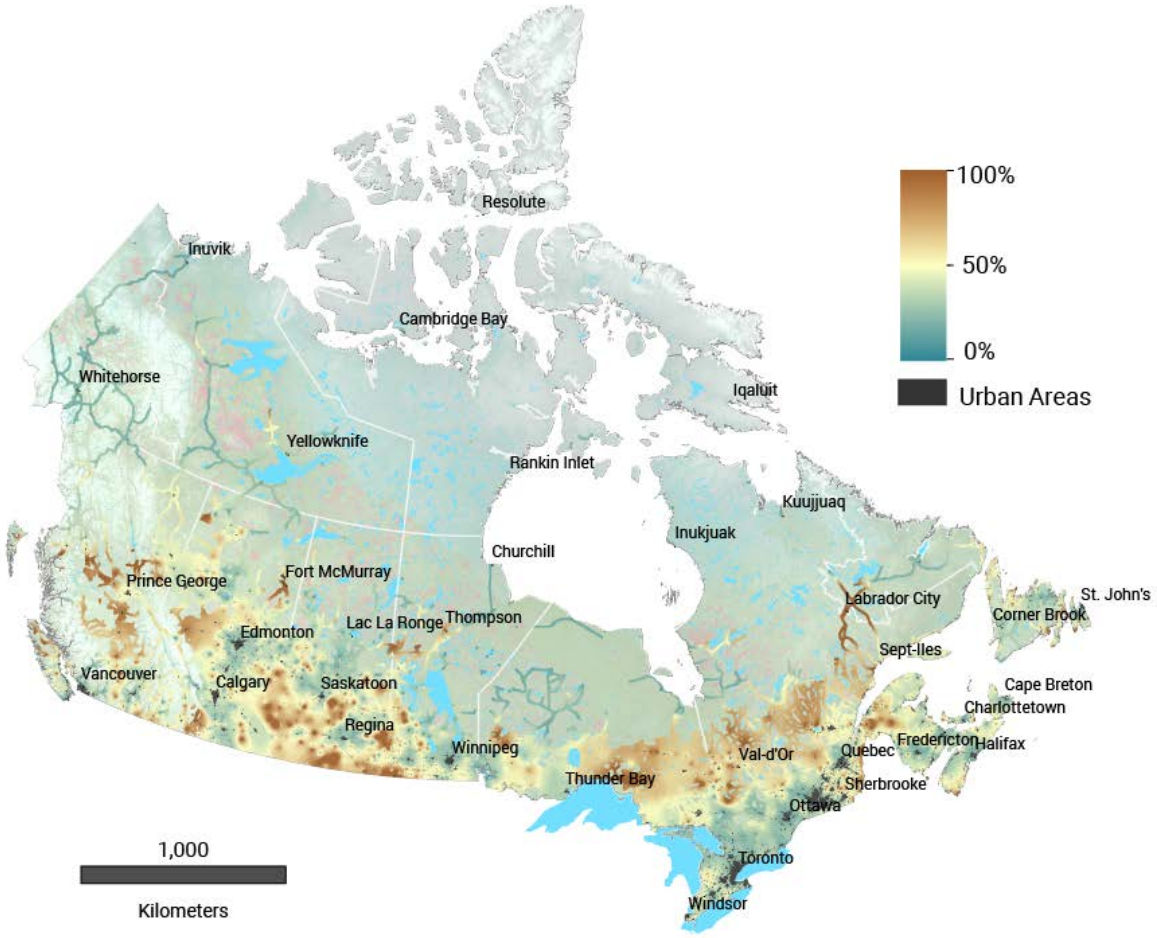

Figure 3.4: Map displaying the average labour-force dependency of communities across Canada on natural resource sectors—including agriculture, fisheries, forestry, energy and mining—for the period 2001–2016. The colours on the map range from blue to red, where blue signifies low dependency, mostly in and surrounding large urban areas, and red indicates high dependency, which is mostly in rural and remote areas. The map shows that natural resource sectors provide as much as 50–100% of the base economic sector income for many rural and remote communities across Canada. Base economic sectors include natural resources (fisheries, agriculture, forestry, minerals, and petroleum and coal), utilities and construction, and manufacturing. Source: Eddy et al., 2020a, b.

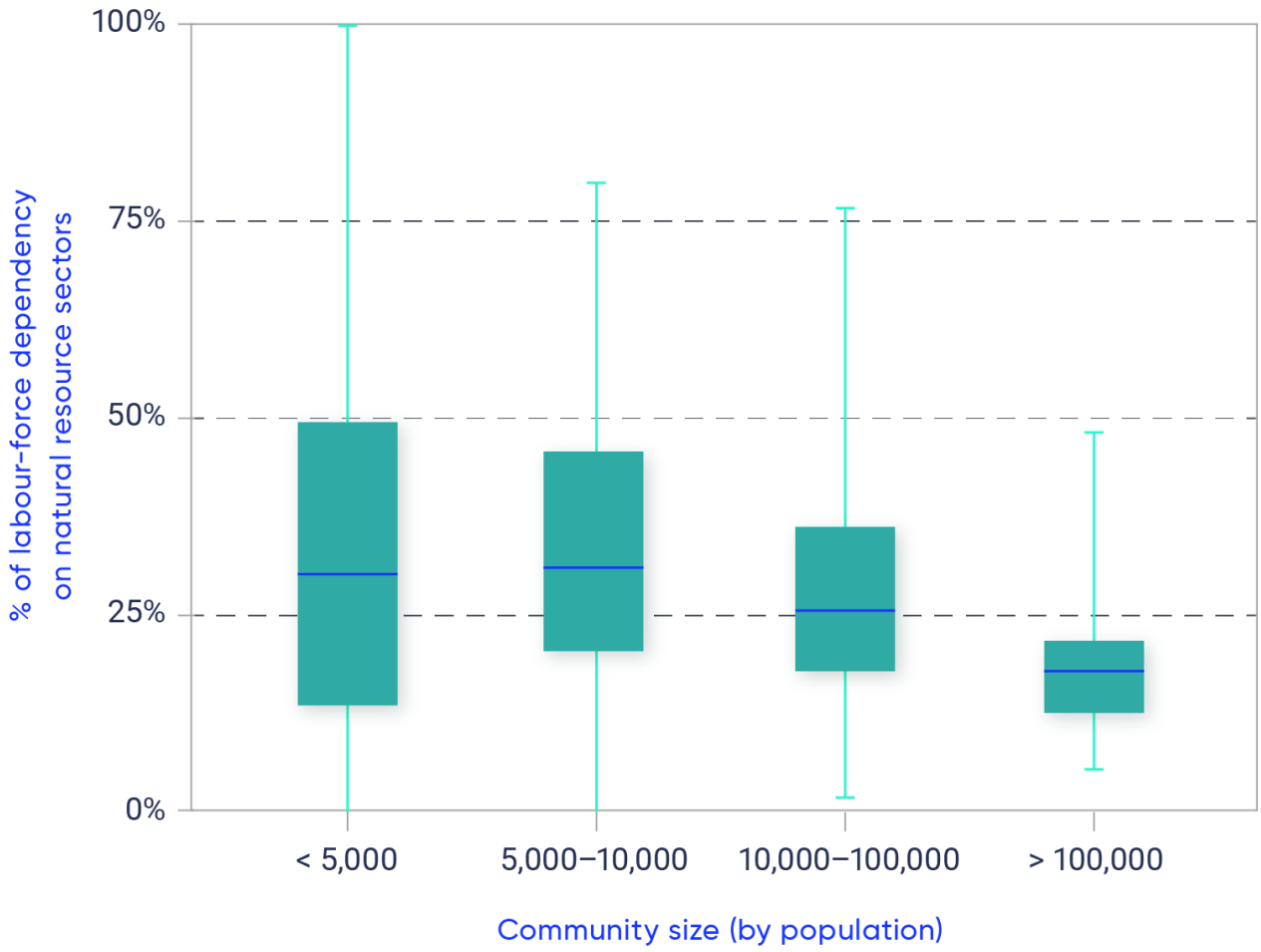

Figure 3.5: Graph illustrating the average labour-force dependency of different-size communities in Canada on natural resource sectors, as a percent of base economic sector income, for the period 2001–2016. Base economic sectors include natural resources (fisheries, agriculture, forestry, minerals, and petroleum and coal), utilities and construction, and manufacturing. Communities are grouped according to four different population sizes: 1) less than 5,000; 2) 5,000–10,000; 3) 10,000–100,000; and 4) greater than 100,000. The boxes indicate the maximum and minimum values for 95% of the data, the solid line within each box indicates the average value and the vertical lines extending from the boxes indicate the full data range. The graph shows that the labour force in communities with smaller populations tends to be more dependent on natural resource sectors than in communities with larger populations. Source: Eddy et al., 2020a, b.

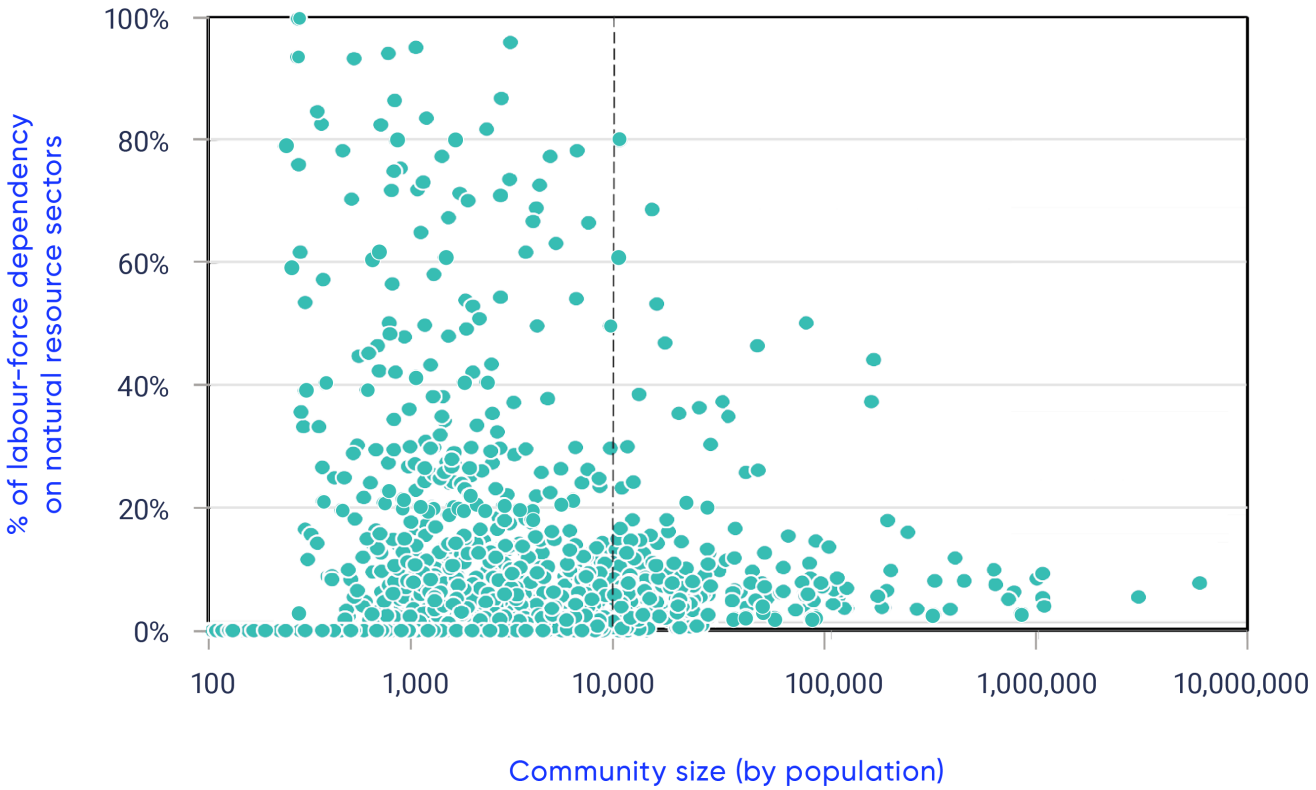

Figure 3.6: Graph showing the distribution of the average labour-force dependency on natural resource sectors, for the period 2001–2016, for communities in Canada with populations ranging from 100 to 10,000,000 people. Labour force dependency is defined as the percentage of labour force income derived from natural resources as a proportion of the total base sector income. Base economic sectors include natural resources (fisheries, agriculture, forestry, minerals, and petroleum and coal), utilities and construction and manufacturing. Each dot in the graph represents a different community in Canada. The vertical dotted line illustrates the population threshold used in this chapter for communities that are considered as being rural and/or remote (e.g., communities with a population of 10,000 or less). The graph shows that the labour force in communities with smaller populations tends to be more dependent on natural resource sectors than in communities with larger populations. Source: Eddy et al., 2020a, b.

Climate change impacts on informal economies such as hunting, fishing, trapping and gathering threaten livelihoods and food security. Residents often rely on these culturally significant activities to supplement wage-income sources in locations where wage-sector employment prospects may be limited (Kornfeld, 2016). Further, when access to locally harvested food (e.g., "country food") is restricted, residents are often forced to switch to costly, nutritionally inferior store-bought products (Statham et al., 2015). Many of these communities are within the traditional territories of First Nations, Inuit and Métis populations whose livelihoods, culture and well-being are deeply connected to the health of the land and water (Gill and Lantz, 2014; Cunsolo Willox et al., 2012). This makes these populations more vulnerable to climate change than populations in urban environments (Kornfeld, 2016). These same rural and remote communities are often experiencing some of the most severe and cumulative effects of climate change. Dependency on ecosystem

resources means that climate change impacts on the economies and livelihoods of rural and remote communities in Canada are particularly acute.

3.4.2 Vulnerability and adaptation in the natural resource sectors

Climate change is expected to increase the vulnerability of natural resource-dependent economies due to impacts on supply, demand, and harvesting and processing operations. For example, climate variables (e.g., temperature and precipitation) and weather-related stressors play important roles in growing season length, as well as agricultural activities and productivity, making the agriculture sector highly vulnerable to climate change (Akkari and Bryant, 2016). Temperature extremes and extreme events have affected growing conditions across the country. Although hotter, drier summers and extreme weather events—including drought, heat waves and flooding—have negatively impacted many agricultural areas, prolonged growing seasons and increasing frost-free days could also provide new opportunities (Roussin et al., 2015; McMartin and Merino, 2014). Efforts to increase local food production as a result may enhance food security, create new jobs and income, and reduce reliance on food imports, which has the added co-benefit of reducing greenhouse gas (GHG) emissions related to the transportation of imports and reduced vulnerability to transportation system disruptions (Roussin et al., 2015). Research highlights the need to ensure that agriculture in new areas does not amplify or exacerbate existing risks. For example, caution would be needed in areas where there are existing water shortages and high demand on water for crop irrigation, as is the case in the area near the Oldman Dam in Alberta (Yusa et al., 2015).

The forest industry and forest-based communities are being affected by multiple impacts related to climate change. The mountain pine beetle epidemic, for example, has provided a powerful illustration of related threats (e.g., loss of merchantable timber and related jobs and business revenues) and opportunities (e.g., for economic transition and biomass energy production) (Drolet and Sampson, 2017; Furness and Nelson, 2016; Blanco et al., 2015). Climate change is also affecting the availability of commercially harvested fish species and impacting fishing seasons and locations. For instance, increases in warmer water species like silver hake in Newfoundland and Labrador, and American lobster across the Scotian Shelf have been observed (Bernier et al., 2018). Also, herring seasons are being extended and there is a need to travel farther offshore for shrimp due to warmer near-shore waters in the Acadian Peninsula (Vasseur et al., 2017). In the Pacific Ocean, fisheries stocks are being affected by warming, acidification and extreme events such as marine heat waves. For example, increasing ocean temperatures are believed to have negatively impacted the survival, size and condition of Chinook Salmon, reducing catch sizes and value (Holsman et al., 2019).

Climate change is also impacting tourism potential in rural and remote areas, many of which are increasingly relying on tourism as a component of their local economies. For example, warmer temperatures, changing sea ice dynamics and shifting weather patterns are expanding existing opportunities as well as opening up new ones in some areas (*see* Sector Impacts and Adaptation chapter). Increased tourism, however, also brings associated direct and indirect impacts that negatively affect ecosystems and transportation, such as increased air travel, greywater discharge and GHG emissions (World Wildlife Fund, 2019; Stoddart and Sodero, 2015). Not all rural and remote communities are benefitting from expanded or new tourism opportunities due to climate change (*see* Table 3.1). For example, many ski areas are negatively impacted by

changing weather patterns, shorter winter seasons and precipitation changes, and are becoming more reliant on snow-making equipment, which increases costs and water demand (Hock et al., 2019; Gilaberte-Búrdalo et al., 2014). Other impacts—including thawing permafrost, rising sea levels, storm surges, flooding and erosion—are leading to the loss and destruction of valued artifacts and heritage sites, such as Fort Conger, Nunavut (*see* Section 3.2). This is not only leading to the loss of cultural heritage, but is also damaging potential tourism opportunities (Abram et al., 2019; Meredith et al., 2019; Dawson and Levy, 2016). Other examples of impacts and adaptation efforts within each of these natural resource sectors are provided in Table 3.1 (*see* Sector Impacts and Adaptation chapter).

Table 3.1: Climate change impacts and adaptation measures in rural and remote sectors

SECTOR	CLIMATE CHANGE IMPACTS	ADAPTATION MEASURES
Agriculture and livestock	• New agricultural opportunities in West Kootenays, BC due to an extended growing season for vegetable crops include the possible expansion of fruit and vegetable varieties; use of poorer quality lands for niche crops such as tree fruits and grapes; and potential to increase mixed small-scale agriculture (Roussin et al., 2015). • Scarce water resources are further depleted due to expanded agricultural development in newly cultivated land (Yusa et al., 2015). • Use climate data and projections from climate models in combination with soil information to assess the agricultural potential of a region and plan for a change in the range and types of crops grown (Roussin et al., 2015). • Heat waves are increasing risks of dairy cow mortality in southern Ontario (Bishop-Williams et al., 2016).	• Farm-level adaptation includes four main and often interdependent approaches: technological development; government programs and insurance; farm practices; and farm financial management (Akkari and Bryant, 2016). • Use climate and crop insurance data to assess costs and risks and support farm planning (Akkari and Bryant, 2016). • Shifts in cropping regimes and seeding times (McMartin and Merino, 2014). • Precision agriculture and other types of water reduction methods are used to conserve water, while maintaining harvest yields (Nicol and Nicol, 2018). • Use climate data and projections from climate models in combination with soil information to assess the agricultural potential of a region and plan for a change in the range and types of crops grown (Roussin et al., 2015).

SECTOR	CLIMATE CHANGE IMPACTS	ADAPTATION MEASURES
Agriculture and livestock (continued)	• In the Province of Quebec, yield declines are expected for wheat, soybeans, green peas, onions, tomatoes and cabbage (with potential implications for costs of dairy production); however, yields for corn, sorghum, canola, sunflowers, potatoes, tobacco and sugar beets may increase (Akkari and Bryant, 2016). • Continued northward expansion of areas feasible for small cereal crops are expected, particularly in north-central Canada, while summer water deficits in some boreal regions will accelerate soil carbon losses and diminish already limited soil quality (King et al., 2018).	• More proactive water management (McMartin and Merino, 2014). • Use of farm environmental management practices and water infrastructure to reduce vulnerability (Hurlbert and Pittman, 2014). • Monitor herds more frequently during heat waves, using heat abatement strategies such as fans and soaking, communicating heat wave warnings through various media channels (Bishop-Williams et al., 2016). • Implement nutritional changes and improved breeding techniques (Rojas-Downing et al., 2017; Climate Action Initiative, 2013). • Combine winter water storage to feed summer irrigation and develop drought-adapted crop varieties to support production and expansion (King et al., 2018).
Forestry	• More frequent and severe droughts, increased windstorms and changes to growing seasons together with other changes have reduced harvest revenues and increased fluctuations in timber supply (Furness and Nelson, 2016). • Increased forest fire frequency, area burned and fire seasons (Blanco et al., 2015).	• Use of guidebooks to assess adaptive capacity and measures to strengthen community assets (e.g., Reed et al., 2014; Pearce and Callihoo, 2011). • Thin and prune forests to reduce fire and drought risk (Furness and Nelson, 2016). • Improve forest health monitoring and response to disturbances (e.g., salvage logging and treatments) (Furness and Nelson, 2016).

SECTOR	CLIMATE CHANGE IMPACTS	ADAPTATION MEASURES
Forestry (continued)	• Increased forest pest and disease infestations (e.g., warmer winter conditions led to a mountain pine beetle epidemic that has destroyed over 18 million acres of forest in British Columbia since the 1990s, with the beetle's range expected to continue expanding into Canada's northern and eastern pine forests) (Natural Resources Canada, 2018b). • Market and policy pressures, due to the awareness of climate change impacts, for energy sources that reduce GHG emissions lead to the use of woody biomass in bioenergy projects (Blanco et al., 2015).	• Climate-informed modelling of future timber supply (Furness and Nelson, 2016). • Adjust planting strategies for a diversity of species, trial seed from a variety of provenances and keep a mix of age classes to spread risk (Furness and Nelson, 2016). • Research expected impacts and changes that could be made; adjust work programs, processes, practices or structures to reduce vulnerability (Furness and Nelson, 2016). • Generate woody biomass from reductions in stand density to reduce risk of future wildfires, which can support local bioenergy projects and reduce GHG emissions (Blanco et al., 2015).
Fisheries	• The herring fishery is extended; shrimp are further offshore due to warmer near-shore waters; lobsters are larger due to milder winters; and there is increased prey in the Acadian Peninsula, New Brunswick (Vasseur et al., 2017). • Collecting shellfish is more difficult in areas that are experiencing sea-level rise (Vasseur et al., 2017).	• Fishers in New Brunswick are working with government scientists to report new species and predict biodiversity changes; assess infrastructure risks; and improve key fisheries infrastructure to enhance resilience to storm events (*see* Atlantic Provinces chapter). • Reduced quotas and regional fisheries closures are used to manage and support declining fish stocks (Dawson, 2019).

SECTOR	CLIMATE CHANGE IMPACTS	ADAPTATION MEASURES
Fisheries (continued)	• Damages to fishing-related infrastructure is particularly challenging for communities with limited ability to afford expensive coastal defenses or relocation (Vasseur et al., 2017). • Pacific salmon fisheries are being impacted by a rise in ocean temperature (Holsman et al., 2019).	
Tourism	• Reduced sea ice duration and extent in Arctic Canada (Pizzolato et al., 2014). • Increased tourism potential and the associated economic benefits and growth in cultural awareness (Johnston et al., 2017). • Increased cruise ship traffic in the Arctic can lead to localised warming (Messner, 2020). • Greywater discharge impacting fragile Arctic ecosystems (World Wildlife Fund, 2019). • Decreased snowpack and unpredictable weather events (Bleau et al., 2015). • Reduced length of winter sports seasons (Rutty et al., 2017). • High water usage with increased snow-making at ski resorts (Gerbaux et al., 2020). • Lower numbers of visitors to ski resorts as a result of deteriorating conditions for snow-based activities (Rutty et al., 2017).	• Services and opportunities for tourists developed by locals living in Arctic regions. • A focus on four-season tourist opportunities, rather than season-specific tourism activities. • Increased communication with tourists to inform them of potential weather events (Bleau et al., 2015). • Smaller resorts are purchased by larger companies that are more able to adapt to climate change (Sorensen, 2016). • Greater reliance on snow-making (Rutty et al., 2017). • A focus on four-season opportunities and activities to reduce the dependence on season-specific activities (Rutty et al., 2017).

3.4.3 Adaptation responses and opportunities

Residents of rural and remote communities have adopted numerous adaptation strategies to address climate change impacts (*see* Case Story 3.2), including in response to changes in subsistence economies. For example, adaptation related to hunting and food security include changing travel routes on the land for hunting; altering hunting patterns by learning to hunt new species as others change when ecosystems shift; increasing preparation and supplies for hunting trips; using new digital technologies for increased safety; and drawing on strong social networks to share food, equipment and knowledge (*see* Table 3.2). In Nunavut, for example, there have been reductions in caribou availability and quality (e.g., caribou are described as being skinnier, with less fat), along with shifts in migration to areas requiring further travel and with greater access restrictions. Under such conditions, hunters in Ulukhaktok, Inuvialuit Settlement Region, shifted their focus from harvesting caribou to muskox. Declining muskox populations now face increased harvest pressure, and hunters must travel further to hunt with varying success, leading to greater stress on the herds and on people who rely on muskox for food security (Fawcett et al., 2017). Longer, land-based routes are often harder on equipment and require more planning and supplies (Durkalec et al., 2015). Further, measures such as replacing canvas tents with cabin structures that can store supplies and withstand stronger winds—or replacing and purchasing new, often expensive safety equipment—are not feasible for all (Archer et al., 2017). In addition, meat returns may be reduced despite higher costs. Low-income hunters, including unemployed individuals and retirees that are dependent on pensions, are at particular risk from such challenges (Statham et al., 2015). New safety risks have also been introduced, especially for inexperienced hunters, as a result of shifting to unfamiliar routes, a reliance on technologies that can and do fail, and snowmobiles breaking down and being expensive to fix (Clark et al., 2016a, b). Reciprocity is also important in social networks: those less able to harvest country food (often due in part to climate-related changes) may become less likely to receive community and/or family support over time. Nevertheless, many communities continue to depend on sharing networks to support subsistence economies in a changing climate. With fewer people hunting, many hunters have increased the numbers of community members for which they provide, although this may be increasingly challenging with declining harvests and further climatic and environmental stressors (Statham et al., 2015).

Table 3.2: Examples of existing and future adaptation strategies to address climate change impacts on informal economies in rural and remote communities across Canada

EXISTING ADAPTATION STRATEGIES	REFERENCES
Added caution and emergency preparedness, such that land users are prepared to overnight and make a shelter, call for help if needed, seek additional guidance from elders before leaving, consult satellite imagery of sea ice and weather forecasts, pack more supplies (e.g., gas, food and cooking fuel, tent, parts, extra clothing and ammunition), and stock gas barrels on land during the winter months for overland travel.	Clark et al., 2016a, b; Pearce et al., 2015; Statham et al., 2015
Altered trail routes and/or hunting locations and related modes of travel (e.g., abandoned boats and travel overland by ATV).	Clark et al., 2016a, b; Pearce et al., 2015; Statham et al., 2015
Use of new technology to address changing, unpredictable conditions combined with traditional navigation skills and knowledge (e.g., satellite navigation systems and emergency satellite response devices, CB and Very High Frequency radios, satellite phones, and distress beacons); widespread use of the internet (e.g., social media to share food and equipment, check online weather forecasts and sea ice reports, request help, coordinate unofficial search and rescue trips, satellite navigation relay); stronger (e.g., aluminum) boats and structures (e.g., cabins vs. tents equipped with stoves, fuel and basic provisions at strategic locations).	Archer et al., 2017; Fawcett et al., 2017; Clark et al., 2016a, b; Pearce et al., 2015
Adapting species hunted according to what is available (e.g., from caribou to muskox, from seals to caribou during longer boating seasons, and from marine-based to land-based animals during the dangerous sea ice season).	Clark et al., 2016a, b; Pearce et al., 2015; Statham et al., 2015
Experienced hunters often make adaptive decisions (e.g., changing trail routes) and then share these with the community through social networks.	Clark et al., 2016a, b
Education and capacity building that strengthens land-based learning and intergenerational knowledge-sharing (e.g., traditional skills workshops, prevention programs, young hunter programs).	Clark et al., 2016a, b
Selling country food to offset increased expenditures on hunting equipment and safety technology, facilitated by markets and social media groups.	Statham et al., 2015

EXISTING ADAPTATION STRATEGIES	REFERENCES
Household food strategies such as switching to cheaper and less preferred foods, reducing food intake, eating elsewhere (e.g., at a friend's or family member's house) and selling belongings.	Statham et al., 2015
Community sharing, intercommunity trade and fostering social capital (e.g., sharing of food, equipment, knowledge).	Clark et al., 2016a, b; Statham et al., 2015
Community-based food programs.	Statham et al., 2015

FUTURE ADAPTATION STRATEGIES	REFERENCES
Ongoing, community-based environmental monitoring, recording of systematic observations of environmental conditions that draw from Indigenous Knowledge and local ways of understanding and interacting with the environment.	Government of Canada, 2016; Gill and Lantz, 2014;
Community climate change adaptation plans that are directly linked to specific places on the landscape and ongoing place-specific monitoring.	Gill and Lantz, 2014
Enhanced harvester assistance programs and support for the generation and transmission of skills among younger Inuit to travel and hunt under changing conditions.	Clark et al., 2016a, b
Improved financial awareness and budgeting skills to assist in coping with food-related stresses.	Statham et al., 2015

Growing demand for more sustainable, less carbon-intensive products and climate-related policy changes (e.g., carbon credits) challenges existing ways of operating in natural resource sectors. This creates new opportunities and encourages alternative development options that aid in transitioning to a more sustainable local economy (Drolet and Sampson, 2017). Examples include those noted above in agriculture, forestry, fisheries and tourism, as well as new biomass, wind and solar energy projects (Dampier et al., 2016; Kornfeld, 2016; Schroth et al., 2015). Hybrid renewable energy projects have been successfully implemented in Deer Lake and Fort Severn, Ontario, and in Colville Lake, Northwest Territories (Arriaga et al., 2017). These efforts have been successful in reducing reliance on fossil fuels and associated spills, transport costs and GHG emissions. While there are some concerns about maladaptation—including potential negative ecosystem impacts, biomass supply and accessibility, transportation costs and, in particular, air quality from biomass energy production—these negative outcomes can be offset by the potential benefits of sustainable energy systems (Blanco et al., 2015). Skills training and local investments in new technology, innovation and transition planning may be required to support economic transition (Drolet and Sampson, 2017). Attention to "just transitions"—which require collaboration, respect, worker support and shared financial costs to build a sustainable future for communities—is essential for moving forward (Government of Canada, 2018).

Government-imposed requirements for corporate carbon footprint reductions and green investment treaties with commitments to reduce GHGs, for example, have the potential to support such transitions (Kornfeld, 2016). Lifecycle analyses and assessment of payback periods for initiatives seeking resiliency to climate change and extremes have also been identified as helpful strategies (McMartin and Merino, 2014).

In summary, the traditional industries and related jobs that rural and remote communities rely on face significant threats that are linked to circumstances including, and exacerbated by, a changing climate and environment. These communities are facing challenges associated with extreme weather events, rising sea levels, retreating sea ice, declining traditional food sources and changes in the populations of target species for resource sectors. To overcome these challenges, communities have taken important and often proactive measures to protect and adapt the subsistence harvesting and natural resource-based industries that support their livelihoods. These adaptations, however, continue to come at a cost and draw on human, social and financial capital. There is a need for ongoing attention to the threat of maladaptation, such as overharvesting of species or new agricultural activities that add excess stress to local water, forest and soil resources. Further support for adaptation can come from knowledge and technology sharing to better predict impacts and changes, investment in resiliency measures, and provision of technical expertise and training for rural and remote communities to provide new skills and knowledge relevant for a changing environment. In the longer term, there may be a need to support more significant measures in some circumstances, like managed retreat (i.e., the purposeful and coordinated movement of people and buildings away from risks) due to sea level rise or the development of new food and water resources.

Case Story 3.2: Government programming and partnerships in support of farm-level adaptation in Saskatchewan

Agricultural producers are playing a leading role in innovating responses to climate variability. They are implementing environmental management practices (such as fallowing, creating wind breaks and installing farm water infrastructure) and other measures (such as direct seeding and growing new crops like canola and lentils) that reduce farm- and ranch-level vulnerability to climate change impacts, including revenue loss due to drought (Hurlbert and Pittman, 2014).

Some of these innovations have been supported by government programs, such as the Canada-Saskatchewan Farm Stewardship Program (FSP) (FSP, n.d.) and the Farm and Ranch Water Infrastructure Program (FRWIP) (FRWIP, n.d.). Each of these programs has assisted thousands of projects or producers in Saskatchewan each year with on-farm projects. The FRWIP helps to address drought by financing infrastructure projects such as dugouts, wells and water pipelines that increase water access. Federal and provincial governments share the costs with the beneficiary (e.g., farmer, rancher or municipality). The FSP supports environmental farm plans and beneficial management practices that assist with climate change adaptation or that maintain or improve water resources and biodiversity (e.g., through reduced soil erosion and improved pasture management).

After a multi-year drought in 2008, producers pushed for the decentralization of program administration

from federal to provincial governments. The federal government continued to provide technological and engineering expertise, and the non-profit Provincial Council of Agriculture Development and Diversification Boards for Saskatchewan Inc. (PCAB) worked with producers to identify beneficial management practices and served as a networking organization to foster interactions between governance institutions at multiple levels, including local farms and grassroots organizations. This shift was identified as more effective in terms of localized adaptation, but also requires grassroots leadership.

One challenge, particularly within rural municipalities without a sufficient tax base to invest in infrastructure projects, has been the requirement for stakeholders to provide matching funds. Inconsistent and uncertain funding has also discouraged some stakeholders from taking advantage of the programs, and thus from implementing adaptation measures. Other challenges include limited staff resources within responsible agencies and political inertia.

3.5 Critical infrastructure and services are at risk

Critical infrastructure and related services, particularly in rural and remote coastal communities, are at risk of failure and disruption from increases in the number and severity of extreme weather events. In response, a growing number of these communities are mainstreaming climate change considerations into community planning and design, and are beginning to reimagine, reinforce and rebuild their built environments.

Rural and remote communities and areas in Canada often struggle with stressed and degraded infrastructure, a retreat from service programming and the centralization of resources and services. Increases in the frequency and intensity of extreme weather events, flooding, sea level rise, permafrost thaw, wildfires and other climate-related changes are substantially exacerbating these challenges. As a result, transportation and energy networks, delivery of services, and infrastructure that support activities necessary for daily life continue to face greater risk of failure and disruption. In response to increasingly severe and unpredictable climatic conditions, rural and remote communities are developing innovative adaptation strategies to address local and regional challenges. These include the consideration of climate change, natural infrastructure and the need for sustainable, livable communities in infrastructure and community planning. Projects that reduce reliance on vulnerable, fossil fuel-dependent energy and transportation networks are important to consider in the development of adaptation strategies. Information technology is also being used to better communicate risks of climate-related infrastructure failure and service disruptions, and to document vulnerable—and in some cases lost—heritage resources.

3.5.1 Introduction

Across Canada, adequate access to infrastructure and services is a growing concern for many rural and remote communities that are experiencing stressed and degraded infrastructure, and a retreat from service delivery. Changing environmental conditions are posing further challenges for both critical and community infrastructure in rural areas (*see* Box 3.4; Berner et al., 2016). Extreme weather events (e.g., high winds, increased precipitation, drought, ice storms, heat waves and storm surges), inland and coastal flooding, sea level rise, permafrost thaw and forest fires are having a significant impact on the built environment in these settings. Regionalization and reduction of services in rural communities forces residents to travel longer distances for services such as medical care and, therefore, to become increasingly reliant on vulnerable transportation networks (e.g., poor, seasonal or non-existent roads, and lack of alternative transportation options). Those responding to emergencies are also at increased risk due to vulnerable rural infrastructure (Nova Scotia Department of Environment and Climate Change, 2018). This makes the consideration of climate change impacts in planning, zoning and land-use decisions vital in reducing risk from climate impacts that adversely affect rural and remote communities (Doberstein et al., 2019).

Box 3.4: Critical and community infrastructure

According to Public Safety Canada, critical infrastructure is "essential to the health, safety, security or economic well-being of Canadians, and the effective functioning of government." Disruptions "could result in catastrophic loss of life, adverse economic effects and significant harm to public confidence." The agency identifies ten sectors of critical infrastructure, including health, information and communication technology, and transportation (Government of Canada, 2020). Examples of community infrastructure include municipal buildings, recreational facilities, schools and grocery stores (Government of Northwest Territories, 2017). Facilities such as recreation or school buildings often have multiple uses and contribute greatly to community functioning and well-being. For example, in Tofino, British Columbia, the community centre has been built with emergency preparedness in mind, containing a generator and supplies to serve people displaced by any emergency event, as well as for hosting regular events, classes and exercise opportunities (Studio 531, 2019). The loss of, or damage to, these facilities can be devastating (Lebel, 2014).

3.5.2 Transportation and energy systems

Transportation infrastructure—including roads, bridges, railways, airstrips, marine shipping routes and trails—are commonly reported in the literature and by community stakeholders as being the most critically the type of infrastructure most dramatically affected by climate change. These impacts are especially pronounced for ice roads. Evidence suggests the length of time that ice roads are viable has already been significantly reduced; in the future, rising temperatures and increased precipitation may be enough to limit the formation

of ice roads of sufficient thickness for the transportation of essential goods and materials in many of the areas that now rely on them (Mullan et al., 2017). Recent projections suggest that damage to infrastructure from climate-related flooding, erosion and permafrost melt is likely to result in the greatest financial costs to communities, and that infrastructure such as roads, bridges, water management facilities and revetment systems are likely to require the most investments (Federation of Canadian Municipalities and Insurance Bureau of Canada, 2019; Federation of Canadian Municipalities, 2018a). Recent research suggests that, among the top priorities for adaptation in rural and remote communities, is the need to address climate change impacts to infrastructure that result in interruptions to residents' daily activities, such as shopping, visiting family and receiving medical treatment (Manuel et al., 2015).

Energy grids and systems are another commonly cited category of rural infrastructure that is negatively affected by climate change, mainly due to failing transmission lines, the high cost of fuel and transportation, and climate-vulnerable transportation routes. Many remote communities across Canada rely solely on diesel power and a grid connection is often not a viable or reliable option; as such, alternatives must be explored, such as natural gas generators and locally generated renewable energy sources (wind energy, solar energy and biomass heating) (Natural Resources Canada, 2018a; Knowles, 2016). Climate change awareness, policies and programs have encouraged the development of new renewable energy projects and other infrastructure aimed at reducing reliance on fossil fuels (Government of Canada, 2017; Province of New Brunswick, 2016).

3.5.3 Regional variation in climate change impacts to infrastructure

While rural and remote communities across Canada are experiencing changing and variable climatic conditions, those located in the northern parts of the country are seeing more pronounced impacts to infrastructure due to rapidly increasing temperatures; changing precipitation patterns; increases in extreme and warm weather events; continued melting of Arctic sea ice, glaciers, and ice caps; rising sea levels; thawing permafrost; and coastal erosion (Bush and Lemmen, 2019; IPCC, 2018). These conditions are already evident and are having serious impacts on infrastructure in northern communities (Berner et al., 2016; Dawson and Levy, 2016; Ford et al., 2015; Boyle et al., 2013).

In more southern regions, rural communities are also concerned about more extreme weather events that cause immediate impacts such as flooding, ice storms and heat waves, and that have the potential to cause damage to critical infrastructure (Félio, 2017; Caldwell, 2015). Rural coastal communities have the added threats of flooding, sea level rise and coastal erosion impacting their infrastructure and lives (Arnold and Fenech, 2017; Vasseur et al., 2017; Manuel et al., 2015; Webster et al., 2014). For example, buildings and services that are instrumental to daily life—such as housing, healthcare facilities, community centres, post offices, grocery stores, and water and wastewater treatment—are increasingly at risk of failure, particularly from flooding and extreme weather events (Félio, 2017). In Atlantic Canada, for example, disruption to these services and access to crucial community infrastructure due to changing climatic conditions is increasing the vulnerability of ageing communities (Krawchenko et al., 2016; Manuel et al., 2015). Rural and remote communities that have one or only a few roads into and out of their communities—found in both coastal and remote regions—are particularly vulnerable to climate change, due to potential isolation when roads are

washed out, which can affect the availability of food and services (Mullan et al., 2017; Krawchenko et al., 2016; Vodden et al., 2012).

3.5.4 Adaptation responses and opportunities

Rural and remote communities have undertaken a number of different approaches to infrastructure adaptation, which are often tailor-made to their specific needs and contexts (*see* Table 3.3; Case Story 3.3). These include assessing the vulnerability of current municipal infrastructure; incorporating climate change into community planning, primarily by updating codes, practices and designs; and constructing new infrastructure with a longer service life (Government of Canada, 2017; Government of Northwest Territories, 2017; Indigenous and Northern Affairs Canada, 2017). Other responses include altering emergency transportation routes, diversifying energy sources, developing local action plans to transition to low carbon economies, and planning for smart growth and sustainable, livable communities. These include communities that facilitate healthy ageing, reduce reliance on daily commuting, and recognize the use of natural infrastructure (such as forests and wetlands) to reduce climate change impacts (Government of Canada, 2017, 2016; Government of Ontario, 2016; Krawchenko et al., 2016; Province of New Brunswick, 2016; Manuel et al., 2015).

Table 3.3: Infrastructure-related adaptation responses in rural and remote communities across Canada

CATEGORIES OF ADAPTATION RESPONSES*	DETAILS ABOUT ADAPTATION RESPONSES	LOCATION(S) WHERE ADAPTATION RESPONSES HAVE BEEN OBSERVED
Green infrastructure and sustainability planning	• Incorporating green infrastructure into new rural planning • Creating age-friendly communities • Designing more compact communities • Transitioning to renewable energy • Designing and implementing waste management plans based on best practices • Increasing government funding for low-carbon initiatives • Incorporating adaptation planning into municipal sustainability plans • Incorporating energy efficiency into building design • Developing strategic planning practices	BC, NB, NL, NS, NU, NWT, ON, YT and at the national-level
Community planning and zoning	• Incorporating climate change into new infrastructure planning • Undertaking floodplain and flood-risk mapping • Improving building standards by drawing on Indigenous Knowledge in building design • Undertaking community-based vulnerability assessments • Building walls and dykes • Strengthening transmission lines • Upgrading treatment facilities	AB, NB, NL, NS, NWT, PEI, QC and at the national-level

CATEGORIES OF ADAPTATION RESPONSES*	DETAILS ABOUT ADAPTATION RESPONSES	LOCATION(S) WHERE ADAPTATION RESPONSES HAVE BEEN OBSERVED
Community planning and zoning (continued)	• Implementing land-use restrictions and considerations • Incorporating "protect, accommodate, retreat or avoid" planning into land-use and zoning considerations	AB, NB, NL, NS, NWT, PEI, QC and at the national-level
Alternative transportation options	• Using rail transport and bicycle paths • Changing shipping times to correspond with changing climate conditions • Implementing changes to emergency transportation routes • Exploring new options to reduce the need for ice roads	NS, NWT, ON and at the national-level
Diversification of energy sources	• Connecting communities to central grids • Exploring the viability of renewable energy sources • Implementing collaboratively designed and installed hybrid renewable energy systems with diesel backup power • Developing stand-alone renewable energy systems	NU, NWT, YT, ON, BC, NL and at the national-level
Use of technology in adaptation	• Creating virtual replicas of fragile, remote and culturally valuable sites • Using multimedia technology to communicate risks from climate change	NB, NU

*Categories of adaptation responses are listed in the order of frequency that they are mentioned in the literature.

For rural and remote coastal communities, adaptations include revetment and building of new walls and dykes to safeguard against high-wave impacts and flooding (Vasseur et al., 2017; Hatcher and Forbes, 2015). Across Canada, rural and remote communities are converting their energy infrastructure by developing renewable energy sources and connecting communities to more centralized grids, where possible (Arriaga et al., 2017; Mortensen et al., 2017). Energy retrofits for homes and municipal facilities, as well as efforts to reduce reliance on fossil fuels for transportation, residential heating and cooking, are adaptation strategies that can also reduce GHG emissions, decrease the stress on fragile infrastructure, such as winter roads, and create cost savings (Climate Action Revenue Incentive Program, 2017; Yukon Legislative Assembly, 2017; Hatcher and Forbes, 2015).

The potential contribution of information and digital media technologies to adaptation in rural and remote communities is also being explored in various ways. For example, the Tantramar Planning District in New Brunswick has utilized information technology-based GIS maps and 3D flood animations to better communicate climate risks related to flooding and infrastructure failure to its residents (Lieske et al., 2014). In other regions, heritage and cultural buildings, trails and sites where physical infrastructure has already failed (or cannot be accessed without risk of injury) are being digitally reconstructed (*see* Section 3.2; Dawson and Levy, 2016).

Although communities are finding innovative ways to adapt, there are challenges that continue to impede progress on climate change adaptation. These include the high costs of infrastructure investment and an already existing infrastructure deficit. For communities with low-average incomes or a limited tax base, measures such as relocating houses due to erosion or building protection walls may not be affordable, so responses are often limited to temporary adaptations (Federation of Canadian Municipalities, 2018b; Vasseur et al., 2017). The lack of climate data, regional climate models, and inadequate and outdated flood-risk mapping, combined with a shortage of trained locals that can work with available climate change information, have led to difficulties in understanding and communicating climate-related risks (Mortensen et al., 2017; Dawson and Levy, 2016). Even where communities are able to access this information, short-term institutional memory can be a concern (Ford et al., 2017, 2013). For example, many northern communities often have high employee turnover rates. When there is a shift in management, large multi-year infrastructure projects may change, be cancelled or be significantly delayed (Ford et al., 2017). Communities require support in building adaptive readiness and establishing the governance, culture and social patterns (also known as “soft infrastructure”) needed to enhance understanding and make “hard” infrastructure investments possible (Pagano et al., 2018). These challenges will be familiar to most communities across Canada. Unfortunately, rural and remote communities often feel exacerbated impacts from these challenges due to their remote locations and the associated transportation and infrastructure limitations and costs.

Case Story 3.3: Adapting to transportation and service disruption in Nova Scotia’s ageing communities

Climate change and extreme weather events (e.g., high winds, storm surges and floods) are causing damage to critical transportation routes, which are necessary for delivering services and for responding to health and

environmental emergencies. At the same time, the Province is projecting increased demand for emergency services due these factors, which is further complicated by the Province's ageing demographic (Climate Change Nova Scotia, 2018a, b; Krawchenko et al., 2016).

In response, provincial-level officials are working with planners and managers to develop strategies for rerouting transportation lanes and updating design standards to ensure that climate change is considered in new projects (Climate Change Nova Scotia, 2018a). Locally, municipal authorities are utilizing flood maps to warn future developers of projected risks from storm surges and associated flooding.

In Annapolis Royal, for example, flood maps identified that the town's fire hall is at risk of being cut off from the rest of the community in the event of projected storm surge flooding (*see* Figure 3.7). The fire department was able to use this information and adapt their emergency response plan, including purchasing a boat and redistributing rescue equipment throughout the community (Natural Resources Canada, 2015).

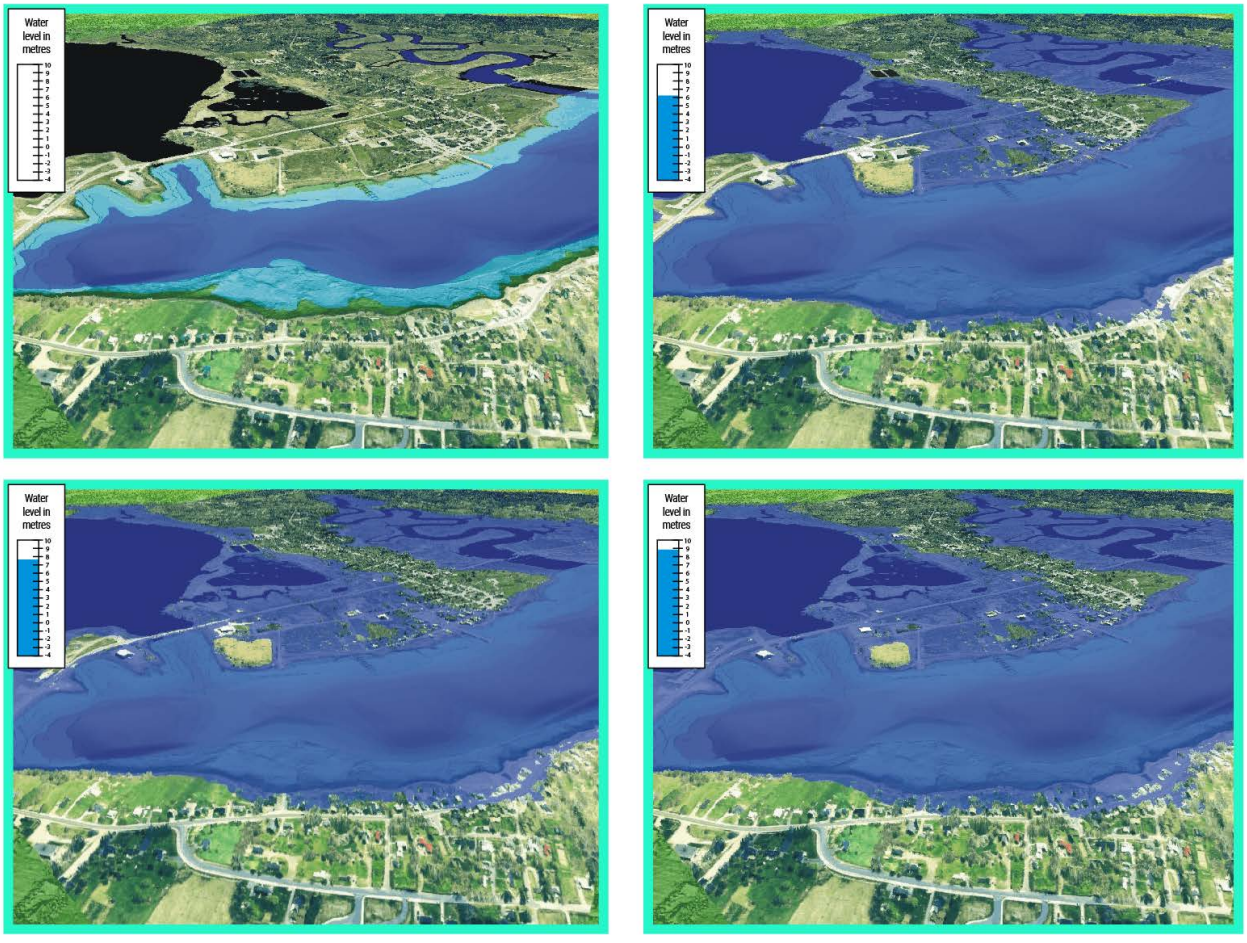

Figure 3.7: Flood-risk mapping in Annapolis Royal, Nova Scotia. Source: Webster et al., 2010.

3.6 Individual and community health and well-being are being negatively affected[2]

In rural and remote communities, health and well-being are strongly influenced by social, cultural and physical environments. Climate change is negatively impacting the health and well-being of individuals and communities, both directly and indirectly. Reducing risk, adapting to climate change impacts and realizing co-benefits from GHG emissions reduction present important opportunities for the health sector.

In rural and remote areas, many individuals and communities have a close connection to the environment; this connection has led to climate change affecting human health and well-being in many ways. Human health challenges linked to climate change in rural and remote communities include challenges with accessing healthy food and water; worsening of existing illnesses and development of new ones; injury or death caused by extreme weather events and changing conditions; and increasing mental health challenges connected to environmental uncertainties. Rural and remote communities have already begun to develop and carry out health-related adaptation plans. For them to continue adapting to the health impacts of climate change, it is important for decision-makers at all levels of government to consider community context, including age, gender, cultural and socioeconomic composition; draw upon and support local knowledge; and view human health within the social, cultural and physical environments of rural and remote areas.

3.6.1 Introduction

In rural and remote areas, human health and well-being are often influenced by the close connection that individuals and communities have to their social, cultural and physical environments (Cunsolo and Ellis, 2018; EPCCARR, 2018; Public Health Agency of Canada, 2017; IPCC, 2014). Many rural and remote communities, particularly Indigenous communities, rely closely on the land for their sustenance, livelihoods and cultural practices, which influences social determinants of health and well-being in a number of ways (Cunsolo and Ellis, 2018; EPCCARR, 2018; Cunsolo Willox et al., 2015; IPCC, 2014). As a result, climate change is leading to both direct (e.g., injury during extreme weather events) and indirect (e.g., poor nutrition caused by changing access to certain foods) effects on the health and well-being of individuals and communities (*see* Figure 2.8; Berner et al., 2016; EPCCARR, 2018; Durkalec et al., 2014; IPCC, 2014).

2 A modified version of this section was published as Kipp, A., Cunsolo, A., Vodden, K., King, N., Manners, S., and Harper, S.L. (2019). Climate Change Impacts on Health and Well-being in Rural and Remote Regions Across Canada: A Synthesis of the Literature. Health Promotion and Chronic Disease Prevention in Canada: Special Issue on Climate Change, 39(4): 22–126. https://doi.org/10.24095/hpcdp.39.4.02.

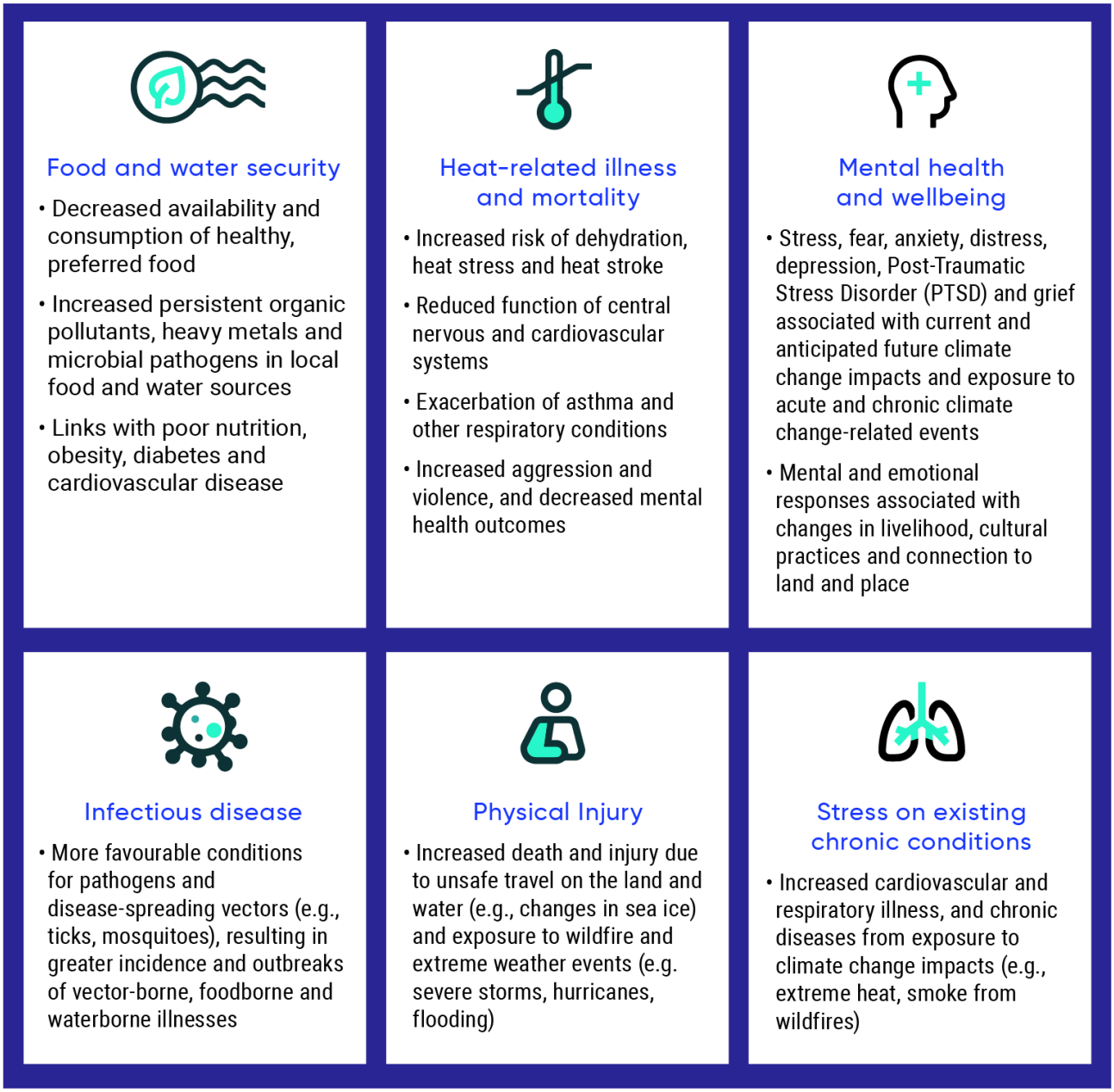

Figure 3.8: Climate change impacts on the health and well-being of individuals living in rural and remote communities.

Examples of negative impacts on individual and community health and well-being in rural and remote areas include increased prevalence and severity of extreme weather events (EPCCARR, 2018; Government of Saskatchewan, 2017; Rapaport et al., 2015; Ford et al., 2014; IPCC, 2014); changes to sea ice, vegetation, fish, wildlife and water (EPCCARR, 2018; IPCC, 2018, 2014; Clark and Ford, 2017; Ford et al., 2014); and weather and environmental uncertainties (Young et al., 2016; Cunsolo Willox et al., 2015; IPCC, 2014). Negative health

outcomes associated with these changes include an increased prevalence of poor nutrition, obesity and diabetes (EPCCARR, 2018; Barbeau et al., 2015; Loring and Gerlach, 2015); vectorborne, waterborne and foodborne disease (EPCCARR, 2018; Loring and Gerlach, 2015; Ford et al., 2014); cardiovascular disease (Barbeau et al., 2015; Loring and Gerlach, 2015; Harper et al., 2011); respiratory issues (Dodd et al., 2018a, b); injury and mortality (Clark and Ford, 2017; Young et al., 2016; Ford et al., 2014); and mental health issues (Cunsolo and Ellis, 2018; Dodd et al., 2018a, b; Government of Northwest Territories, 2017; Cunsolo Willox et al., 2015; Statham et al., 2015). Characteristics of rural and remote areas that may increase sensitivity to these risks include their remote geography and limited transportation infrastructure; reliance on natural resources; under-resourced social and physical infrastructure; limited health system capacity due in part to there being fewer health professionals living and working in these areas; limited health infrastructure and access to health-sustaining resources; and reduced emergency response capacity (EPCCARR, 2018; IPCC, 2014).

Vulnerability to climate change is influenced by the intersection of demographic, social, cultural and political factors in rural and remote communities, as well as individual characteristics and circumstances (EPCCARR, 2018; Drolet and Sampson, 2017; Krawchenko et al., 2016; IPCC, 2014). Furthermore, the literature highlights indigeneity, age, gender and socioeconomic status (*see* Box 3.2) as key factors influencing individual and community vulnerability to climate change in rural and remote communities.

3.6.2 Availability of nourishing, accessible and preferred food and water sources

Many rural and remote communities have experienced changing access to and quality of food and water systems linked to environmental changes such as rising temperatures (Medeiros et al., 2017; Berner et al., 2016; Loring and Gerlach, 2015), changing precipitation patterns and increasing extreme weather events (Dodd et al., 2018a, b; Medeiros et al., 2017; Berner et al., 2016). For example, in many Northern remote First Nations and Inuit communities, climate change-related disruptions to sea ice, wildlife and vegetation impact the ability of individuals to hunt, fish and forage, leading to decreased consumption of healthy and culturally preferred local food and increased reliance on retail food (Dodd et al., 2018a, b; Government of Northwest Territories, 2017; Medeiros et al., 2017; Berner et al., 2016; Loring and Gerlach, 2015). Water security may also be challenging for rural and remote communities, where rising temperatures and more frequent extreme weather events can overwhelm fragile water treatment systems and interrupt the provision of safe drinking water (Medeiros et al., 2017; Berner et al., 2016) (*see* Water Resources chapter). Across Northern Canada—where many communities rely on surface water sources—changes to water levels, run-off, flow regimes and sediment accumulation can seriously affect drinking water availability and quality (Bakaic and Medeiros, 2017; Medeiros et al., 2017). Both food and water insecurity have been linked to negative health outcomes, including poor nutrition, obesity, diabetes, cardiovascular disease, acute gastrointestinal illness and mental health concerns (Berner et al., 2016; Harper et al., 2015; Loring and Gerlach, 2015; Ford et al., 2014).

3.6.3 Infectious disease and exacerbating existing chronic illnesses

Changing precipitation patterns, rising temperatures and increased frequency and severity of extreme weather can also exacerbate chronic illnesses and infectious diseases in rural and remote communities by increasing exposure to environmental contaminants and vectorborne, foodborne and waterborne diseases; putting enhanced stress on underlying chronic conditions (e.g., cardiovascular and respiratory illness) (Dodd et al., 2018b; Public Health Agency of Canada, 2017); and disrupting healthcare provision and chronic disease management (Cunsolo Willox et al., 2015). Research has also documented increased risk of waterborne disease in rural and remote communities due to weather-related contamination events (EPCCARR, 2018; Harper et al., 2015). Changing winds, ocean currents and rivers carrying environmental contaminants in the North may also lead to increased levels of persistent organic pollutants and toxic heavy metals in local food and water sources in remote polar regions (*see* Northern Canada chapter; Medeiros et al., 2017; Berner et al., 2016; Loring and Gerlach, 2015). Consumption of contaminants can result in many health concerns (Medeiros et al., 2017; Berner et al., 2016; Loring and Gerlach, 2015).

3.6.4 Increased risk of injury and mortality

Extreme and rapidly changing weather conditions—including heat waves, storms, droughts, floods and changing sea ice conditions—have had significant negative effects on the health of individuals living in rural and remote communities. For example, wildfires and associated health challenges—such as respiratory issues, mental health stressors and damage to critical health infrastructure—have been identified in forest communities across Canada as a threat to safety and well-being (*see* Case Story 3.4 and Sector Impacts and Adaptation chapter; Dodd et al., 2018a, b; Government of Northwest Territories, 2017; Government of Saskatchewan, 2017). Northern and remote communities have identified increased death and injury from changing weather and sea ice, leading to unsafe or unfamiliar travel conditions and reliance on technologies that can and do fail (e.g., snowmobiles breaking down, navigation systems failing) (Clark et al., 2016a, b).

3.6.5 Impacts on mental health and well-being

As environments change and people adapt to new and often less desirable conditions, the mental health and well-being of individuals living in rural and remote communities is also affected. For example, in Indigenous communities in rural and remote areas of Canada, individuals are often deeply connected to the land for their well-being; as climate change alters the environment, access to places and practices of cultural significance are often disrupted (Cunsolo and Ellis, 2018; Cunsolo et al., 2017; Cunsolo Willox et al., 2015; Ford et al., 2014). For Inuit in Nunatsiavut, for example, these changes have led to increased anxiety, fear, distress, anger, grief and depression related to changes to land-based activities, connection to land, and cultural identity (Cunsolo and Ellis, 2018; Cunsolo et al., 2017; Harper et al., 2015; Lament for the Land, 2014). Regional plans in Manitoba identify the potential loss of livelihoods associated with drought as a climate-sensitive mental

health concern (Government of Manitoba, 2017). In Atlantic Canada, individuals have connected increases in the storm prevalence and severity in rural coastal communities and subsequent damage to important infrastructure with mental health challenges, which often differs by gender (Vasseur et al., 2015).

3.6.6 Adaptation responses and opportunities

Despite these challenges, focusing on climate change adaptation, risk reduction and realizing co-benefits from GHG emissions reduction presents an important opportunity for the health sector. Already, many rural and remote communities in Canada have begun to develop and implement health-related adaptation strategies (*see* Table 3.4). To support adaptation to the health effects of climate change, recommended changes to existing adaptation strategies include:

- using multiple knowledge systems that are specific to sociocultural contexts;
- addressing non-climatic factors impacting adaptation;
- utilizing innovative forms of technology;
- improving and integrating health surveillance with environmental monitoring;
- supporting sustainable development practices;
- enhancing awareness of risks and response;
- expanding knowledge of climate change impacts; and
- developing the capacity of the health sector to respond to climate change.

Ultimately, for rural and remote communities to continue adapting to the health impacts of climate change, it is important to consider specific local and regional, economic and geographic elements; support and draw upon existing expertise of individuals and communities in rural and remote areas in Canada; and continue viewing human health within the social-cultural and physical environments of rural and remote communities.

Table 3.4: Examples of existing and potential adaptation strategies to negative health effects of climate change in rural and remote communities across Canada

EXAMPLES OF EXISTING ADAPTATION STRATEGIES	REFERENCES
Introducing local food production systems	Government of Northwest Territories, 2017; Barbeau et al., 2015; Loring and Gerlach, 2015
Using experience-based knowledge of local communities to support community resilience	Cunsolo and Ellis, 2018; Cunsolo Willox et al., 2015; Ford et al., 2014
Developing community-based monitoring programs and research to gather data about environment and health to inform decision-making	Dodd et al., 2018; EPCCARR, 2018; Berner et al., 2016; Cunsolo Willox et al., 2015; Harper et al., 2015
Using Indigenous and local knowledge about the physical environment to support hazard avoidance and emergency preparedness	Clark and Ford, 2017; Young et al., 2016; Ford et al., 2014
Utilizing a social development approach—which involves health professionals, social workers and people working in caring professions that support those directly impacted by climate change—to strengthen community capacity	Drolet and Sampson, 2017
Fostering protective factors for physical and mental health through connection to land-based activities, cultural arts and crafts, and opportunities for bringing community together	Cunsolo et al., 2017
Using local knowledge, Indigenous Knowledge and/or scientific knowledge to adapt in a way that responds to specific local sociocultural contexts	Drolet and Sampson, 2017; Government of Northwest Territories, 2017; Berner et al., 2016; Ford et al., 2014

EXAMPLES OF POTENTIAL ADAPTATION STRATEGIES	REFERENCES
Eliminating social barriers to adaptation (e.g., poverty, inequality, housing concerns, etc.) and reducing non-climatic factors (e.g., chronic disease)	EPCCARR, 2018; Drolet and Sampson, 2017
Utilizing innovative forms of technology (e.g., telehealth, mobile monitoring applications, satellite imagery)	EPCCARR, 2018; Government of Northwest Territories, 2017
Improving public health surveillance and furthering monitoring programs	EPCCARR, 2018; Bakaic and Medeiros, 2017; Medeiros et al., 2017; Berner et al., 2016; Province of New Brunswick, 2016; Young et al., 2016; Barbeau et al., 2015; Durkalec et al., 2015; Ford et al., 2014
Supporting sustainable development practices (e.g., clean energy programs)	Drolet and Sampson, 2017; Government of Northwest Territories, 2017; Province of New Brunswick, 2016; Ford et al., 2014
Enhancing communication and awareness of risks and responses (e.g., lists of safe spaces, pamphlets regarding disease outbreaks, developing outreach strategies)	Dodd et al., 2018; EPCCARR, 2018; Government of Northwest Territories, 2017; Province of New Brunswick, 2016; Ford et al., 2014
Expanding knowledge of climate change impacts on health through research and investment, and sharing best practices for public health adaptation	EPCCARR, 2018; Government of Northwest Territories, 2017; Province of New Brunswick, 2016
Developing the capacity of health systems and emergency response to withstand and respond to climate risks (e.g., creating technical guidance and training courses, integrating climate change into medical and public health training)	Government of Northwest Territories, 2017; Young et al., 2016

Case Story 3.4: Coping with the health impacts of wildfire in the Northwest Territories

In the Northwest Territories, the summer of 2014 was one of the worst wildfire seasons on record, with prolonged smoke events and poor air quality. A study exploring the experiences of individuals in four subarctic communities found both short- and long-term effects of prolonged smoke exposure and isolation on their physical, emotional and mental health (Dodd et al., 2018a, b). While the prolonged smoke events were linked to extended time indoors and respiratory problems, interviewees also reported that their experiences of evacuation and isolation, as well as feelings of fear, stress and uncertainty, negatively impacted their mental and emotional well-being. In many cases, land-based activities were also impacted, with implications for individual and community well-being. Interviews also revealed that communities developed adaptation strategies that included educational workshops and physical activity programs to help reduce health risks. Nevertheless, there is a clear need for improved coordination and communication at the local and territorial level to better prepare for future wildfire events and reduce resulting health-related impacts.

3.7 Climate change is resulting in intangible losses and damages

Climate change impacts are leading to a wide range of intangible losses and damages in many rural and remote communities and areas, including the loss of identity, cultural continuity and sense of place. These intangible losses and damages are expected to be widespread and cumulative, and are critical to consider in climate change adaptation and policy.

In rural and remote areas, individuals and communities often have strong social and cultural connections to the environment. As a result, when the climate changes, individuals and communities in rural and remote areas can face impacts on their identity, culture and sense of place. Climate change is contributing to these losses and damages through several pathways, including shifts in cultural practices and identity; changes to the social fabric of rural and remote communities; and damages and destruction to both landscapes and spaces of cultural and social importance. Adaptation to these negative impacts has already begun as individuals and communities come to understand the links between climate change and identity, culture and place. As places of social and cultural importance shift in new ways, more research is needed on how these changes will affect the cultural and social fabric of communities, including cultural practices and identities, sharing and social ties, and place meaning and connection.

3.7.1 Introduction

Individuals and communities living in rural and remote communities and areas often have a strong social and cultural ties to their environments, which influence identity, cultural continuity and sense of place in numerous ways. Examples of this connection to place can be seen in remote Indigenous communities across Canada, where many individuals rely on the land for their culture and well-being, and practice land-based cultural activities including hunting, fishing and berry picking (Cunsolo Willox et al., 2015, 2013a, b, 2012; Harper et al., 2015; Loring and Gerlach, 2015; Pearce et al., 2015; Ford et al., 2014). It is also seen in rural areas throughout the prairies, where individuals in agricultural communities often have a strong heritage associated with farming and daily personal interactions with their land (McMartin and Merino, 2014). Place-based connection is also reflected in other rural and small-town communities—such as coastal and forest communities—where individual and group identities are often tied to local landscapes and reliance on natural resources (Dodd et al., 2018a, b; Vasseur et al., 2017).

Climate change and associated environmental impacts are leading to wide-ranging intangible losses and damages in many rural and remote communities (*see* Figure 3.9; Cunsolo and Ellis, 2018; Cunsolo Willox et al., 2015, 2013a, b, 2012). Specifically, recent studies have explored how climate change is disrupting cultural practices associated with the land (e.g., hunting, sewing, travelling on sea ice, etc.) (Cunsolo Willox et al., 2015, 2013a, b, 2012; Loring and Gerlach, 2015; Pearce et al., 2015; Ford et al., 2014); altering the inter-generational transmission of Indigenous Knowledge (Cunsolo Willox et al., 2015, 2013a, b, 2012; Durkalec et al., 2015; Ford et al., 2014); limiting access to places of cultural significance (e.g., hunting camps, sources of fresh water, etc.) (Government of Northwest Territories, 2017; Cunsolo Willox et al., 2015, 2013a, b, 2012); and damaging or destroying landscapes and sites of cultural and social significance (e.g., heritage and archeological sites) (Vasseur et al., 2017; Dawson and Levy, 2016). These climate-related changes are further exacerbated by non-climatic changes that also affect identity, cultural continuity and sense of place, which include ageing populations, rural to urban outmigration and the adoption of labour-saving technologies.

Although the impacts of climate change on identity, cultural continuity and sense of place are experienced differently by each individual and community, prominent themes include shifts in cultural practices and identity; the changing social fabric of rural and remote communities; and the damage and destruction of landscapes and sites of cultural and social significance.

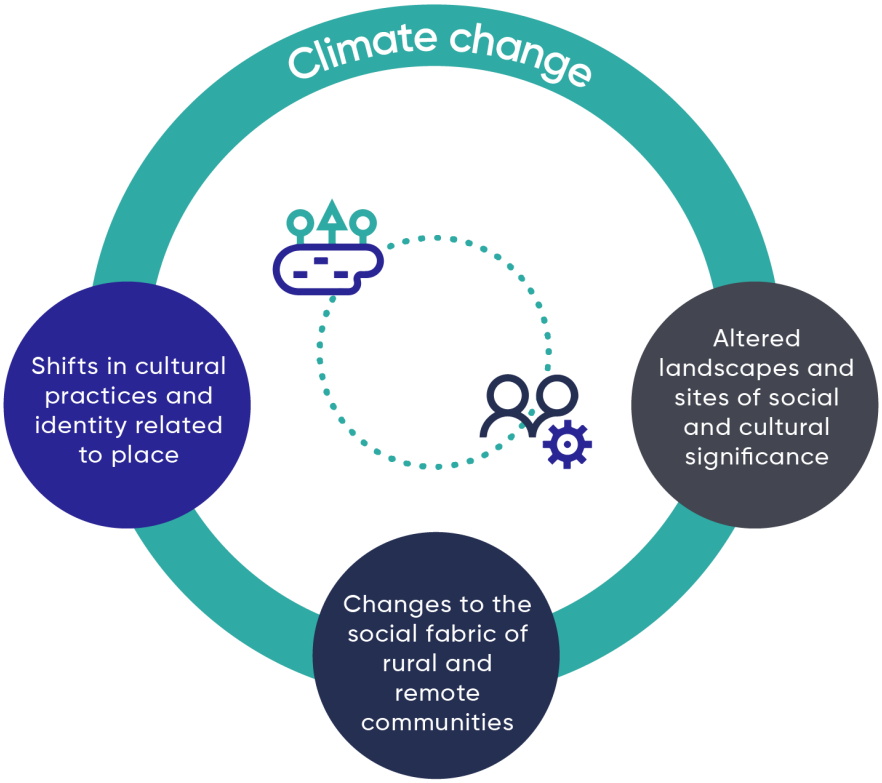

Figure 3.9: Summary of the intangible losses and damages of climate change on identity, cultural continuity and sense of place in rural and remote communities and areas in Canada.

3.7.2 Shifting cultural practices and identity related to place

The deep connections that individuals and communities in rural and remote areas share with their natural environments mean that many of their cultural practices are strongly connected to the land. For example, in many remote Inuit communities, spending time on the land and engaging with land-based activities hold important cultural and spiritual value; contribute to Inuit identity and cultural autonomy; and provide opportunities for the inter-generational transmission of knowledge (Clark et al., 2016b; Cunsolo Willox et al., 2015, 2013a, b, 2012; Durkalec et al., 2015; Harper et al., 2015; Pearce et al., 2015). Changing climatic conditions that alter the natural environment—such as changes to harvesting seasons, wildlife and plant species, traditional medicines and waterways—have the potential to disrupt cultural practices in a number of ways (Province of New Brunswick, 2016; Cunsolo Willox et al., 2015, 2013a, b, 2012; Harper et al., 2015).

Indigenous communities in rural and remote areas are at particular risk of experiencing cultural changes as a result of climate change. For example, climate change has impacted culturally important subsistence activities in many Indigenous communities, such as hunting, fishing, trapping, berry-picking, water collection, and subsequently the consumption of culturally significant food and water (Boulanger-Lapointe et al., 2019;

Archer et al., 2017; Government of Northwest Territories, 2017; Cunsolo Willox et al., 2015, 2013a, b, 2012; Harper et al., 2015; Pearce et al., 2015; Ford et al., 2014; Hanrahan et al., 2014). Such activities are altered as changes—including thinning sea ice, warming temperatures and increased storm prevalence—occur and impact the ability of Inuit to spend time on these changing landscapes (EPCCARR, 2018; Clark et al., 2016b; Cunsolo Willox et al., 2015, 2013a, b, 2012; Durkalec et al., 2015; Odland et al., 2015; Pearce et al., 2015; Ford et al., 2014).

Climate change is also impacting the ability of Indigenous Knowledge holders and Elders to use their knowledge on the land in rural and remote areas, since past knowledge becomes less applicable to current conditions (Government of Northwest Territories, 2017). These changes are altering place meanings and attachment, decreasing transmission of knowledge, eroding land-based skills and disrupting cultural identity and continuity (Clark et al., 2016b; Cunsolo Willox et al., 2015, 2013a, b, 2012; Durkalec et al., 2015; Pearce et al., 2015; Ford et al., 2014). There is limited research in a Canadian context regarding the impacts of climate change on the cultural practices of individuals and communities in rural and remote areas more broadly (e.g., in agricultural, coastal, forest and mountain communities). However, international literature indicates this is an important area of concern (Cunsolo and Ellis, 2018; Casanova-Pérez et al., 2016; Hall et al., 2016; Cunsolo Willox, 2012; Wolf et al., 2012). Thus, more research and engagement are needed to further explore the cultural dimensions of climate change in rural and remote communities across Canada.

3.7.3 Changes to the social fabric of rural and remote communities

Climate change is also influencing the social fabric of rural and remote communities, which includes the people living in these areas, interactions between people and the distribution and use of social spaces and services (Krawchenko et al., 2016). An example of climate change altering the social dimensions within communities can be seen in Saskatoon's Swift Current Creek Watershed, where drought associated with climate change has led to both economic and social stressors (McMartin and Merino, 2014). The socioeconomic structure of rural and remote communities—which may include a gendered-stratified workforce, declining economies, low levels of education, youth migration, distance from decision-makers and reliance on natural resources—may heighten the vulnerability of individuals and communities to the negative social effects of climate change (Vasseur et al., 2015). For example, in the rural coastal community of Ste. Flavie, Quebec, storm damage associated with climate change was identified as enhancing social stress in the community and corresponded with an increase in the out-migration of youth and families, as well as familial tensions and interpersonal conflict (Vasseur et al., 2015). In Rigolet, Nunatsiavut, shifts in weather, ice and seasonal patterns led to increased family and community stress, with concerns for increased family violence (Cunsolo Willox et al., 2013a).

In addition to disrupting cultural practices, climate change and associated stresses and challenges have resulted in the fragmentation of previously robust social networks and a loss of social capital in many rural and remote communities (EPCCARR, 2018; Medeiros et al., 2017). Rural and remote Indigenous communities, in particular, are disproportionately burdened by the social impacts of climate change, which exacerbate existing socioeconomic challenges such as issues with service provision and limited economic opportunities (EPCCARR, 2018; Picketts et al., 2017). In rural and remote communities more broadly, individuals with

limited social capital and a lack of access to resources are often more at risk to the adverse effects of climate change (EPCCARR, 2018; Krawchenko et al., 2016).

Climate change in rural and remote areas has also influenced the social structure of communities in terms of gender roles. In agricultural communities in Saskatchewan, for example, a study found that environmental crises further entrench traditional conceptions of women's roles on farms, positioning men as the primary "farmer" and women as "caregivers, helpers and supporters," and assigning women less agency over climate change adaptation strategies (Women's Environment and Development Organization, 2018). Similarly, in forestry communities in Western Canada, women's marginal economic and social positions have influenced their vulnerability to changing climatic conditions (Williams et al., 2018; Reed et al., 2014). In Clyde River and Qikiqtarjuaq, Nunavut, climate change-related impacts to the accessibility of wildlife have resulted in shifts to women's primary economic roles in traditional food preparation and handicraft production (e.g., sewing of sealskin), with negative economic impacts for them and their communities, as well as important social and cultural impacts (Williams et al., 2018).

3.7.4 Loss and damage to landscapes and sites of cultural and social significance

Cultural landscapes and places of cultural and social significance, such as archeological and heritage sites, often contribute to a sense of place and cultural continuity for the individuals and communities connected to these places. In many rural and remote communities across Canada, climate change impacts—such as coastal erosion, changing precipitation patterns, increased forest fires and changes to freeze-thaw cycles—are contributing to the destruction of these sites, leading to irreversible loss and damages (Clarke and Clarke, 2018; EPCCARR, 2018). In rural and remote communities, such sites are at particular risk due to geographic locations, existing concerns with ageing infrastructure and limited resources for risk reduction and adaptation (EPCCARR, 2018). Furthermore, it is challenging to adapt to climate change by altering cultural landscapes or relocating heritage or archeological sites as their value is often tied directly to place; once these places are lost, they cannot be recovered (Clarke and Clarke, 2018; EPCCARR, 2018; Government of Canada, 2016).

In rural and remote coastal communities, climate change impacts such as sea level rise, loss of sea ice, storm surges, increased wind speeds and coastal erosion are directly damaging sites of cultural and social importance (Clarke and Clarke, 2018). In rural Nova Scotia, for example, a study examining climate change impacts on elderly populations found that flooding related to storm surges and changing precipitation patterns was negatively impacting social spaces and assets in the community that are important for daily routine and social engagement (Manuel et al., 2015). Increased winds and storm surges have also contributed to the deterioration of structures along the coast (e.g., lighthouses, piers), as well as natural heritage and landscapes (e.g., blown-down trees and loss of beaches and dunes) (Clarke and Clarke, 2018). Similarly, in Arctic and Subarctic regions, climate change impacts have destroyed rich archaeological records, natural and constructed heritage sites, and landscapes of cultural and social significance (Government of Northwest Territories, 2017; Andrews et al., 2016; Dawson and Levy, 2016).

In Northern regions, specific climate change concerns include the melting of sea ice and permanent snow pack; severe ice and snow storms; and a more dramatic rise in temperatures (Clarke and Clarke, 2018;

Government of Northwest Territories, 2017; Andrews et al., 2016). Fort Conger in Nunavut (*see* Section 3.2) and other heritage sites in the Arctic have been damaged by the accumulation of ice, snow and water; strong winds; increased freeze-thaw cycles; and the increased presence of fungi and subsequent rot supported by warming Arctic temperatures (Clarke and Clarke, 2018; Dawson and Levy, 2016). Changing temperatures, including both heat and cold extremes, also have potential to influence local extinction of wildlife and plant species that are important aspects of natural heritage (Clarke and Clarke, 2018). Changing climatic conditions have altered important landmarks used by Indigenous harvesters along travel routes and disrupted access to places of cultural, social, spiritual and emotional significance (Andrews et al., 2016). Although there is a gap in understanding about the full impacts related to the destruction of social and cultural sites throughout Canadian rural and remote communities, preserving these cultural assets can be seen as a symbol of resilience and community stability in rapidly changing times (Clarke and Clarke, 2018; Government of Northwest Territories, 2017).

3.7.5 Adaptation responses and opportunities

The intangible losses and damages of climate change on identity, cultural continuity and sense of place associated with climate change are widespread and cumulative, and will be critical to consider in climate change adaptation. Despite numerous challenges, adaptation to these negative impacts has already begun as individuals and communities in rural and remote areas identify how climate change impacts the interconnectedness and importance of identity, culture and place (*see* Table 3.5; Case Story 3.5). In many rural and remote Indigenous communities in Northern Canada, for example, the importance of drawing on Indigenous Knowledge, sharing networks and inter-generational transmission of knowledge has been highlighted as key to adaptation (Archer et al., 2017; Fawcett et al., 2017; Durkalec et al., 2015; Pearce et al., 2015; Statham et al., 2015). In rural prairie communities, agricultural producers have recognized the vital role of community, social and natural capital, and the need to respond collectively to climate change (Sauchyn, 2017). Moreover, in coastal communities in Atlantic and Northern Canada, where communities have identities that are strongly tied to cultural landscapes and sites of sociocultural significance, strategies to preserve and maintain at-risk sites are currently being explored (Clarke and Clarke, 2018; Government of Northwest Territories, 2017).

Table 3.5: Examples of existing and future adaptation strategies to address the impacts of climate change on identity, cultural continuity and sense of place in rural and remote communities across Canada

EXISTING ADAPTATION STRATEGIES	REFERENCES
Using technology to mobilize knowledge about sites of cultural and social significance that are at risk due to climate change can help gain support for preserving them.	Dawson and Levy, 2016

EXISTING ADAPTATION STRATEGIES	REFERENCES
Increasing technological capacity to address unpredictable conditions.	Archer et al., 2017; Fawcett et al., 2017
Community development programs focused on mobilizing local knowledge by drawing on local culture, skills and resources.	Drolet and Sampson, 2017
Using Indigenous Knowledge—including learned and land-based skills, experiences and group memory—to support flexibility and innovation in hunting (e.g., adapting seasonal cycles to hunt what is available); hazard avoidance; and emergency preparedness.	Fawcett et al., 2017; Cunsolo Willox et al., 2015, 2013a, b, 2012; Durkalec et al., 2015; Harper et al., 2015; Pearce et al., 2015
Social networks, community sharing, intercommunity trade and fostering social capital (e.g., sharing of food, equipment and knowledge when individuals are in need; delivering skills-based workshops).	Archer et al., 2017; Durkalec et al., 2015; Pearce et al., 2015; Statham et al., 2015
Building community resilience by creating a climate change action plan that draws from social networks, experiences, diversity, consensus building and culturally relevant tools.	Clarke and Clarke, 2018
Resurgence of Indigenous ceremonies, practices and values.	EPCCARR, 2018

POTENTIAL ADAPTATION STRATEGIES	REFERENCES
Integrating the geographical, social and cultural context of a community, as well as risks posed by climate change, in policy may improve relevancy and help to avoid maladaptation.	Drolet and Sampson, 2017; Ford et al., 2017; Krawchenko et al., 2016; Manuel et al., 2015
Inclusive design may contribute to recognizing the interdependency of social, economic and environmental considerations for adaptation, including social demographics (i.e., age, gender, socioeconomic status).	Drolet and Sampson, 2017; Rapaport et al., 2015; Vasseur et al., 2015
Developing and supporting adaptation strategies in Indigenous communities that are rooted in cultural values and Indigenous Knowledge can contribute to climate resilience (e.g., engaging community leaders and Elders).	Archer et al., 2017; Ford et al., 2017, 2014; Pearce et al., 2015; Gill and Lantz, 2014

POTENTIAL ADAPTATION STRATEGIES	REFERENCES
Developing new modes of knowledge mobilization through co-production of knowledge; creating adaptation tools and messaging that provide concrete practical advice; and creating incentives for implementation.	Ford et al., 2017; Reed et al., 2014
Establishing community-based environmental monitoring to encourage the protection of the land.	Government of Canada, 2016; Gill and Lantz, 2014
Incorporating culturally relevant and locally appropriate materials into education, programming and services; developing targeted education and knowledge transfer (e.g., teaching equipment and operability).	Clark et al., 2016a, b; Ford et al., 2014
Strengthening local autonomy in decision-making.	Ford et al., 2014
Strengthening land-based learning and inter-generational knowledge sharing.	Government of Northwest Territories, 2017; Ford et al., 2014
Considering cultural value and cultural identity in terms of long-term benefits to the community.	Clarke and Clarke, 2018
Establishing interdisciplinary teams to make decisions about preserving and maintaining heritage and sites of sociocultural significance.	Clarke and Clarke, 2018
Prioritizing excavating and collecting information from archaeological sites at greatest risk from climate change impacts.	Government of Northwest Territories, 2017
Potentially moving sites and structures of cultural and social significance to protect them from climate-related risks.	Clarke and Clarke, 2018; Government of Northwest Territories, 2017

A strong sense of culture has been identified as a protective factor moderating exposure to climate-related risks and plays a crucial role in influencing adaptive capacity (Cunsolo et al., 2017; Ford et al., 2014). Although many rural and remote communities have traditional cultural practices, culture is dynamic. For example, in Dawson Creek, British Columbia—where local cultural identities of self-sufficiency are closely tied to a heritage of farming—the community has used climate change adaptation to promote a renewed community identity around sustainability and energy independence, including through the creation of the Bear Mountain Wind Farm (Shaw et al., 2014). Ultimately, existing social capital in rural and remote communities, such as strong social networks and place-based knowledge systems, are key to adaptation (Furness and Nelson, 2016). As places of social and cultural significance shift in unprecedented ways, more research is needed on how these changes will alter the cultural practices and social fabric of communities.

Research indicates that intangible climate change impacts, such as adverse effects on culture or social capital, stem from direct impacts, as well as strategies for adaptation and GHG emissions reduction. In the movement towards clean energy, for example, the banning of a coal mine in the rural town of Atikokan, Ontario led to layoffs for approximately 90 individuals that worked for the power plant, with resulting adverse effects on the social fabric of the community (Dampier et al., 2016). Alternatively, as seen in the First Nations community of Fort Albany, Ontario, strategies for adaptation, risk reduction and GHG emissions reduction have promoted social cohesion and sharing (Barbeau et al., 2015). In this subarctic community, where local food systems have been introduced as a way of combating food insecurity, the act of gardening has strengthened family ties and provided space for knowledge transfer between generations (Barbeau et al., 2015). New forms of social networks can also help to strengthen social connections, such as using social media to identify individuals at risk during extreme weather events and to facilitate food and equipment sharing (Archer et al., 2017).

Case Story 3.5: Supporting Inuit wellness, strength, resilience and cultural continuity in Nunatsiavut, Labrador

Inuit throughout Inuit Nunangat (Inuit homelands) are at the forefront of a rapidly changing climate and environment. As a result, a priority of many Inuit communities is to develop strategies to support community wellness, foster livelihoods, maintain cultural values, enhance resilience, and preserve and promote cultural continuity. Responding to these stressors and needs, and building on previous research conducted in the region, the Inuit communities of Nunatsiavut, Labrador have been actively designing research and evidence-based programs to support Inuit wellness, strength, resilience and cultural continuity.

For example, communities in Nain and Hopedale established the Aullak, Sangilivallianginnatuk (Going Off, Growing Strong) program to bring youth and experienced harvesters together to support social and cultural connections, and community food security. The Inuit Community Governments of Rigolet, Makkovik and Postville in the Nunatsiavut region of Labrador designed and piloted the IlikKuset-Ilingannet (Culture-Connect!) program (Cunsolo et al., 2017; IllikKuset-Illingannet Team, 2014). This program was premised on the Inuit relational epistemology of piliriqatigiinniq (“working in a collaborative way for the common good”) and united youth with adult mentors to learn cultural skills, including trapping, snowshoe-making, carving, art and sewing.

Both programs supported hands-on knowledge transmission; created new or enhanced relationships between and among the youth and mentors; revitalized cultural pride and well-being; promoted cultural preservation and promotion; and showed promise as a strategy for supporting cultural sustainability and resilience to change. This resonates with the growing emphasis on Indigenous-led programs that support cultural preservation, promotion, reclamation and resurgence, and contribute to a holistic understanding of, and strategies for, Northern sustainability.

3.8 Local participation in adaptation decision-making improves outcomes

Enhancing governance capacity and decision-making related to climate change adaptation in rural and remote communities requires access to additional resources, information and support. Decision-making processes related to adaptation programs and policy can be made more effective through greater participation of local residents and organizations, inclusion of local and Indigenous Knowledge, and consideration for the specific circumstances of rural and remote communities and areas.

Governments, civil society organizations, academic institutions and businesses are addressing climate change in various ways, including through planning, policy and program development. Access to resources, information and technical support have enhanced adaptive capacity in some rural and remote communities; however, further support in the form of region-specific information, trained personnel such as planners and engineers, and funding sources are needed to address adaptation planning and implementation requirements, and limited local governance capacity. Coordination among actors—including government agencies at all levels—is also critical, while recognizing the need for place-based planning and responses.

3.8.1 Introduction

Rural and remote governance structures at multiple levels and across many sectors are facing challenges due to a changing climate (*see* Box 3.5), and are attempting to respond to these challenges and associated opportunities (Northwest Territories Legislative Assembly, 2018; Government of Canada, 2017; Hurlbert and Pittman, 2014; McMartin and Merino, 2014). Climate change impacts are affecting not only planning and policy, but also infrastructure and service delivery—particularly during emergencies and related to community and economic development, and the governance of lands and natural resources.

Box 3.5: The governance of adaptation

Governance is understood as the ways in which government and non-government actors organize themselves to respond to societal problems or new opportunities, including establishing and shaping formal and informal institutions to help guide such responses. Adaptation governance, more specifically, refers to the combined efforts of these various actors to adapt to climate change. Efforts include the institutions, policies, plans and strategies that are formed or used to tackle adaptation issues, ideas of how adaptation should be undertaken and governed, and decisions that are made—such as the identification of problems, and mechanisms used for implementation and enforcement (Huitema et al., 2016).

3.8.2 The need for a collaborative approach to governance

All levels of government are playing a role in responding to climate change within rural and remote communities (*see* Table 3.6). Current research highlights the importance of federal, provincial and territorial levels of governments, as well as Indigenous governments and organizations, and international intergovernmental initiatives in supporting rural and remote communities in their adaptation efforts. It is essential that institutionalized knowledge and research institutions meaningfully engage with local and Indigenous Knowledge holders and citizen scientists to better understand and respond to the challenges of climate change. Creating and setting new policies, legislation, funding, training and technical assistance programs are important tools used by these governments and organizations (Government of Northwest Territories, 2016; Hurlbert and Pittman, 2014).

Table 3.6: Governance processes related to climate change adaptation in rural and remote communities across Canada

ADAPTATION GOVERNANCE PROCESSES	LOCATIONS OBSERVED*	LEVELS OF GOVERNMENT INVOLVED*	OTHER ACTORS INVOLVED*
Policy-setting and implementation: Legislative changes; devolution of planning powers to municipalities; development of community charters; social policy development; climate change strategic frameworks; and the Pan-Canadian Framework on Clean Growth and Energy.	BC, NS, NU, ON, SK and at the national level	Local/municipal, provincial/ territorial, federal, international	Academic/ research, NGOs (non-governmental organizations)
Planning: Climate change adaptation planning; waste management plans; development of disaster risk management strategies; transportation planning; energy planning; integration of health planning and climate change watershed planning; and community planning.	BC, NB, NL, NWT, ON, QC, YT and at the national level	Local/municipal, Indigenous, Tribal Council, provincial/ territorial, federal, international	Academic/research, NGOs, private sector, industry

ADAPTATION GOVERNANCE PROCESSES	LOCATIONS OBSERVED*	LEVELS OF GOVERNMENT INVOLVED*	OTHER ACTORS INVOLVED*
Program development and implementation: Implementation of adaptive management programs; pilot adaptation initiatives; training; supporting beneficial management practices; and other actions.	AB, BC, MB, NWT, ON, QC, SK, YT and at the national level	Local/municipal, Indigenous, provincial/ territorial, federal, international	Academic/research, NGOs, private sector, industry
Information gathering and sharing: Development of risk assessment tools; information gathering; monitoring and evaluation; information sharing; research; and public engagement.	BC, MB, NB, NL, NWT, PEI, QC, SK and at the national level	Local/municipal, Indigenous, provincial/ territorial, federal, international	Academic/research, NGOs, private sector, industry

*As noted in recent literature that has been identified and reviewed.

Civil society organizations, including NGOs, as well as research institutions and the private sector are also playing crucial roles. Many governments are facilitating and fostering relationships with NGOs to assist with the implementation of adaptation initiatives (Drolet and Sampson, 2017; Caldwell, 2015). Civil society organizations, along with Indigenous and municipal governments, are taking on important roles in adaptation by providing place-based solutions to climate change impacts at the local and regional level. One way that adaptation is being addressed is through collaborative watershed management, where a range of different stakeholders (e.g., governments, local public health, local conservation, landowners, community groups, etc.) work together to protect a transboundary area (Healthy Lake Huron, 2019). For example, in British Columbia, watershed organizations such as the Similkameen Valley Planning Association, Fraser Basin Council, Nechako Watershed Alliance and Columbia Basin Trust are working with governments at all levels and post-secondary, business and community partners to conduct climate change- and adaptation-related research, planning, education and monitoring (*see* Case Story 3.6; Horning et al., 2016a, b; Picketts et al., 2017).

Local governments and organizations in rural and remote areas—in collaboration with provincial, territorial and federal partners—are developing community-, regional- and sector-specific adaptive management plans and strategies to address climate variability and uncertainty (Warren and Lemmen, 2014; McMartin and Merino, 2014). For example, recent projections include increases in average temperature, climate variability, droughts and soil degradation in the prairie region (Bush and Lemmen, 2019), creating great uncertainty for agricultural communities. Acknowledging that adaptation depends on both the availability of resources and the capacity to utilize them, the Canada-Saskatchewan Farm Stewardship Program and Farm and Ranch Water Program were created to provide support to agricultural producers to adapt to environmental risks (Hurlbert and Pittman, 2014) (*see* Case Story 3.2). Similarly, in British Columbia, the Agriculture and Food

Climate Action Initiative was created by the BC Agriculture Council in cooperation with federal and provincial governments to develop tools and resources that will help the agriculture sector to be more resilient in dealing with climate change (BC Agriculture and Food Climate Action Initiative, 2018).

Climate change is straining the ability of existing governance structures and institutions to respond to the social, economic, cultural and environmental impacts faced by many rural and remote communities. In light of these challenges, civil society organizations, research institutions and local businesses have emerged to fill vital gaps. Their efforts are helping to turn research, funding and expertise into practical adaptation planning within communities. To this end, rural and remote communities are engaging in a number of formal and informal governance processes that include multiple agencies in adaptation planning, policies and programs to enhance local decision-making capacity, public engagement and action (Blanco et al., 2015; Schroth et al., 2015).

3.8.3 Responding to governance challenges

Climate change poses significant governance challenges. Although collaborative forms of adaptation governance are increasingly recommended, they require considerable intergovernmental and multi-stakeholder coordination efforts (Auditor General of Canada, 2018). Responding to climate change in rural and remote communities is increasingly complex, as the associated roles and responsibilities are spread across multiple agencies, organizations and levels of government. Uncertainties related to ownership and responsibility for service delivery may have sometimes resulted in an inability to adequately respond to environmental emergencies across the country, such as floods and heat waves, which is indicative of the challenges associated with coordination (Caldwell, 2015).

There is also concern that current forms of adaptation governance may further encourage or support the downloading of additional responsibility from senior levels of government to already stretched local institutions, without their agreement and/or additional required resources. For instance, many of the provincial mechanisms for addressing climate-related disasters in rural and remote communities have been structured to rely heavily on local volunteers and community members—many of whom may come from vulnerable or marginalized populations and face heightened risks associated with natural disasters, unemployment or even forced migration, for example, and may already be dealing with personal impacts related to livelihoods, healthcare and housing (Drolet and Sampson, 2017; Caldwell, 2015). For Indigenous communities, the development of collaborative governance approaches requires particular care, trust-building and acknowledgement of Indigenous rightsholders, given Canada's colonial legacy and its impacts on relationships and adaptive capacity (Archer et al. 2017; Pearce et al., 2015).

In addition to overcoming institutional legacies and the need for coordination, other challenges exist in developing local adaptation strategies (*see* Table 3.7; Climate Action Revenue Incentive Program, 2017; Yukon Legislative Assembly, 2017). Incomplete information or lack of research and evidence represents an ongoing challenge for rural and remote communities that are hoping to begin adaptation planning. While some communities in these regions have created partnerships with academic institutions and other organizations to address gaps in data collection, problem identification, monitoring and evaluation of adaptation options, these institutions are often located outside of rural and remote areas. As a result, these institutions are

not always easily accessible to citizens residing in rural and remote areas who are seeking to understand, respond and adapt to climate change impacts (Harneet and Lantz, 2014). Further complicating the issue is the need for locally appropriate information, which is often lacking.

Table 3.7: Challenges related to adaptation governance in rural and remote communities across Canada

CATEGORIES OF GOVERNANCE CHALLENGES	LOCATION(S) OBSERVED*
Policy and planning: Problem identification; existence of pressing socioeconomic issues; delivery of services and support; inability to maintain infrastructure (e.g., winter roads); management of change and community support systems; lack of regional regulations; development of local adaptation strategies; and integration of climate change into spatial planning.	BC, ON, NS, NWT, NU, SK, YK
Responding to climate-related emergencies: Responding to floods and changing flood risks; developing strategies for combating wildfires; and responding to environmental emergencies.	BC, NB, ON, PEI, QC
Resources and capacity: Providing technical and financial training; providing funding and subsidization opportunities for local adaptation efforts; stimulating private sector investments; competing for resources at all levels; high costs of adaptation and responding to natural disasters; and measuring the adaptive capacity of communities.	AB, BC, MB, NB, ON, NL, NWT, PEI, QC, SK, YT and at the national level
Trade-offs between adaptation, GHG emissions reduction and resource development: Adaptation vs. GHG emissions reduction; carbon taxation; and reliance on natural resource sectors.	BC, YT
Intergovernmental coordination: Clarification of roles and responsibilities; increased cooperation between jurisdictions; fragmented communication between government departments; and water and watershed governance.	BC, ON, NL, NU, SK
Communicating risks: Communicating complexities of climate change to the public.	BC, QC

* Locations noted in recent literature that has been identified and reviewed.

Another challenge that is facing institutions responding to climate change in rural and remote communities is balancing the need to adapt to changing environmental conditions with meeting nationally set GHG reduction targets. In many cases, GHG emission reduction targets are being weighed against economic benefits that are derived from resource development (Drolet and Sampson, 2017). When planning adaptation, the need to remain competitive while adhering to international commitments to reduce emissions and to protect against environmental degradation can further stress already stretched resources and human capacity (Government of Canada, 2017, 2016; Yukon Legislative Assembly, 2017; Furness and Nelson, 2016; Government of Ontario, 2016; Province of New Brunswick, 2016; The Ontario Bar Association, 2015). Oxford County, Ontario has incorporated national GHG emissions reduction targets into its sustainability plan, and goes further to address some of the regional challenges it is experiencing, with the aim of building a healthier environment and population, and a vibrant economy that supports sustainability (Oxford County Council, 2015).

Regional case studies provide insights into how factors such as human and financial resources relate to local governance capacity and climate change (*see* Case Story 3.6). Regional governance responses to climate change, such as watershed-scale efforts in British Columbia, point to the necessity of place-specific adaptation partnerships in policy and action (Breen and Rethoret, 2018). In another example, the Qalipu First Nation in Newfoundland has been conducting a regional assessment of climate change impacts on services, health and infrastructure, which will help communities adapt. This ongoing assessment is using information collected through interviews with residents, public data and GIS, and examining issues such as water quality, vulnerability and potential for flooding in nine communities (Sullivan, 2018). Support to strengthen asset management capacity, such as that provided by the Federation of Canadian Municipalities (FCM) to Municipalities Newfoundland and Labrador (the provincial-level municipal association), is vitally important in a province where just one quarter of municipalities have more than one staff person for all municipal responsibilities (Parewick, 2018; Irvine et al., 2016). The FCM has provided critical support to such initiatives through the Municipalities for Climate Innovation Program, which assists communities in both reducing GHG emissions and adapting to climate change through c apacity building (Federation of Canadian Municipalities, 2018b; Infrastructure Canada, 2018).

Case Story 3.6: Co-constructing and building rural adaptation capacity

The impacts of climate change are already being felt in the rural Kootenay Region of southeast British Columbia and are expected to increase over time. Impacts include increases in the number and severity of wildfires and extreme weather events, as well as changes in the landscape. These impacts are also affecting infrastructure, emergency planning and community development.

Local governments are front-line responders when it comes to adapting to climate change. However, in the Kootenays, like elsewhere, they face challenges including human and financial capacity limitations, reliance on natural resources, limited jurisdictional authority and a lack of appropriate supports and data. In this light, climate change can feel like an insurmountable hurdle. However, Kootenay communities also have unique, place-based assets that have been used to strengthen adaptive capacity, particularly in the form of local

expertise and partner organizations like the Columbia Basin Rural Development Institute (RDI), a community college-based research institute, and the Columbia Basin Trust (CBT), a regional trust (Columbia Basin Rural Development Institute, 2017; Columbia Basin Trust, 2015).

In 2014, the RDI partnered with the CBT to explore how communities could measure their progress in adapting to climate change, resulting in the State of Climate Adaptation and Resilience in the Basin (SoCARB) indicator suite. SoCARB took a comprehensive view of adaptation by linking climate change indicators to indicators of environmental and community impacts, which were in turn linked to indicators of adaptation actions and capacity. SoCARB was also rooted in the regional context, with the indicators being organized into five "adaptation pathways" (each representing a regional adaptation priority) (Columbia Basin Trust, 2015).

In 2016, the RDI initiated a pilot of the SoCARB indicators, with the intention of developing a replicable approach to adaptation measurement. RDI collaborated with the municipalities of Kimberley and Rossland, as well as the Regional Districts of Central Kootenay and East Kootenay. The project team included local government staff, elected officials, college researchers, a co-op student, a graduate student, two liaisons and advisors with climate change expertise.

The team brainstormed how to operationalize the SoCARB approach, particularly in light of limited time and money. A review of the adaptation pathways against local priorities resulted in a custom list of indicators for each community. Researchers, local government staff and students gathered the related data. Liaisons and staff guided the analysis, based on what they needed to know. The resulting community reports were developed to support each community in identifying and tracking key indicators, and using the results to inform their actions and related plans. A graduate student conducted an evaluation of the process, providing an external reflection.

This project is one example of an adaptation project that was locally driven, place-specific and collaborative. The partnerships were critical to the success of the project, with each team member playing a role in ensuring that the approach and results were rigorous, adaptive and locally relevant (Columbia Basin Rural Development Institute, 2017).

The RDI's work on rural climate change adaptation continues to grow and evolve. For more information, visit www.cbrdi.ca.

3.9 Moving forward

3.9.1 Knowledge gaps and research needs

There has been substantial work to better understand and adapt to climate change in Canadian rural and remote communities, although many knowledge gaps remain. For instance, challenges in accessing, interpreting and applying regional climate trend data at the scales needed for decision-making are important obstacles to better understanding climate change and incorporating this understanding into all levels of governance. Gaps in the collection and analysis of local data result in a limited ability to understand and plan appropriate responses for reducing vulnerability and risk related to projected climate change impacts in communities. Other knowledge gaps include the need for information on changes in the behaviour of forest fires; baseline data about community-level water supply; identifying threats from pests, pathogens, weeds and invasive species; and the need for new or updated flood risk mapping. In particular, improved knowledge of how shoreline shape may relate to coastal flooding in different contexts would also be useful for examining vulnerability at the local level, and for informing planning and related policies (Vasseur et al., 2017). Increased knowledge of strategies for responding to these threats and to environmental emergencies is also needed (Furness and Nelson, 2016). Further studies are also needed related to climate change impacts in rural sectors such as aquaculture, mining, oil and gas, and tourism in Canada (Weatherdon et al., 2016). Overall, scientific challenges related to climate change modelling and analysis for rural and remote communities include the limited availability of locally relevant data, knowledge and expertise, as well as the associated financial resources.

While it is evident that climate change is having impacts on human health in rural and remote Canada, the extent to which these impacts are, and will continue to be, felt is not fully understood (Kipp et al., 2019; Furness and Nelson, 2016). For example, changing dynamics related to travel on ice and land have the potential to contribute to injuries experienced during transit, as landscape features become exposed, temperatures rise and ice becomes thinner. However, understanding how these changing environmental conditions may be affecting injury rates, particularly in Inuit regions that often see higher rates of unintentional injury, is still lacking (Durkalec et al., 2015). Furthermore, research is needed to determine the extent to which injuries related to climate change differ based on individual capacities, activities and roles in communities (Clark et al., 2016a, b). There is very little information available about how different social dynamics (e.g., factors such as gender, age and culture) within communities contribute to their overall capacity and ability to adapt to climate change (Reed et al., 2014). Research related to changes in demographics and social cohesion is key to understanding social capacities in rural and remote communities.

There are also knowledge gaps in the understanding of the mental health ramifications of climate change, which are closely related to the impacts of climate change on physical and environmental health (Middleton et al., 2020; Cunsolo Willox et al., 2013a, b). Topics like ecological grief and anxiety (Cunsolo and Ellis, 2018) require further study to better understand their impact on different population groups. The mental health of Indigenous people and others who rely closely on the land for their culture, sustenance and livelihoods (e.g., farmers and fishers) is a particular area of concern. These groups are especially exposed to climate

change impacts, although research related to their mental health and well-being in the context of climate change is limited (e.g., Middleton et al., 2020; Dodd et al., 2018; Cunsolo Willox et al., 2015; Harper et al., 2015; Cunsolo Willox et al. 2013a, b). Research on understanding how intangible losses affect different people and communities, and how best to account for these losses is similarly limited (Tschakert et al., 2019; Tschakert et al., 2017). Indeed, there is a general need to better examine the human component of climate change throughout rural and remote communities in Canada (Akkari and Bryant, 2016; Statham et al., 2015).

Research on place-based monitoring of environmental, health and social changes related to climate change and adaptation is urgently needed. More research is also needed to explore the impacts of environmental shifts on knowledge systems, language and cultural practices in rural and remote communities. Furthermore, for rural and remote Indigenous communities, mental health, sense of place and sociocultural well-being are topics that vitally require further inquiry (Durkalec et al., 2015). Despite considerable research in recent years on how climate change interacts with Inuit communities, little research has explored the long-term responses to, and experiences of, climate change in Inuit communities (Archer et al., 2017). It is also important to identify ways for better defining and including local and Indigenous Knowledge in adaptation research and action.

The importance of community governance and values in relation to adaptive capacity suggests that further questions on these issues may need to be addressed (Furness and Nelson, 2016, 256). To assess their effectiveness and efficiency in implementation, plans and policy changes aimed at addressing the issues discussed here need to be closely analyzed. Two-way communication and knowledge transfer on the nature of climate change and related policy is key to ensuring the successful implementation of such policies. Another knowledge gap relates to the effective transfer and mobilization of climate change knowledge (Akkari and Bryant, 2016; Burch and Harris, 2014; Larsen et al., 2012). In general, more research is needed to determine the most effective ways for making local and regional climate change data available, as well as information on potential impacts and adaptation options. For instance, how climate change affects decision-making for farmers is an area in need of further research, and it has been suggested that focused and regularly timed reports on climate change to farm decision-makers would be useful for adaptation and response (Akkari and Bryant, 2016). Better understanding the nature and culture of climate denial within the Canadian context might also allow for the development of more effective and targeted educational tools to assist in increasing knowledge and action around adaptation, risk reduction and GHG emissions reduction in rural and remote communities (Furness and Nelson, 2016; Stoddart and Sodero, 2015). Finally, there is a need for a better understanding of the drivers and perspectives that drive people to learn about climate change, of how effectively and quickly that learning is happening and of the impacts and potential uses of technology for learning and knowledge sharing in rural and remote communities (Archer et al., 2017; Fawcett et al., 2017).

3.9.2 Emerging issues

Throughout these sections, some of the emerging climate change-related issues facing rural and remote communities in Canada have been outlined. There are significant safety concerns for communities, not only in terms of the potential impact of extreme weather events, but also related to the impacts of gradual changes in climate. From a health perspective, it is also important to better understand how climate change will affect mental health in communities, as mentioned above. Rural and remote communities are undergoing

multiple social and cultural changes throughout Canada, and researchers are only beginning to understand how these intersecting changes interact with climate change and the ability of communities to adapt. For example, although some Arctic water fish stocks are growing as a result of increases in ocean temperature, there are concerns that potential new opportunities related to this may be offset by factors such as rising competition for these new resources; increased presence of industrial fishing; reduced availability of traditionally harvested species; limited management controls; and issues concerning Indigenous access and sovereignty over fish stocks in their homelands (Bindoff et al., 2019; Meredith et al., 2019; Weatherdon et al., 2016). Changes are also happening in communities related to GHG emissions reduction efforts—including shifts to low-carbon economies and a resulting growth in renewables and biofuels—which pose different challenges and opportunities, and require attention to ensure they are developed in sustainable ways and that rural and remote communities are provided with the necessary support for economic transition.

Climate change will require continued infrastructure upgrades and enhancements to services at the local level across Canada for adaptation efforts to be successful. However, these requirements come at the same time as growing infrastructure deficits, service withdrawals and demographic shifts in rural and remote communities. Governance has likewise become a core consideration in ensuring effective coping and adaptation in response to climate change. As with infrastructure and services, governance for climate change adaptation is evolving and will require local support, as community leaders continue to struggle with increasing demands from stakeholders, but with decreasing resources to meet those demands. Governance entails a complex series of relationships between different agencies across all levels of government, as well as other organizations. Communication and coordination are key to successful governance, as is ensuring that communities can lead adaptation activities with place-specific solutions. Indeed, national-level and international-level climate policy, programs and measures may not always be well suited to the circumstances of rural and remote communities. Understanding these factors and evolving dynamics will be essential to future success; they are emerging issues worthy of ongoing attention.

3.10 Conclusion

Rural and remote regions in Canada are experiencing significant climate change impacts. They are home to residents, businesses and organizations that tend to rely on climate-sensitive natural resources and ecosystems for their cultures, livelihoods and well-being, while also having fewer financial, human and formal institutional resources with which to respond than their urban counterparts (*see* Table 3.8 for short, medium and long-term risks of climate change for rural and remote communities). Despite these challenges and risks, rural and remote regions continue to display strong resilience, drawing upon assets such as strong informal economies, social networks, and connections to place, community and culture. Place-based knowledge systems (e.g., local and/or Indigenous Knowledge) and lived experience have been key to understanding the impacts associated with climate change, as well as for developing successful responses and adaptations.

Adaptation strategies related to local economies have included planning for economic change and protecting traditional economies through technology, capacity building and changing land practices. These efforts have

been necessary responses to the effects of changing sea ice conditions, warmer temperatures and drought on economic sectors, such as agriculture, forestry, fishing and tourism, as well as subsistence activities, such as hunting and gathering, which are vital to livelihoods and economic well-being in many rural and remote regions.

Rural and remote transportation networks and services also continue to face a greater risk of failure and disruption from projected increases in extreme weather events, with coastal communities being particularly vulnerable to environmental emergencies disrupting infrastructure and activities necessary for carrying out daily life. As a result, rural and remote communities and regions are incorporating climate change considerations in their community planning and design and beginning to reinforce, rebuild and reimagine their built environments.

These climate-related changes directly and indirectly impact the physical and mental health and well-being of individuals and communities. Focusing on climate change adaptation, as well as realizing co-benefits from GHG emissions reduction and risk reduction, present an important opportunity for the health sector. Climate change and its associated impacts are leading to wide-ranging intangible losses and damages in many communities, including loss of identity, cultural continuity and sense of place. These effects are expected to be widespread and cumulative, and are critical to consider in climate change adaptation and policy.

Despite the tremendous resilience of rural and remote communities, their adaptive capacities are increasingly strained by ongoing and often rapid social-ecological change. Increased funding to support local adaptation planning and initiatives, information and support is needed to enhance governance capacity and decision-making related to climate change adaptation in these regions. Furthermore, the diverse range of impacts and potential costs of adaptation will require communities to prioritize actions, and mainstream adaptation actions and related investments. Greater inclusion will be essential along with provincial and federal level planning, programs and policy that take into account the specific circumstances of rural and remote regions.

Table 3.8: Climate-related risk in rural and remote communities across Canada

NEAR	MEDIUM	LONG-TERM
Place-based knowledge systems		
• Changing sea ice conditions, warmer temperatures and drought are posing immediate risks to local and Indigenous Knowledge in the agriculture, forestry, fishing and tourism sectors, as well as to subsistence activities such as hunting and gathering.	• Changing weather stressors are affecting agricultural production and local, land-based knowledge systems. • Climate change is creating an ongoing challenge for Indigenous Knowledge Systems that are founded on skills and knowledge related to the land, and which form the basis for safe practice and hazard avoidance while out on the land.	• Threats to long-term and ongoing relationships between people and their natural environments. • Disruptions to the social fabric and cultural identities of rural and remote communities.
Livelihoods and economy		
• Immediate impacts to infrastructure that livelihood rely on due to severe weather, thawing permafrost, droughts, flooding, storm surges and erosion. • Current observed changes in fish and wildlife species and related impacts. • Reduced accessibility of traditional food sources. • Changes in the supply of renewable resources related to species changes (e.g., agriculture, fishery, forestry)	• Continued and cumulative changes in marine and terrestrial ecosystems, including changes in renewable resource supply. • Continued impacts on accessibility of traditional food sources. • Fluctuations in energy supply and demand (e.g., fossil fuels, hydroelectric, renewables). • Continuation and intensification of all near-term impacts, except for successful early adapters.	• Interconnections between climate change impacts, adaptation measures and other socioecological changes at multiple levels, which are likely to create multiple and continually emerging risks. • Maximum uncertainty related to extreme climate change impacts. • Adaptive communities are likely still in transition. • Likely abandonment of non-adapted communities.

NEAR	MEDIUM	LONG-TERM
Livelihoods and economy (continued)		
• Increasing risk related to economic uncertainty. • Early adapters begin transitioning their economies at higher costs and with greater risk of failure. • Fluctuations in energy supply and demand (e.g., fossil fuels, hydroelectric, renewables).	• Potential loss of livelihoods and economies in many communities. • Fundamental changes to infrastructure, planning and economic transition in most communities; some may be abandoned due to loss of livelihoods.	• Possible migration with new forms of livelihood and economy.
Infrastructure		
• Transportation networks and services face increased risk of failure and disruption. • Impacts to transmission lines and energy grids. • Serious impacts on Northern infrastructure due to rapidly increasing average temperatures, precipitation and related changes. • Risk of injury from failure of physical infrastructure and stressed or degraded roads and traditional transportation routes. • Issues sustaining water and food security.	• Coastal communities are increasingly vulnerable to environmental emergencies, which disrupt activities necessary for daily life. • Loss and damage to critical and community infrastructure as a result of extreme weather events, inland and coastal flooding, sea level rise, permafrost thaw and forest fires. • Continuation and intensification of all near-term impacts.	• Continued disruptions to critical infrastructure, which are likely to result in adverse economic effects. • Increased energy prices. • Thawing permafrost and coastal erosion continue to affect residential and community infrastructure, particularly where planning and design have not considered changing climate conditions.

NEAR	MEDIUM	LONG-TERM
Health and well-being		
• Increasing challenges with accessing healthy and culturally preferred food and water sources. • Risk of contamination in local food and water sources in remote polar regions due to increased levels of persistent organic pollutants and toxic metals in the natural environment. • Worsening of existing vectorborne, waterborne and foodborne diseases. • Development of new infectious diseases. • Risk of injury and death caused by extreme weather events and changing climate conditions. • Increasing mental health challenges connected to environmental uncertainties.	• Increasing prevalence and severity of poor nutrition, obesity and diabetes related to changing access to certain foods. • Rising temperatures and more frequent extreme weather events may overwhelm fragile water treatment systems, affecting water security. • Changes to water levels, run-off, flow regimes and sediment, affecting drinking water availability and quality. • Increasing threats to safety and well-being in forest communities due to wildfire. • Continued intensification of mental health challenges.	• The effectiveness of rural and remote health systems is increasingly challenged by reduced system capacity and the ongoing buildup of stresses related to climate change.
Identity, culture and society		
• Shifts in cultural practices and identity associated with changes to the land. • Altered inter-generational transmission of Indigenous Knowledge. • Changes to the social fabric of rural and remote communities.	• Loss of Indigenous Knowledge and disruptions to cultural continuity. • Erosion of land-based skills and knowledge.	• Potential outmigration of youth and families, associated with increases in climate-related extreme weather events. • Climate-related stresses to the fabric of rural and remote communities.

NEAR	MEDIUM	LONG-TERM
Identity, culture and society (continued)		
• Increased storms, wind, sea level rise and coastal erosion, directly damaging sites of social and cultural importance. • Changing conditions leading to altered travel routes and disruptions in accessing places of cultural, social, spiritual and emotional significance.	• Continued losses to sense of place and identity resulting from irreversible losses, damage and destruction to landscapes and areas of cultural and social importance. • Continued alterations to place meanings and attachment, resulting from disruptions to connections to the land. • Storm damage associated with climate change can lead to enhanced social stress. • Climate-related stresses can heighten familial tensions and interpersonal conflict. • Climate-related stresses compound existing challenges to service provision and limited economic opportunities.	• Environmental crises may further entrench traditional gender roles, leading to less agency over adaptation strategies. • Continued intensification of challenges to cultural autonomy. • Continued losses to social capital. • Changing temperatures leading to potential extinction of local wildlife and plant species that are important aspects of natural heritage. • Unintended negative consequences of GHG emissions reduction and adaptation strategies, including adverse effects on economic opportunities and on the social fabric of communities.
Governance and institutions		
• Climate change impacts affecting infrastructure and service delivery, particularly during emergencies and related to the governance of land and natural resources.	• Climate change impacts continue to affect and require adaptation planning and policy.	• Continued strains on the ability of governance structures and institutions to respond to social, economic, cultural and environmental impacts related to climate change.

NEAR	MEDIUM	LONG-TERM
Governance and institutions (continued)		
• Difficulties in resolving disruptions to service delivery and in adaptation, due to disputes over jurisdictional responsibility and the need for continued improvements in communication and coordination. • Concern at local levels that senior levels of government are downloading additional responsibility to local institutions, which are already overstretched. • Challenges related to balancing the need to adapt to changing environmental conditions with meeting nationally-set GHG emissions reduction targets.	• Increases in average temperature, climate variability, drought and soil degradation result in high degrees of uncertainty for agricultural and other resource-dependent communities. • Increased uncertainty and challenges related to the ability to respond to environmental emergencies. Increased concern related to local capacity, without the provision of increased resources and support. • Continued challenges associated with top-down, inflexible governance structures, and in implementing intergovernmental and multi-stakeholder adaptation efforts.	• Incorporation of international perspectives into adaptation planning can further stress existing resources and human capacity.

3.11 References

Abram, N., Gattuso, J.P., Prakash, A., Cheng, L., Chidichimo, M.P., Crate, S., Enomoto, H., Garschagen, M., Gruber, N., Harper, S., Holland, E., Kudela, R.M., Rice, J., Steffen, K. and von Schuckmann, K. (2019). Summary for Policymakers, in IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama and N.M. Weyer In press. Retrieved February 2020, from <https://report.ipcc.ch/srocc/pdf/SROCC_FinalDraft_FullReport.pdf>

Akkari, C. and Bryant, C.R. (2016). The co-construction approach as approach to developing adaptation strategies in the face of climate change and variability: A conceptual framework. Agricultural Research, 5, 162–173. Retrieved February 2020, from <https://doi.org/10.1007/s40003-016-0208-8>

Andrews, T.D., S.V. Kokelj, S.V., MacKay, G., Buysee, J., Kritsch, I., Andre, A. and Lantz, T. (2016). Permafrost thaw and Aboriginal cultural landscapes in the Gwich'in Region, Canada. The Journal of Preservation Technology, 47(1), 15–22. Retrieved February 2020, from <https://www.gwichin.ca/publications/permafrost-thaw-and-aboriginal-cultural-landscapes-gwich%E2%80%99-region-canada>

Archer L., Ford J.D., Pearce T., Kowal S., Gough W.A. and Allurut M. (2017). Longitudinal assessment of climate vulnerability: a case study from the Canadian Arctic. Sustainability Science, 12, 15–29. <https://doi.org/10.1007/s11625-016-0401-5>

Arnold, S. and Fenech, A. (2017). Prince Edward Island climate change adaptation recommendations report. University of Prince Edward Island Climate Lab, Charlottetown, Canada, 172 p. Retrieved February 2020, from: <http://projects.upei.ca/climate/files/2018/10/PEI-Climate-Change-Adaptation-Recommendations-Report_medres.pdf>

Arriaga, M., Nasr, E. and Rutherford, H. (2017). Renewable energy microgrids in northern remote communities. Institute of Electrical and Electronics Engineers Potentials, 36(5), 22–29.

Auditor General of Canada (2018). Perspectives on climate change action in Canada – a collaborative report from Auditors General. Retrieved February 2020, from <http://www.oag-bvg.gc.ca/internet/English/parl_otp_201803_e_42883.html#ex6>

Bakaic M. and Medeiros A.S. (2017). Vulnerability of northern water supply lakes to changing climate and demand. Arctic Science, 3(1), 1–16. Retrieved February 2020, from <https://doi.org/10.1139/as-2016-0029>

Barbeau C.D., Oelbermann M., Karagatzides J.D. and Tsuji L.J.S. (2015). Sustainable agriculture and climate change: producing potatoes (Solanum tuberosum L.) and bush beans (phaseolus vulgaris L.) for improved food security and resilience in a Canadian subarctic First Nations community. Sustainability, 7(5), 5664–5681. Retrieved February 2020, from <https://doi.org/10.3390/su7055664>

BC Agriculture and Food Climate Action Initiative (2018). About us. Retrieved February 2020, from <https://www.bcagclimateaction.ca/overview/about-us/>

Berner, J., Brubaker, M., Revitch, B., Kreummel, E., Tcheripanoff, M. and Bell, J. (2016). Adaptation in Arctic circumpolar communities: food and water security in a changing climate. International Journal of Circumpolar Health, 75. Retrieved February 2020, from <https://10.3402/ijch.v75.33820>

Bernier, R.Y., Jamieson, R.E. and Moore, A.M. (Eds.) (2018). State of the Atlantic Ocean Synthesis Report. Canadian Technical Report of Fisheries and Aquatic Sciences 3167, 149 p. Retrieved February 2020, from <https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2018/atlantic-synthesis-atlantique-synthese/index-eng.html>

Bindoff, N.L., Cheung, W.W.L. Kairo, J.G., Arístegui, J., Guinder, V.A., Hallberg, R., Hilmi, N., Jiao, N., Karim, M.S., Levin, L., O'Donoghue, S., Purca Cuicapusa, S.R., Rinkevich, B., Suga, T., Tagliabue, A. and Williamson, P. (2019). Changing ocean, marine ecosystems, and dependent communities, Chapter 5 in IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds) H.O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama and N.M. Weyer. In press. Retrieved February 2020, from <https://www.ipcc.ch/srocc/download/>

Bishop-Williams, K.E., Berke, O., Pearl, D.L and Kelton, D.F. (2016). Mapping rural community and dairy cow heat stress in Southern Ontario: a common geographic pattern from 2010 to 2012. Archives of Environmental and Occupational Health, 71, 199–207. Retrieved February 2020, from <https://doi.org/10.1080/19338244.2015.1058235>

Bishop-Williams, K.E., Berke, O., Pearl D.L., Hand, K. and Kelton, D.F. (2015a). Heat stress related dairy cow mortality during heat waves and control periods in rural Southern Ontario from 2010–2012. BioMed Central Veterinary Research, 11 (291). Retrieved February 2020, from <https://doi.org/10.1186/s12917-015-0607-2>

Bishop-Williams K.E., Berke, O., Pearl, D.L. and Kelton, D.F. (2015b). A spatial analysis of heat stress related emergency room visits in rural Southern Ontario during heat waves. BioMed Central Emergency Medicine, 15(1), 1–9. Retrieved February 2020, from <https://doi.org/10.1186/s12873-015-0043-4>

Blanco, J.A., Dubois D., Littlejohn, D., Flanders, D.N., Robinson, P., Moshofsky, M. and Welham, C. (2015). Fire in the woods or fire in the boiler: implementing rural district heating to reduce wildfire risks in the forest-urban interface. Process Safety and Environmental Protection, 96, 1–13. Retrieved February 2020, from <https://doi.org/10.1016/j.psep.2015.04.002>

Bleau, S., Blangy, S. and Archambault, M. (2015). Adapting nature-based seasonal activities in Quebec (Canada) to climate change. Handbook of Climate Change Adaptation, 93–121. Retrieved February 2020, from <https://doi.org/10.1007/978-3-642-38670-1_44>

Boulanger-Lapointe, N., Gérin-lajoie, J., Collier, L. S., Desrosiers, S., Spiech, C., Henry, G. H. R. and Cuerrier, A. (2019). Berry plants and berry picking in Inuit Nunangat: traditions in a changing socio-ecological landscape. Human Ecology, 47(1), 81–93. Retrieved February 2020, from <https://doi.org/10.1007/s10745-018-0044-5>

Boyle, J., Cunningham, M. and Dekens, J. (2013). Climate change adaptation and Canadian infrastructure, a review of the literature. IISD Report. The International Institute for International Development. Retrieved February 2020, from <https://www.iisd.org/publications/climate-change-adaptation-and-canadian-infrastructure-review-literature>

Breen, S. and Rethoret, L. (2018). Co-constructing adaptation: rural capacity and addressing climate change. Retrieved February 2020, from <https://grosmorneclimatesymposium.files.wordpress.com/2018/09/co-constructing-adaptation-v3-sb.pdf>

Burch, S. and Harris, S. (2014). Understanding Climate Change: Science, Policy, and Practice. University of Toronto Press, Toronto, Ontario, 328 p.

Bush, E. and Lemmen, D.S. (Eds.) (2019). Canada's changing climate report. Government of Canada, Ottawa, Ontario, 444 p. Retrieved February 2020, from <https://changingclimate.ca/CCCR2019/about/>

Caldwell, W.J. (Ed.) (2015). Planning for Rural Resilience: Coping with Climate Change and Energy Futures. University of Manitoba Press, Manitoba, Canada, 192 p.

Canadian Rural Revitalization Foundation (2015). State of rural Canada 2015. Retrieved February 2020, from <http://sorc.crrf.ca/>

Casanova-Pérez, L., Martínez-Dávila, J.P., López-Ortiz, S., Landeros-Sánchez, C. and López-Romero, G. (2016). Sociocultural dimension in agriculture adaptation to climate change. Agroecology and Sustainable Food Systems, 40(8), 848–862. Retrieved February 2020, from <https://doi.org/10.1080/21683565.2016.1204582>

Chapin, F. S., Sommerkorn, M., Robards, M. D. and Hillmer-Pegram, K. (2015). Ecosystem stewardship: A resilience framework for arctic conservation. Global Environmental Change, 34, 207–217. Retrieved February 2020, from <https://doi.org/10.1016/j.gloenvcha.2015.07.003>

Clark, D.G., Ford, J.D., Berrang-Ford, L., Pearce, T., Kowal, S. and Gough, W.A. (2016a). The role of environmental factors in search and rescue incidents in Nunavut, Canada. Public Health, 137, 44–49. Retrieved February 2020, from <https://doi.org/10.1016/j.puhe.2016.06.003>

Clark, D.G., Ford, J.D., Pearce T. and Berrang-Ford, L. (2016b). Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada. Social Science and Medicine, 169, 18–26. Retrieved February 2020, from <https://doi.org/10.1016/j.socscimed.2016.09.026>

Clark, D.G. and Ford J.D. (2017). Emergency response in a rapidly changing Arctic. Canadian Medical Association Journal, 189, 135-36. Retrieved February 2020, from <https://doi.org/10.1503/cmaj.161085>

Clarke, C. S. L. M. and Clarke, A. J. (2018). The adaptation primers. Canadian Society of Landscape Architects (1–4). Retrieved February 2020, from <https://www.csla-aapc.ca/primers>

Climate Action Initiative (2013). BC farm practices & climate change adaptation. Retrieved March 2020, from <https://www.bcagclimateaction.ca/wp/wp-content/media/FarmPractices-NutrientManagement.pdf>

Climate Action Revenue Incentive Program (2017). Summary report on local government climate actions 2016. Retrieved February 2020, from <https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/local-governments/planning-land-use/carip_2017_summary.pdf>

Climate Change Nova Scotia (2018a). Health impacts. Retrieved February 2020, from <https://climatechange.novascotia.ca/adapting-to-climate-change/impacts/health>

Climate Change Nova Scotia (2018b). Transportation impacts. Retrieved February 2020, from <https://climatechange.novascotia.ca/adapting-to-climate-change/impacts/transportation>

Columbia Basin Rural Development Institute (2017). Communities of the Columbia Basin. Selkirk College. Retrieved February 2020, from <http://cbrdi.ca/Communities>

Columbia Basin Trust. (2015). Measuring progress on climate adaptation in the Columbia Basin. Retrieved March 2020, from <http://datacat.cbrdi.ca/sites/default/files/attachments/ClimateAdaptation_Summary_11-03-15%5B1%5D.pdf>

Cunsolo, A. and Ellis, N. R. (2018). Ecological grief as a mental health response to climate change-related loss. Nature Climate Change, 8(4), 275–281. Retrieved February 2020, from <https://doi.org/10.1038/s41558-018-0092-2>

Cunsolo, A., Shiwak, I. and Wood, M. (2017). You need to be a well-rounded cultural person: youth mentorship programs for cultural preservation, promotion, and sustainability in the Nunatsiavut Region of Labrador, Chapter in Northern Sustainabilities: Understanding and Addressing Change in the Circumpolar World, (Eds.) G. Fondahl and G.Wilson. Springer Polar Sciences, 285–303.

Cunsolo Willox, A. (2012). Climate change as the work of mourning. Ethics and the Environment, 17(2), 137–164. Retrieved February 2020, from <https://www.jstor.org/stable/10.2979/ethicsenviro.17.issue-2>

Cunsolo Willox, A., Harper, S.L., Ford, J.D., Edge, V., Landman, K., Houle, K., Blake, S. and Wolfrey, C. (2013a). Climate change and mental health: an exploratory case study from Rigolet, Nunatsiavut, Labrador. Climate Change, 121(2), 255–270. Retrieved February 2020, from <https://doi.org/10.1007/s10584-013-0875-4>

Cunsolo Willox, A., Harper, S. L., Edge, V. L., Landman, K., Houle, K. Ford, J. D., and the Rigolet Inuit Community Government (2013b). The land enriches the soul: On climatic and environmental change, affect, and emotional health and well-being in Rigolet, Nunatsiavut, Canada. Emotion, Space and Society, 6(1), 14–24. Retrieved February 2020, from <http://dx.doi.org/10.1016/j.emospa.2011.08.005>

Cunsolo Willox, A., Harper, S. L., Ford, J. D., Landman, K., Houle, K., Edge, V. L. and the Rigolet Inuit Community Government (2012). "From this place and of this place:" climate change, sense of place, and health in Nunatsiavut, Canada. Social Science and Medicine, 75(3), 538–547. Retrieved February 2020, from <https://doi.org/10.1016/j.socscimed.2012.03.043>

Cunsolo Willox, A., Stephenson, E., Allen, J., Bourque, F., Drossos, A., Elgarøy, S., Kral, M.J., Mauro, I., Moses, J., Pearce, T., MacDonald, J.P. and Wexler, L. (2015). Examining relationships between climate change and mental health in the Circumpolar North. Regional Environmental Change, 15(1), 169–182. Retrieved February 2020, from <https://doi.org/10.1007/s10113-014-0630-z>

Dampier, J. E. E., Chander, S., Lemelin, R.H. and Luckai, N. (2016). Assessment of potential local and regional induced economic impact of an energy policy change in rural Northwestern Ontario. Energy, Sustainability and Society, 6(14). Retrieved February 2020, from <https://doi.org/10.1186/s13705-016-0079-7>

Dawson, F. (2019). Sweeping closures in British Columbia for 2019 fishing season. Sea West News. Retrieved February 2020, from <https://seawestnews.com/sweeping-closures-in-british-columbia-for-2019-fishing-season/>

Dawson, P. and Levy, R. (2016). From science to survival: using virtual exhibits to communicate the significance of polar heritage sites in the Canadian Arctic. Open Archaeology 2(1), 209–231. Retrieved February 2020, from <https://doi.org/10.1515/opar-2016-0016>

Doberstein, B., Fitzgibbons, J. and Mitchell, C. (2019). Protect, accommodate, retreat or avoid (PARA): Canadian community options for flood disaster risk reduction and flood resilience. Natural Hazards, 98(1), 31–50. Retrieved February 2020, from <https://doi.org/10.1007/s11069-018-3529-z>

Dodd, W., Scott P., Howard, C., Scott, C., Rose, C., Cunsolo, A. and Orbinski, J. (2018). Lived experience of a record wildfire season in the Northwest Territories, Canada. Canadian Journal of Public Health, 109(3), 327–337. Retrieved February 2020, from <https://doi.org/10.17269/s41997-018-0070-5>

Drolet, J. L. and Sampson, T. (2017). Addressing climate change from a social development approach: Small cities and rural communities' adaptation and response to climate change in British Columbia, Canada. International Social Work, 60(1), 61–73. Retrieved February 2020, from <https://doi.org/10.1177/0020872814539984>

Durkalec, A., Furgal, C., Skinner, M. W. and Sheldon, T. (2014). Investigating environmental determinants of injury and trauma in the Canadian North. International Journal of Environmental Research and Public Health, 11(2), 1536–1548. Retrieved February 2020, from <https://doi.org/10.3390/ijerph110201536>

Durkalec, A., Furgal, C., Skinner, M. W. and Sheldon, T. (2015). Climate change influences on environment as a determinant of Indigenous health: Relationships to place, sea ice, and health in an Inuit community. Social Science and Medicine, 136-137, 17–26. Retrieved February 2020, from <https://doi.org/10.1016/j.socscimed.2015.04.026>

Eddy, B.G., Muggridge, M., LeBlanc, R., Osmond, J., Kean, C. and Boyd, E. (2020a). The CanEcumene 2.0 GIS Database. Federal Geospatial Platform (FGP), Natural Resources Canada. Retrieved October 2020, from <https://open.canada.ca/data/en/dataset/3f599fcb-8d77-4dbb-8b1e-d3f27f932a4b>

Eddy, B., Muggridge, M., LeBlanc, R., Osmond, J., Kean, C. and Boyd, E. (2020b). An Ecological Approach for Mapping Socio-Economic Data in Support of Ecosystems Analysis: Examples in Mapping Canada's Forest Ecumene. One Ecosystem, 5, e55881. Retrieved October 2020, from <https://doi.org/10.3897/oneeco.5.e55881>

Ellis, N. R. and Albrecht, G. A. (2017). Climate change threats to family farmers' sense of place and mental well-being: A case study from the Western Australian Wheatbelt. Social Science and Medicine, 175, 161–168. Retrieved February 2020, from <https://doi.org/10.1016/j.socscimed.2017.01.009>

eNuk (n.d.). The eNuk environment and health monitoring program. Retrieved April 9, 2020, from <www.enuk.ca>

EPCCARR [Expert Panel on Climate Change Adaptation and Resilience Results] (2018). Measuring progress on adaptation and climate resilience: Recommendations to the Government of Canada. Environment and Climate Change Canada, Ottawa, Ontario, 188 p. Retrieved February 2020, from <https://www.canada.ca/en/environment-climate-change/services/climate-change/adapting/expert-panel-adaptation-resilience.html>

Fawcett, D., Pearce, T., Ford, J.D. and Archer, L. (2017). Operationalizing longitudinal approaches to climate change vulnerability assessment. Global Environmental Change, 45, 79–88. Retrieved February 2020, from <https://doi.org/10.1016/j.gloenvcha.2017.05.002>

Federation of Canadian Municipalities (2018a). Rural challenges, national opportunity: Shaping the future of Canada. Retrieved February 2020, from <https://fcm.ca/sites/default/files/documents/resources/report/rural-challenges-national-opportunities.pdf>

Federation of Canadian Municipalities (2018b). Year 2 annual progress report: Municipalities for Climate Innovation Program. Retrieved February 2020, from <https://fcm.ca/sites/default/files/documents/resources/report/annual-progress-report-yr2-mcip.pdf>

Federation of Canadian Municipalities and Insurance Bureau of Canada (2019). Investing in Canada's future: The cost of climate adaptation. Retrieved February 2020, from <http://assets.ibc.ca/Documents/Disaster/The-Cost-of-Climate-Adaptation-Summary-EN.pdf>

Félio, G. (2017). Climate change impacts on water and wastewater infrastructure at Akwesasne. Retrieved February 2020, from <https://pievc.ca/sites/default/files/climate-change-impacts-water-wastewater-akwesasne-05-18-e.pdf>

Fletcher, A. J. and Knuttila, E. (2016). Gendering change: Canadian farm women respond to drought, Chapter 7 in Vulnerability and Adaptation to Drought: The Canadian Prairies and South America. University of Calgary Press, Calgary, Alberta, 159–177.

Ford, J. D., Cameron, L., Rubis, J., Maillet, M., Nakashima, D., Willox, A. C. and Pearce, T. (2016). Including Indigenous Knowledge and experience in IPCC assessment reports. Nature Climate Change, 6(4), 349–353. Retrieved February 2020, from <https://doi.org/10.1038/nclimate2954>

Ford, J. D., Champalle, C., Tudge, P., Riedlsperger, R., Bell, T. and Sparling, E. (2015). Evaluating climate change vulnerability assessments: A case study of research focusing on the built environment in northern Canada. Mitigation and Adaptation Strategies for Global Change, 20(8), 1267–1288. Retrieved February 2020, from <https://doi.org/10.1007/s11027-014-9543-x>

Ford, J. D., Labbé, J., Flynn, M. Araos, M., and IHACC Research Team (2017). Readiness for climate change adaptation in the Arctic: A case study from Nunavut, Canada. Climate Change, 145, 85–100. Retrieved February 2020, from <https://doi.org/10.1007/s10584-017-2071-4>

Ford, J. D., Cunsolo Willox, A., Chatwood, S., Furgal, C., Harper, S., Mauro, I. and Pearce, T. (2014). Adapting to the effects of climate change on Inuit health. American Journal of Public Health, 104(3), 9–17. Retrieved February 2020, from <https://doi.org/10.2105/AJPH.2013.301724>

FRWIP [Farm and Ranch Water Infrastructure Program] (n.d.). Saskatchewan farm and ranch water infrastructure program. Retrieved April 9, 2020, from <https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/canadian-agricultural-partnership-cap/environmental-sustainability-and-climate-change/farm-and-ranch-water-infrastructure-program-frwip>

FSP [Farm Stewardship Program] (n.d.). Saskatchewan farm stewardship program. Retrieved April 9, 2020, from <https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/canadian-agricultural-partnership-cap/environmental-sustainability-and-climate-change/farm-stewardship-program-fsp>

Furness, E. and Nelson, H. (2016). Are human values and community participation key to climate adaptation? The case of community forest organizations in British Columbia. Climatic Change, 135, 243–259. Retrieved February 2020, from <https://doi.org/10.1007/s10584-015-1564-2>

Gerbaux, M., Spandre, P., François, H., George, E. and Morin, S. (2020). Snow Reliability and Water Availability for Snowmaking in the Ski resorts of the Isère Département (French Alps), Under Current and Future Climate Conditions. Revue de géographie alpine, 108(1). Retrieved December 2020, from <https://doi.org/10.4000/rga.6742>

Gilaberte-Búrdalo, M., López-Martín, F., Pino-Otín, M. and López-Moreno, J. (2014). Impacts of climate change on ski industry. Environmental Science and Policy, 44, 51–61. Retrieved February 2020, from <https://doi.org/10.1016/j.envsci.2014.07.003>

Gill, H. and Lantz, T. (2014). A community-based approach to mapping Gwich'in observations of environmental changes in the Lower Peel River Watershed, Northwest Territories. Journal of Ethnobiology, 34(3), 294–314. Retrieved February 2020, from <https://doi.org/10.2993/0278-0771-34.3.294>

Goodridge, D. and Marciniuk, D. (2016). Rural and remote care: Overcoming the challenges of distance. Chronic Respiratory Disease, 13(2), 192–203. Retrieved February 2020, from <https://doi.org/10.1177/1479972316633414>

Government of Canada (2016). The Pan-Canadian Framework on clean growth and climate change. Ottawa, Ontario, Canada. Retrieved February 2020, from <https://www.canada.ca/content/dam/themes/environment/documents/weather1/20170125-en.pdf>

Government of Canada (2017). Budget of 2017: Chapter 2, communities built for change. Retrieved February 2020, from <https://www.canada.ca/content/dam/themes/environment/weather/climatechange/PCF-FirstSynthesis_ENG.pdf>

Government of Canada (2018). A just transition for Canadian coal power workers and communities. Retrieved February 2020, from <http://publications.gc.ca/pub?id=9.867000&sl=0>

Government of Canada (2020). Critical infrastructure. Retrieved February 2020, from <https://www.publicsafety.gc.ca/cnt/ntnl-scrt/crtcl-nfrstrctr/index-en.aspx>

Government of Manitoba (2017). A made-in-Manitoba climate and green plan: Hearing from Manitobans. Retrieved February 2020, from <http://www.gov.mb.ca/asset_library/en/climatechange/climategreenplandiscussionpaper.pdf>

Government of Northwest Territories (2016). Environment economy and climate change commitment progress report. Retrieved February 2020, from <https://www.eia.gov.nt.ca/en/mandates/economy-environment-and-climate-change>

Government of Northwest Territories (2017). Climate change strategic framework 2018–2030: Draft for public comment. Retrieved February 2020, from <https://www.enr.gov.nt.ca/sites/enr/files/resources/final_pdf_nwt_ccsf_draft_for_public_comment_nov_29_2017.pdf>

Government of Ontario (2016). Ontario's Five year Climate Change Action Plan 2016–2017. Retrieved February 2020, from <https://www.ontario.ca/page/climate-change-action-plan>

Government of Saskatchewan (2017). Prairie resilience: A made-in-Saskatchewan climate change strategy. Retrieved February, 2020, from <https://www.saskatchewan.ca/business/environmental-protection-and-sustainability/a-made-in-saskatchewan-climate-change-strategy>

Groulx, M. (2017). "Other people's initiatives": Exploring mediation and appropriation of place as barriers to community-based climate change adaptation. Local Environment, 22(11), 1378–1393. Retrieved February 2020, from <https://doi.org/10.1080/13549839.2017.1348343>

Groulx, M., Lewis, J., Lemieux, C. and Dawson, J. (2014). Place-based climate change adaptation: A critical case study of climate change messaging and collective action in Churchill, Manitoba. Landscape and Urban Planning, 132, 136–147. Retrieved February 2020, from <https://dx.doi.org/10.1016/j.landurbplan.2014.09.002>

Hall, C.M., Baird, T., James, M. and Ram, Y. (2016). Climate change and cultural heritage: Conservation and heritage tourism in the Anthropocene. Journal of Heritage Tourism, 11(1), 10–24. Retrieved February 2020, from <https://doi.org/10.1080/1743873X.2015.1082573>

Hanrahan, M., Sarkar, A. and Hudson, A. (2014). Exploring water insecurity in a northern indigenous community in Canada: The "never-ending job" of the Southern Inuit of Black Tickle, Labrador. Arctic Anthropology, 51(2), 9–22. Retrieved February 2020, from <https://www.jstor.org/stable/24475826>

Harneet, G. and Lantz, T. (2014). A community-based approach to mapping Gwich'in observations of environmental changes in the lower Peel River Watershed, NT. Journal of Ethnobiology, 34(3), 294–314. Retrieved February 2020, from <https://doi.org/10.2993/0278-0771-34.3.294>

Harper, S. L., Edge, V. L., Schuster-Wallace, C. J., Berke, O. and McEwen, S. A. (2011). Weather, water quality and infectious gastrointestinal illness in two Inuit communities in Nunatsiavut, Canada: Potential implications for climate change. EcoHealth, 8(1), 93–108. Retrieved February 2020, from <https://doi.org/10.1007/s10393-011-0690-1>

Harper, S. L., Edge, V. L. and Willox, A. C. (2012). 'Changing climate, changing health, changing stories' profile: Using an EcoHealth approach to explore impacts of climate change on Inuit health. EcoHealth, 9(1), 89–101. Retrieved February 2020, from <https://doi.org/10.1007/s10393-012-0762-x>

Harper, S. L., Edge, V. L., Ford, J., Cunsolo Willox, A., Wood, M., Indigenous Health Adaptation to Climate Change Research Team, Rigolet Inuit Community Government, and McEwen, S. (2015). Climate-sensitive health priorities in Nunatsiavut, Canada. BioMed Central Public Health, 15(1), 605. Retrieved February 2020, from <https://doi.org/10.1186/s12889-015-1874-3>

Hatcher, S. V. and Forbes, D. L. (2015). Exposure to coastal hazards in a rapidly expanding northern urban centre, Iqaluit, Nunavut. Arctic Institute of North America, 68(4), 453–471. Retrieved February 2020, from <www.jstor.org/stable/43871361>

Healthy Lake Huron (2019). Healthy Lake Huron: clean water, clean beaches. Retrieved February 2020, from <http://www.healthylakehuron.ca/about/>

Hock, R., Rasul, G., Adler, C., Cáceres, B., Gruber, S., Hirabayashi, Y., Jackson, M., Kääb, A., Kang, S., Kutuzov, S., Milner, A., Molau, U., Morin, S., Orlove, B. and Steltzer, H. (2019). High Mountain Areas, Chapter 2 in IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama and N.M. Weyer. Retrieved February 2020, from <https://www.ipcc.ch/srocc/chapter/chapter-2/>

Holsman, K., Hollowed, A., Ito, S. I., Bograd, S., Hazen, E., King, J., Mueter, F. and Perry, R. I. (2019). Climate change impacts, vulnerabilities and adaptations: North Pacific and Pacific Arctic marine fisheries, Chapter 6 in Impacts of climate change on fisheries and aquaculture synthesis of current knowledge, adaptation and mitigation options, (Eds.) M. Barange, T. Bahri, M.C.M. Bereridge, K.L. Cochrane, S. Finge-Smith and F. Poulain. Food and Agriculture Organization of the United Nations, 19–39. Retrieved February 2020, from <http://www.fao.org/3/i9705en/i9705en.pdf>

Horning, D., Bauer, B. O. and Cohen, S. J. (2016a). Missing bridges: Social network (dis)connectivity in water governance. Utilities Policy, 43, 59–70. Retrieved February 2020, from <http://dx.doi.org/10.1016%2Fj.jup.2016.06.006>

Horning, D., Bauer, B. O. and Cohen, S. J. (2016b). Watershed governance for rural communities: Aligning network structure with stakeholder vision. Journal of Rural and Community Development, 11(2), 45–71. Retrieved February 2020, from <https://journals.brandonu.ca/jrcd/article/view/1453/305>

Huitema, D., Adger, W. N., Berkhout, F. Massey, E., Mazmanian, D., Munaretto, S., Plummer, R. and Termeer, C. C. J. A. M. (2016). The governance of adaptation: Choices, reasons, and effects. Introduction to the Special Feature. Ecology and Society, 21(3), 37. Retrieved February 2020, from <http://dx.doi.org/10.5751/ES-08797-210337>

Hurlbert, M. and Pittman, J. (2014). Exploring adaptive management in environmental farm programs in Saskatchewan, Canada. Journal of Natural Resources Policy Research, 6(2–3), 195–212. Retrieved February 2020, from <https://doi.org/10.1080/19390459.2014.915131>

IllikKuset-Illingannet Team (2014). Introducing the IllikKuset-Illingannet/Culture-Connect Program. Retrieved April 9, 2010, from <https://www.youtube.com/watch?v=EAulcH3uXnc>

Indigenous and Northern Affairs Canada (2017). 2017–2018 Departmental Plan. Ottawa, Ontario, Canada. Retrieved February 2020, from: <https://www.canada.ca/content/dam/polar-polaire/documents/pdf/POLAR_PAA_Based_2017-18_DP_FINAL_ENG.pdf>

Infrastructure Canada (2018). Communities across Canada receive support for green innovation, climate change resiliency, and infrastructure planning initiatives. Ottawa, Ontario, Canada. Retrieved February 2020, from <https://www.newswire.ca/news-releases/communities-across-canada-receive-support-for-green-innovation-climate-change-resiliency-and-infrastructure-planning-initiatives-700926721.html>

IPCC [Intergovernmental Panel on Climate Change] (2014). Part B: Regional Aspects (Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change) in Climate Change 2014: Impacts, adaptation, and vulnerability, (Eds.) V.R. Barros, C.B. Field, J.D. Dokke, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea and L.L. White. Cambridge University Press, Cambridge, United Kingdom and New York, New York, 688-1132. Retrieved February 2020, from <https://www.ipcc.ch/report/ar5/wg2/>

IPCC [Intergovernmental Panel on Climate Change] (2018). Global Warming of 1.5 °C: IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, in Summary for Policy Makers. Retrieved February 2020, from <http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf>

Irvine, M., Vodden, K. and Keenan, R. (2016). Developing assessment and adaptation capacity: Integrating climate change considerations into municipal planning in Newfoundland and Labrador, Chapter 6 in Sustainability Planning and Collaboration in Rural Canada: Taking the Next Steps, (Eds.) L. Hallstrom, M. Beckie, G. Hvenegaard and K. Mündel. University of Alberta Press, Edmonton, Alberta, 117–144.

Johnson, R. (2019). Saugeen Ojibway Nation confronts effects of climate change on whitefish fishery. Retrieved April 9, 2020, from <https://www.cbc.ca/news/indigenous/saugeen-ojibway-whitefish-fishery-climate-change-1.4982666>.

Johnston, M.E., Dawson, J. and Maher, P.T. (2017). Strategic development challenges in marine tourism in Nunavut. Resources, 6(3), 25. Retrieved February 2020, from <https://doi.org/10.3390/resources6030025>

King, M., Altdorff, D., Li, P., Galagedara, L., Holden, J. and Unc, A. (2018). Northward shift of the agricultural climate zone under 21st-century global climate change. Scientific Reports, 8(1), 7904. Retrieved February 2020, from <https://www.nature.com/articles/s41598-018-26321-8.pdf>

Kipp, A., Cunsolo, A., Gillis, D., Sawatzky, A., Wood, M. and Harper, S. (2019). The need for community-led, integrated, and innovative monitoring programs when responding to the health impacts of climate change. International Journal of Circumpolar Health, 78(2). Retrieved February 2020, from <https://doi.org/10.1080/22423982.2018.1517581>

Knowles, J. (2016). Power Shift: Electricity for Canada's remote communities. The Conference Board of Canada, Ottawa. Retrieved February 2020, from <https://www.conferenceboard.ca/e-Library/document.aspx?did=8249>

Kornfeld, I.E. (2016). The impact of climate change on American and Canadian Indigenous peoples and their water resources: A climate justice perspective. Hebrew University of Jerusalem Legal Research Paper No. 17–32. Retrieved February 2020, from <https://dx.doi.org/10.2139/ssrn.2832879>

Krawchenko, T., Keefe, J., Manuel, P. and Rapaport, E. (2016). Coastal climate change, vulnerability and age friendly communities: Linking planning for climate change to the age friendly communities agenda. Journal of Rural Studies, 44, 55–62. Retrieved February 2020, from <https://doi.org/10.1016/j.jrurstud.2015.12.013>

Lament for the Land (2014). Lament for the Land film. Retrieved February 2020, from <http://www.lamentfortheland.ca/film/>

Larsen, R.K., Swartling, Å.G., Powell, N., May, B., Plummer, R., Simonsson, L. and Osbeck, M. (2012). A framework for facilitating dialogue between policy planners and local climate change adaptation professionals: Cases from Sweden, Canada and Indonesia. Environment, Science and Policy, 23, 12–23. Retrieved February 2020, from <http://dx.doi.org/10.1016/j.envsci.2012.06.014>

Lebel, D. (2014). Infrastructure Canada report on plans and priorities. Retrieved February 2020, from: <http://publications.gc.ca/collections/collection_2014/infc/T91-2-2014-eng.pdf>

Lemmen, D.S.,Warren, F.J., Lacroix, J. and Bush, E. (Eds.) (2008). From impacts to adaptation: Canada in a changing climate. Government of Canada, Ottawa, Ontario, 448 p. Retrieved February 2020, from <https://www.nrcan.gc.ca/impacts-adaptation-canada-changing-climate/10253>

Lieske, D.J. (2015). Coping with climate change: The role of spatial decision support tools in facilitating community adaptation. Environmental Modelling Software, 68, 98–109. Retrieved February 2020, from <http://dx.doi.org/10.1016/j.envsoft.2015.02.005>

Lieske, D.J., Wade, T. and Roness, A.L. (2014). Climate change awareness and strategies for communicating the risk of coastal flooding: A Canadian Maritime case example. Estuarine and Coast Shelf Science, 140, 83–94. Retrieved February 2020, from <http://dx.doi.org/10.1016/j.ecss.2013.04.017>

Loring, P. A. and Gerlach, S. C. (2015). Searching for progress on food security in the North American North: A research synthesis and meta-analysis of the peer-reviewed literature. Arctic, 68(3), 380–392. Retrieved February 2020, from <http://dx.doi.org/10.14430/arctic4509>

Manuel, P., Rapaport, E., Keefe, J. and Krawchenko, T. (2015). Coastal climate change and aging communities in Atlantic Canada: A methodological overview of community asset and social vulnerability mapping. Canadian Geographer, 59(4), 433–446. Retrieved February 2020, from <https://doi.org/10.1111/cag.12203>

McMartin, D.W. and Merino, B.H.H. (2014). Analysing the links between agriculture and climate change: can “best management practices” be responsive to climate extremes? International Journal of Agricultural Resources, Governance and Ecology, 10(1), 50. <http://doi.org/10.1504/IJARGE.2014.061042>

Medeiros, A.S., Wood, P., Wesche, S.D., Bakaic, M. and Peters, J.F. (2017). Water security for northern peoples: review of threats to Arctic freshwater systems in Nunavut, Canada. Regional Environmental Change, 17(3), 635–647. Retrieved February 2020, from <http://dx.doi.org/10.1007/s10113-016-1084-2>

Meredith, M., Sommerkorn, M., Cassotta, S., Derksen, C., A. Ekaykin, A., Hollowed, A., Kofinas, G. Mackintosh, A., Melbourne-Thomas, J., Muelbert, M.M.C., Ottersen, G., Pritchard, H. and Schuur, E.A.G. (2019). Polar Regions, Chapter 3 in IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, (Eds.) H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama and Weyer, N.M. In press. Retrieved February 2020, from <https://www.ipcc.ch/srocc/chapter/chapter-3-2>

Messner, S. (2020). Future Arctic shipping, black carbon emissions, and climate change, Chapter 11 in Maritime Transport and Regional Sustainability. (Eds.) K.Y. Adolf, J.M. Ng, C. Jiang. Elsevier Incorporated, 195–208. Retrieved February 2020, from <https://doi.org/10.1016/C2018-0-04694-0>

Middleton, J., Cunsolo, A., Jones-Bitton, A., Wright, C. and Harper S.L. (2020). Indigenous mental health in a changing climate: A systematic scoping review of the global literature. Environmental Research Letters, 15(5). Retrieved December 2020, from <https://doi.org/10.1088/1748-9326/ab68a9>.

Minnes, S. and Vodden, K. (2019). Introduction, Chapter 1 in The Theory, Practice, and Potential of Regional Development: The Case of Canada, (Eds.) K. Vodden, D. Douglas, S. Markey, S. Minnes and B. Reimer. Routledge, London, United Kingdom, 1–11.

Mortensen, L., Hansen, A.M. and Shestakov, A. (2017). How three key factors are driving and challenging implementation of renewable energy systems in remote Arctic communities. Polar Geography, 40(3), 163–185. Retrieved December 2020, from <https://doi.org/10.1080/1088937X.2017.1329758>

Mullan, D., Swindles, G., Patterson, T., Galloway, J., Macumber, A., Falck, H., Crossley, L., Chen, J. and Pisaric, M. (2017). Climate change and the long-term viability of the world’s busiest heavy haul ice road. Theoretical and Applied Climatology, 129(3–4), 1089–1108. Retrieved February 2020, from <https://doi.org/10.1007/s00704-016-1830-x>

Nicol, L.A. and Nicol, C.J. (2018). Adoption of precision agriculture to reduce inputs, enhance sustainability and increase food production: A study of southern Alberta, Canada, Chapter in Sustainable development and planning, (Eds.) G. Passerini and N. Marchettini. WIT Press, Boston, Massachusetts, United States, 327–336.

Northwest Territories Legislative Assembly (2018). 2030 NWT Climate Change Strategic Framework. Retrieved February 2020, from <http://library.assembly.gov.nt.ca/2018/ENR/a382207_td_211-183_2030_NWT_Climate_Change_Strategic_Framework.pdf>

Nova Scotia Department of Environment and Climate Change (2018). Climate change impacts: Transportation. Retrieved February 2020, from <https://climatechange.novascotia.ca/adapting-to-climate-change/impacts/transportation>

Natural Resources Canada (2015). Preparing for Storm Surges in Annapolis Royal, Nova Scotia. Retrieved February 2020, from <https://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/tools-guides/16303>

Natural Resources Canada (2018a). Remote communities energy database. The Atlas of Canada. Retrieved February 2020, from <https://atlas.gc.ca/rced-bdece/en/index.html>

Natural Resources Canada (2018b). Mountain pine beetle. Retrieved February 2020, from <https://www.nrcan.gc.ca/forests/fire-insects-disturbances/top-insects/13381>

Odland, J. O., Donaldson, S., Dudarev, A. and Carlsen, A. (2015). Arctic monitoring and assessment program [AMAP] assessment 2015: Human health in the Arctic. International Journal of Circumpolar Health, 75(1). Retrieved February 2020, from <http://doi.org/10.3402/ijch.v75.33949>

Oxford County Council (2015). Future Oxford: Our path towards sustainability. Retrieved February 2020, from: <http://futureoxford.ca/general/sustainabilityplan/pdf/2015_FutureOxford_CommunitySustainabilityPlan.pdf>

Pagano, A., Pluchinotta, I., Giordano, R. and Fratino, U. (2018). Integrating "hard" and "soft" infrastructural resilience assessment for water distribution systems. Complexity, 2018, 1–16. Retrieved February 2020, from <https://doi.org/10.1155/2018/3074791>

Parewick, K. (2018). BAM! NL – Building asset management here. Retrieved February 2020, from <https://grosmorneclimatesymposium.com/day-2/>

Pearce, C. and Callihoo, C. (2011). Pathways to climate change resilience: A guidebook for Canadian forest-based communities. Retrieved February 2020, from <https://www.researchgate.net/profile/David_Natcher/publication/275011321_Linking_gender_climate_change_adaptive_capacity_and_forest-based_communities_in_Canada/links/56709ce608ae5252e6f1f39e/Linking-gender-climate-change-adaptive-capacity-and-forest-based-communities-in-Canada.pdf?origin=publication_detail>

Pearce, T., Ford, J.D., Caron, A. and Kudlak, B.P. (2012). Climate change adaptation planning in remote, resource-dependent communities: An Arctic example. Regional Environmental Change, 12(4), 825–837. Retrieved February 2020, from <https://doi.org/10.1007/s10113-012-0297-2>

Pearce, T., Ford, J., Cunsolo Willox, A. and Smit, B. (2015). Inuit Traditional Ecological Knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. Arctic, 68(2), 233–245. Retrieved February 2020, from <http://www.jstor.org/stable/43871322>

Picketts, I.M., Parkes, M.W. and Déry, S.J. (2017). Climate change and resource development impacts in watersheds: Insights from the Nechako River Basin, Canada. The Canadian Geographer, 61(2), 196–211. Retrieved February 2020, from <https://doi.org/10.1111/cag.12327>

Pizzolato, L., Howell, S.E.L., Derksen, C., Dawson, J. and Coplan, L. (2014) Changing sea ice conditions and marine transportation activity in Canadian Arctic waters between 1990 and 2012. Climate Change, 123, 161–173. Retrieved February 2020, from <https://doi.org/10.1007/s10584-013-1038-3>

Province of New Brunswick (2016). Transitioning to a low-carbon economy: New Brunswick's climate change action plan. Retrieved February 2020, from <https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf>

Public Health Agency of Canada (2017). Climate change impacts on the health of Canadians. Retrieved February 2020, from <http://publications.gc.ca/collections/collection_2017/aspc-phac/HP5-122-2017-eng.pdf>

Rapaport, E., Manuel, P., Krawchenko, T. and Keefe, J. (2015). How can aging communities adapt to coastal climate change? Planning for both social and place vulnerability. Canadian Public Policy, 41(2), 166–177. Retrieved February 2020, from <http://doi.org/10.3138/cpp.2014-055>

Reed, M.G., Scott, A., Natcher, D. and Johnston, M. (2014). Linking gender, climate change, adaptive capacity, and forest-based communities in Canada. Canadian Journal of Research, 44(9), 995-1004. Retrieved February 2020, from <http://doi.org/10.1139/cjfr-2014-0174>

Rojas-Downing, M.M., Nejadhashemi, A.P., Harrigan, T. and Woznicki, S.A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management, 16, 145–163. Retrieved December 2020, from <https://doi.org/10.1016/j.crm.2017.02.001>

Roussin, R., Wilson, J., Utzig, G. and Lavkulich, L. (2015). Assessing the potential for pocket agriculture in mountainous regions: A case study in West Kootenay, British Columbia, Canada. Journal of Agriculture, Food Systems, and Community Development, 6(1), 175–188. Retrieved February 2020, from <http://dx.doi.org/10.5304/jafscd.2015.061.016>

Rutty, M., Scott, D., Johnson, P., Pons, M., Steiger, R. and Vilella, M. (2017). Using ski industry response to climatic variability to assess climate change risk: An analogue study in Eastern Canada. Tourism Management, 58, 196–204. Retrieved February 2020, from <https://doi.org/10.1016/j.tourman.2016.10.020>

Sauchyn, D. (2017). Climate change adaptation on the farm and ranch. Policy Options. Retrieved February 2020, from: <http://policyoptions.irpp.org/magazines/may-2017/climate-change-adaptation-on-the-farm-and-ranch/>

Savo, V., Morton, C. and Lepofsky, D. (2017). Impacts of climate change for coastal fishers and implications for fisheries. Fish and Fisheries, 18(5), 877–889. Retrieved February 2020, from <https://doi.org/10.1111/faf.12212>

Sawatzky, A., Cunsolo, A., Gillis, D., Shiwak, I., Flowers, C., Cook, O., Wood, M., the Rigolet Inuit Community Government, and Harper, S. (2017). Profiling the eNuk program: An Inuit-led strategy for monitoring and responding to the impacts of environmental change on health and well-being in Rigolet, Nunatsiavut. Northern Public Affairs, 5(2). Retrieved February 2020, from <http://www.northernpublicaffairs.ca/index/wp-content/uploads/2017/07/npa_5_2_july_2017_pg18-22.pdf>

Schroth, O., Pond, E. and Sheppard, S. R. (2015). Evaluating presentation formats of local climate change in community planning with regard to process and outcomes. Landscape Urban Planning, 142, 147–158. Retrieved February 2020, from <https://doi.org/10.1016/j.landurbplan.2015.03.011>

Science and Survival at Fort Conger (2015). Why we're still fascinated by Fort Conger. Retrieved February 2020, from <http://fortconger.org>

Shaw, A., Burch, S., Kristensen, F., Robinson, J. and Dale, A. (2014). Accelerating the sustainability transition: Exploring synergies between adaptation and mitigation in British Columbian communities. Global Environmental Change, 25(1), 41–51. Retrieved February 2020, from <http://dx.doi.org/10.1016/j.gloenvcha.2014.01.002>

Sorensen, C. (2016). How snowless ski resorts are adapting to climate change. MacLeans. Retrieved February 2020, from: <https://www.macleans.ca/economy/business/how-snowless-ski-resorts-are-adapting-to-climate-change/>

Statham, S., Ford, J., Berrang-Ford, L., Lardeau, M.P., Gough, W. and Siewierski, R. (2015). Anomalous climatic conditions during winter 2010–2011 and vulnerability of the traditional Inuit food system in Iqaluit, Nunavut. Polar Record, 51(3), 301–317. Retrieved February 2020, from <https://doi.org/10.1017/S0032247414000151>

Statistics Canada (2016). Census of population. Ottawa, Ontario, Canada. Retrieved February 2020, from <https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Geo2=PR&Code2=01&SearchType=Begins&SearchPR=01&TABID=1&B1=All&type=0&Code1=3506008&SearchText=ottawa>

Stoddart M.C.J. and Sodero S. (2015). From fisheries decline to tourism destination: Mass media, tourism mobility, and the Newfoundland coastal environment. Mobilities, 10(3), 445–465. Retrieved February 2020, from <https://doi.org/10.1080/17450101.2013.860281>

Studio 531(2019). Tofino indoor recreation centre. Retrieved February 2020, from <https://tofino.civicweb.net/filepro/document/91262/Recreation%20Facility%20Design%20Report.pdf>

Sullivan, I. (2018). Impacts of climate change on Qalipu First Nation communities. Retrieved February 2020, from <https://grosmorneclimatesymposium.files.wordpress.com/2018/09/impactclimatechangeqfn_slides.pdf>

Taylor, M.M. (2019). Public health solutions to rural health disparities, Chapter 3 in Rural Health Disparities. Springer, 25–35. Retrieved February 2020, from <https://link.springer.com/book/10.1007%2F978-3-030-11467-1>

The Ontario Bar Association (2015). Ontario's climate change discussion paper. Ottawa, Ontario, Canada. Retrieved February 2020, from <https://www.oba.org/CMSPages/GetFile.aspx?guid=f35f4dbb-ea42-4178-aa28-a7835e80b568>

Tschakert, P., Barnett, J., Ellis, N., Lawrence, C., Tuana, N., New, M., Elrick-Barr, C., Pandit, R. and Pannell, D. (2017). Climate change and loss, as if people mattered: Values, places, and experiences. Wiley Interdisciplinary Reviews: Climate Change, 8(5). Retrieved February 2020, from <https://doi.org/10.1002/wcc.476>

Tschakert, P., Ellis, N., Anderson, C., Kelly, A. and Obeng, J. (2019). One thousand ways to experience loss: A systematic analysis of climate-related intangible harm from around the world. Global Environmental Change, 55, 55–72. Retrieved February 2020, from <https://doi.org/10.1016/j.gloenvcha.2018.11.006>

Vasseur, L., Thornbush, M. and Plante, S. (2015). Gender-based experiences and perceptions after the 2010 winter storms in Atlantic Canada. International Journal of Environmental Research and Public Health, 12(10), 12518–12529. Retrieved February 2020, from <https://dx.doi.org/10.3390%2Fijerph121012518>

Vasseur, L., Thornbush, M. and Plante, S. (2017). Climatic and environmental changes affecting communities in Atlantic Canada. Sustainability, 9(8), 1–10. Retrieved February 2020, from <https://doi.org/10.3390/su9081293>

Vodden, K., Douglas, D., Minnes, S., Markey, S., Reimer, B. and Breen, S. (2019). Conclusions: Implications for policy and practice, Chapter in The Theory, Practice, and Potential of Regional Development: The Case of Canada, (Eds.) K. Vodden, D. Douglas, S. Markey, S. Minnes and B. Reimer, Routledge, London, United Kingdom, 212–234. Retrieved February 2020, from <https://doi.org/10.4324/9781351262163>

Vodden, K., Catto, N., Irvine, M., Parewick, K. and Renaud, N. (2012). 7 Steps to Assess Climate Change Vulnerability in Your Community. Memorial University, Department of Geography. Prepared for the Atlantic Canada Adaptation Solutions Association and the Department of Environment & Conservation, 1–278: <https://www.turnbackthetide.ca/pdf/7_Steps_Tool.pdf>

Warren, F.J. and Lemmen, D.S., (Eds.) (2014). Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation. Government of Canada, Ottawa, Ontario, 286 p. Retrieved February 2020, from <https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/assess/2014/pdf/Full-Report_Eng.pdf>

Weatherdon, L.V., Magnan, A.K., Rogers, A.D., Sumaila, U.R. and Cheung, W.W.L. (2016). Observed and projected impacts of climate change on marine fisheries, aquaculture, coastal tourism, and human health: An update. Frontiers in Marine Science 3(48). Retrieved February 2020, from <https://doi.org/10.3389/fmars.2016.00048>

Webster, Tim. L. (2010). Flood risk mapping using LiDAR for Annapolis Royal, Nova Scotia, Canada. Remote Sensing, 2(9), 2060–2082. Retrieved February 2020, from: <https://doi.org/10.3390/rs2092060>

Webster, T., McGuigan, K., Collins, K. and MacDonald, C. (2014). Integrated river and coastal hydrodynamic flood risk mapping of the Lahave River estuary and town of Bridgewater, Nova Scotia, Canada. Water, 6(3), 517–546. Retrieved February 2020, from <https://doi.org/10.3390/w6030517>

Williams L., Fletcher A., Hanson, C., Neapole, J. and Pollack, M. (2018). Women and climate change impacts and action in Canada. Retrieved February 2020, from: <https://www.criaw-icref.ca/images/userfiles/files/Women%20and%20Climate%20Change_FINAL.pdf>

Wolf, J., Allice, I. and Bell., T. (2012). Values, climate change, and implications for adaptation: Evidence from two communities in Labrador, Canada. Global Environmental Change, 23(2), 548–562. Retrieved February 2020, from <https://doi.org/10.1016/j.gloenvcha.2012.11.007>

Women's Environment and Development Organization (2018). Climate change and gender in Canada: A review. Retrieved February 2020, from <https://wedo.org/wp-content/uploads/2018/04/GGCA-CA-RP-07.pdf>

World Wildlife Fund (2019). Canadian Arctic greywater report: Estimates, forecasts and treatment technologies. Retrieved February 2020, from <http://d2akrl9rvxl3z3.cloudfront.net/downloads/wwf_canada_grey_water_report_2018_1.pdf>

Young, S., Tabish, T., Pollock, N. and Young, T. (2016). Backcountry travel emergencies in Arctic Canada: A pilot study in public health surveillance, International Journal of Environmental Research and Public Health, 13(3), 276. Retrieved February 2020, from <https://doi.org/10.3390/ijerph13030276>

Yukon Legislative Assembly (2017). Fall sitting. Number 32, 2nd session, 34th legislature. Retrieved February 2020, from <https://yukonassembly.ca/sites/default/files/inline-files/Journals-34-2-2017-10-03-2017-11-27.pdf>

Yusa, A., Berry, P., Cheng, J., Ogden, N., Bonsal, B., Stewart, R. and Waldick, R. (2015). Climate change, drought and human health in Canada. International Journal of Environmental Research and Public Health, 12(7), 8359–8412. Retrieved February 2020, from <https://doi.org/10.3390/ijerph120708359>

4-H Ontario. (n.d.). Field crops, weeds, insects, and disease. Retrieved April 9, 2020, from <https://4-hontario.ca/youth/club-projects/field-crops-weeds-insects-diseases-project/>