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Climate Change and the Upper St'at'imc Territory

Poverty Action Research Project

Centre for Indigenous Research and Community-Led Engagement

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It is noteworthy to mention that this report consists of direct quotes and information acquired from a variety of sources, including international and national reports, agreements, journal articles and internet materials. The original sources and authors are acknowledged using parenthetical in-text citations to document quotations, paraphrases and summaries throughout the report. Bibliographic entries are also found in the Reference Section of this document. This report is not intended in any way to replace the originality their work.

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ACRONYMS

BC Hydro	British Columbia Hydro and Power Authority
CBC	Canadian Broadcasting Corporation
EPFL	École Polytechnique Fédérale de Lausanne University
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Green House Gas
GPS	Global Positioning System
IIPFCC	International Indigenous Peoples Forum on Climate Change
IOHP	Igloolik Oral History Project
IPCC	Intergovernmental Panel on Climate Change
PCIC	Pacific Climate Impacts Consortium
SER	St'at'imc Eco-Resources
SLRD	Squamish-Lillooet Regional District
UBC	University of British Columbia
UNFCCC	United Nations Framework Convention on Climate Change
WC^2N	Western Canadian Cryospheric Network
WHO	World Health Organization
WUP	Bridge River Water Use Plan
WWF	World Wide Fund for Nature

KEY DEFINITIONS

Adaptation	Adaptation refers 'to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change" (UNFCCC, 2014, para. 1).
Adaptive capacity	"Adaptive capacity refers to the community's ability to adapt to changes, and is typically a function of things such as income, education level, and social structures" (Reid et al., 2014, p 408, as cited in Ingram and Hamilton, 2014).
Bridge River Water Use Plan	"a technical document that, once reviewed by provincial and federal agencies and accepted by the provincial Comptroller of Water Rights, defines how water control facilities will be operated" (BC Hydro, n.d).
Community exposure	Exposure refers to those climate changes that are already being felt and those systems that are exposed to future climate variations (Reid et al., 2014, p. 408, as cited in Fussel and Klein 2006).
Community sensitivity	"Sensitivity, in the climate change context, refers to the degree to which a community is affected by the climatic change that they are exposed to" (Reid et al., 2014, p. 408).
Climate Change	"change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations, 1992, p. 7).
Dothistroma needle blight	"Dothistroma needle blight, caused by the fungus *Dothistroma septosporum*, is a major pest of pine plantations in the Southern Hemisphere... it "causes extensive defoliation and mortality in plantations of lodgepole pine in northwestern British Columbia, Canada" (Woods et al., 2005, p. 761).
Extreme heat	Extreme heat events are "periods of abnormally hot and often humid weather, are dangerous to some and can result

	in increased rates of heat-related mortality and morbidity" (Health Canada, 2011, para. 9).
Food insecurity	Food insecurity occurs "when food systems are stressed so that food is not accessible, available, and/or of sufficient quality" (Beaumier and Ford, 2010, para. 1).
Food security	"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Food and Agriculture Organization (FAO), 2006, para. 1).
Glacial recession or retreat	Glacial retreat occurs when the "glacier's terminus doesn't extend as far down valley as it previously did; occurs when ablation surpasses accumulation" (National Snow and Ice Data Centre, 2016, para. 1).
Global warming	"Global warming is the increase in Earth's average surface temperature due to rising levels of greenhouse gases" (National Aeronautics and Space Administration, 2008, para. 2).
Mitigation	Mitigation is "a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere" (UNFCCC, 2014).
Mold/mildew	"Molds are fungi that can be found both indoors and outdoors. Molds grow best in warm, damp, and humid conditions, and spread and reproduce by making spores" (CDC, 2014, para. 1).
Mountain pine beetle	"The mountain pine beetle (MPB) is a native insect that attacks pines in western North American forests" (Government of Canada, n.d).
Participatory-based approach	"Community-based participatory research is a "collaborative approach to research that equitably involves all partners in the research process and recognizes the

	unique strengths that each brings" (Community-Campus Partnerships for Health, 2013, para. 1)
Resilience	Community resilience "is the capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change" (Community and Regional resilience Institute, 2013, p. 10).
Settlement agreement	A legal agreement made among St'át'imc, the Province of British Columbia and BC Hydro that "provides mitigation, compensation, and an ongoing long-term relationship to address all past, present, and future impacts, grievances, and claims of the St'át'imc related to the construction and operation of existing BC Hydro facilities. It also provides the Province and BC Hydro with operational certainty for these facilities into the future" (World Wide Fund for Nature Canada, 2014, p. 30).
Sustainable development	"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (International Institute for Sustainable Development, n.d, para. 1).
Traditional/local knowledge	Traditional knowledge (TK) "is knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity" (World Intellectual Property Organization, n.d, para. 1).
Values assessment	Identification of key community values and objectives with regards to climate change (Reid et al., 2014, p. 408).
Vulnerability assessment	"The assessment of current vulnerability requires analyzing and documenting communities' experiences with climatic risks (current exposure) and the adaptive options and resource management strategies employed to address these risks (current adaptive capacity)" (Ford and Smit, 2014, p. 395).

1.0 ABSTRACT

Canada ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. This agreement came into force in 1994 (United Nations Framework Convention on Climate Change, 2014). The UNFCCC defines Climate Change as "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations, 1992, p. 7).

In recent years, studies have shown that British Columbia's environment have been adversely affected (directly and indirectly) by variations in climatic conditions. Impacts, such as the mountain pine beetle (*Dendroctonus ponderosae*) infestation, which as a result of warmer winters, that devastated the forest industry between 1990 - 2008 (Woods, 2011; Furness and Nelson, 2012; Cox, Gardner and Fraser, 2015); the seasonal droughts of 2003 and 2009, which resulted from limited or lack of water supply; and the wildfires of 2003 (Ministry of Environment, 2010), which occurred in the town of Kelowna, that unfortunately destroyed about 300 homes and eradicated approximately 260,000 hectares of forest lands and resources (Pacific Institute for Climate solutions, 2008; "Climate change is a growing concern in B.C., says scientist," 2015).

The Intergovernmental Panel on Climate Change (IPCC, 2014) concludes that climate change is "unequivocal" and "unprecedented" (p. 2). Changes in weather and climate; such as, increase in warm temperatures, increase in precipitation, rise in sea levels, and melting of snow and ice are the results of anthropogenic activities or human influences (IPCC, 2014; Gayton, 2008).

People across the globe; including Canada, have noticed these changes in their environment and are learning to adapt in order to survive. This statement is mainly true of indigenous and local communities across British Columbia who are strongly connected to the natural environment for subsistence, and for the preservation of their culture (Krishnaswamy, Simmons and Joseph, 2012;

Turner and Clifton, 2009; Downing and Cuerrier, 2011). However, because of the frequency of fluctuations in weather patterns and the intensity of natural disasters (as a result of climate change), communities are unable to make predictions using traditional knowledge; and as such, have become vulnerable, plummeting their resilience to the impacts of climate change (Turner and Clifton, 2009). Indigenous people (including, First Nations and Inuit communities) in comparison to the rest of the world are also more susceptible to the impacts of climate change due to their challenging economic situation, their remote locations, and their heavy dependence on the environment (Krishnaswamy et al., 2012).

SECTION 1

The first Section of this report explores climate change impacts and also provides information on future climate change risks across the province of British Columbia, specifically as it relates to the Upper St'at'imc Territory. This document also outlines the implications of climate change on community activities and lifestyle; including, agriculture (farming) and food security, fishing, hunting, logging, food collecting and/or gathering; and highlights the effects of climate change on community culture. In this synthesis, examples of management practices in the form of case studies will be discussed in detail. This section of the report will identify adaptation and mitigation strategies that are currently being implemented by various communities across Canada in an effort to alleviate the effects of climate change. These examples can be integrated into current and future community plans and strategies for the St'at'imc Territory to strengthen their resilience to natural disturbances and climate change. This section of the report concludes with recommendations for First Nation communities, taking into consideration key aspects and findings that were addressed throughout the report.

SECTION 2

Second two of this report addresses the impacts of climate change on the Bridge River Power Development (also known as the Bridge-Seton Hydroelectric System). This section highlights the general operations of the hydroelectric power system; the concerns of BC Hydro and the Upper St'at'imc Territory; the current and projected effects of changing climate on the hydroelectric

system; and outlines brief recommendations which may help enable BC Hydro adapt to the inevitable effects of climate change.

1.1 Goal

To inform the Upper St'at'imc Territory about climate change risks and impacts, and to provide examples of successful management practices that can be used to strengthen their resilience.

1.2 Objectives

Section 1

Section 1 identifies, through a variety of case studies, the approaches and/or best practices that are currently being implemented by communities across Canada. Consequently, this section will provide community leaders, managers and relevant stakeholders with a better understanding of the most suitable approaches or strategies necessary to reduce the effects of climate change in the Upper St'at'imc Territory, taking into consideration the current sensitivities of the Territory.

- To describe the effects of climate change in the province of British Columbia, specifically within the St'at'imc Territory;

- To identify the implications of climate change on community activities and lifestyle; including, agriculture (farming) and food security, fishing, hunting, logging, food collecting and/or gathering;

- To identify and evaluate management response strategies (adaptation and mitigation) that are currently being used by communities across Canada to alleviate the effects of climate change; and

- To make recommendations as to which strategies may prove most effective in managing communities' response to climate change.

Section 2

Section 2 of this report identifies through research, the current and projected challenges of the Bridge River Power Development System as a consequence of climate change. This document will provide managers, engineers and scientists of the Bridge River Power Development System with a consolidated report, describing the present and potential challenges of the hydroelectric system. It will also outline recommendations for adaptation based on studies that were successfully conducted by renowned researchers and scientists.

- To discuss current and projected impacts of climate change on the Bridge River Power Development (also known as the Bridge-Seton Hydroelectric System); and

- To identify adaptation responses that will help BC Hydro effectively adjust its hydroelectric system to the influences of climate change.

1.3 Methodology

- A literature review was conducted (for **Section 1**) to provide a synopsis of the impacts of climate change within the province of British Columbia, and specifically within the Upper St'at'imc Territory. Information relating to future climate risks and/or predictions was also addressed.

A second literature was done (for **Section 2**) to highlight the current and projected impacts of climate change on BC Hydro's Bridge River Power Development System. This research included skype meetings and conference calls with the PARP Community Project Manager and representatives from the St'at'imc Eco-Resource Limited and the St'at'imc sub-committee.

The overall review process garnered relevant information from documents; including, scientific and academic journal articles, reports and internet materials.

- **Section 1**: Specific attention was drawn to a cross-section of case studies where adaptive response strategies have already been implemented by various communities across Canada.

- **Section 2**: This section of this report specifically discusses research related to two major concerns of BC Hydro: 1.) Glacial recession or retreat and 2.) Dam safety.

- The information gathered was assessed, taking into consideration the current situation of the St'at'imc Territory and the present challenges of BC Hydro as the consequence of climate change.

The overall purpose of **Section 1** is to provide communities with examples of successful coping mechanisms to reduce their vulnerabilities, and to strengthen their resilience to the adverse effects of climate change and global warming in British Columbia.

The primary focus of **Section 2** is to highlight current concerns of BC Hydro, and to provide brief recommendations on how their hydroelectric system can adapt to current and future climate change impacts.

SECTION 1

2.0 INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is described as "unequivocal" and "unprecedented" (p. 2). Since the 1950s, unsystematic changes in weather and climatic patterns have been observed (IPCC, 2014). In recent years, these changes have resulted in natural disturbances, which have become increasingly frequent and more intense.

Studies suggest that there have been increase in warm temperatures, increase in precipitation, rise in sea levels, and melting of snow and ice (IPCC, 2014; Gayton, 2008; Krishnaswamy et al., 2012; Downing and Cuerrier, 2011). Costello et al. (2009) identified climate change as the "biggest global health threat of the 21st century" (para. 1) and predicted that the earth's average surface temperature is likely to exceed 2°C (which is considered the utmost temperature for life forms to adjust). Costello et al. (2009) also predict that there will be a 4°C - 5°C rise in temperature in northern Canada by 2090, which will affect the lives and welfare of billions of people worldwide. The IPCC expects a rise in global temperatures over the next 100 years by 1.4°C - 5.8°C. However, according to Nordhaus (2007), temperatures above 4°C is expected to be catastrophic to humanity and earth's natural systems. There is also a high level of confidence that changes in temperatures, resulting in global warming, emanates from anthropogenic activities or human influences; such as the burning of fossil fuels, agricultural activities and deforestation (IPCC, 2014; Gayton, 2008; Ministry of Forests, Lands and Natural Resource Operations, 2009).

Climate Change Planning is of particular interest in British Columbia since the province is the only place in North America that has enacted the *Local Government Statutes Amendment Act* (*Bill 27*). This Bill requires that municipal community plans include policies, measures and actions in order to mitigate greenhouse gas emissions (Baynham and Stevens, 2014). Studies have shown; however, in recent years, that the climate of British Columbia has warmed significantly, affecting the physical and biological systems.

3.0 CLIMATE CHANGE IMPACTS AND PREDICTIONS IN BRITISH COLUMBIA

3.1 Changes in temperature, Sea levels and Precipitation

Historical records suggest that the average annual temperatures across the province have risen by 0.5°C - 1.7°C (LiveSmart BC, n.d; Ministry of Environment, 2015). Average annual temperatures have increased by 0.6°C on the coastland regions, by 1.1°C in the interior regions, and by 1.7°C in the northern regions of British Columbia (West Coast Environmental Law, 2012; Gayton, 2008).

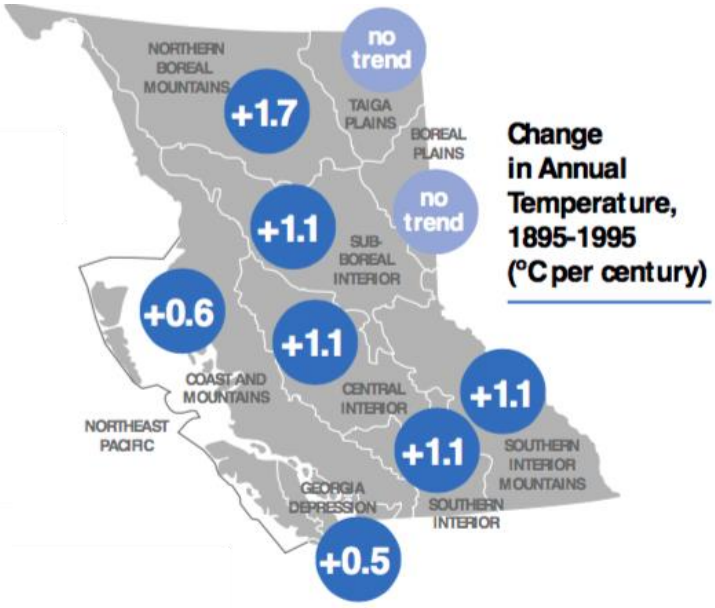

Figure 1: Temperature increases across the province of British Columbia (Source: Ministry of Water, Land and Air Protection, 2002)

Climate models suggest that by 2100, the average temperature per year across the province will increase by 1°C - 4°C. Furthermore, predictions indicate that the interior regions will warm at a faster rate than the coastal areas. However, temperatures in the northern regions are expected to rise sooner in comparison to other areas of the province (Gayton, 2008; West Coast Environmental Law, 2012; Ministry of Water, Land and Air Protection, 2002).

Precipitation is a "fundamental aspect "and "key indicator" of climate change (para.1). The Ministry of Environment (2015) affirms that the annual average precipitation for the province of British Columbia has increased by 12% per century. Gayton (2008) confirms that the average annual precipitation in southern part of the province has increased by 2% - 4% per decade between 1929 and1998. Generally, literature suggests that annual precipitation has been increasing throughout the province trending more so in the form of rainfall and less snow (Sanderson et al., 2015). The Ministry of Water, Land and Air Protection (2002) predicts that the annual precipitation of the province will increase by 10% - 20% over the 21st century. Other studies illustrate that British Columbia will obtain up to 26% more precipitation in some of its areas (West Coast Environmental Law, 2012).

Gayton (2008) reiterates that between1941 - 2001 sea surface temperatures rose by 0.9°C - 1.8°C. Average sea levels have increased by 4cm - 12 cm along the coastal regions to levels of 16cm - 34 cm in the Vancouver area. The Ministry of Water, Land and Air Protection (2002) expects sea levels to rise to about 88 cm along various parts of the coast, and by 2050 sea levels will continue to rise to about 50 cm along the northern Yukon coast (Livesmart BC, n.d). Studies have also illustrated that snow depth and snow water contents have declined in various parts of the province. For example, between 1945 and 1993, lakes and rivers became ice-free in the early parts of spring. Research has also shown that mountain glaciers, which are known to regulate summer stream temperatures and play a vital role in aquatic ecological systems, are melting rapidly (Moore et al., 2007). Sanderson et al. (2015), LiveSmart BC. (n.d), Gayton (2008) and West Coast Environmental Law (2012) confirmed that two glaciers, located in the southern part of British Columbia (between 1895 and1995), have reduced significantly by more than 1km respectively.

3.2 Changes in the Fraser River and the impacts on fish species

Another indicator of climate change is the observed documented changes of the Fraser River. The Fraser River is approximately 217,000 Km^2 and flows for about 1370 km (Morrison et al., 2002). The headwaters of Fraser River are located near Jasper, Alta in the Rocky Mountains, whereas the end of the river discharges into the Strait of Georgia in close proximity to the Vancouver area (Morrison et al., 2002). This river is an essential spawning ground for Sockeye and Chinook

salmon, and has been described as the most important river system in North America for Salmon production (Jacob, Mc Daniels and Hinch, 2010). It is also economically valuable to the commercial fishing industry in Canada.

Records dating back to 1912; however, indicate that the Fraser River has been changing over time. Temperatures as high as 21.2°C were recorded in August of 1998, and as low as 11°C were recorded in July of 1955 (Morrison et al., 2002). In the summer of 2004, the temperature of the River was 20°C to 21°C. These temperatures can be fatal to sockeye salmon since they prefer cooler temperatures of 15°C or less. Gayton (2008) also emphasised that Fraser River releases its "total annual flow earlier in the year" (p. 2) than usual. Such rapid changes in temperatures and flow rates can adversely impact the survival of salmon. In fact, various authors have analysed the potential impact of climate change on the lifecycle of the salmon, and have stated that lower reproduction rates are linked to warmer temperatures. These authors have also concluded that salmon production will continue to decline as long as there is changing climate (Hinch and Martins, 2011; Jacob et al., 2010).

3.3 Changes to the forestland and forest industry in British Columbia

3.3.1 The Mountain Pine Beetle infestation

The mountain pine beetle (*Dendroctonus ponderosae*) infestation is another indirect consequence of climate change because of warmer winters. This outbreak occurred during the period 1990 - 2008 in the northwest region of British Columbia and has devastated the forest industry (Woods, 2011; Furness and Nelson, 2012; Cox, Gardner and Fraser, 2015).

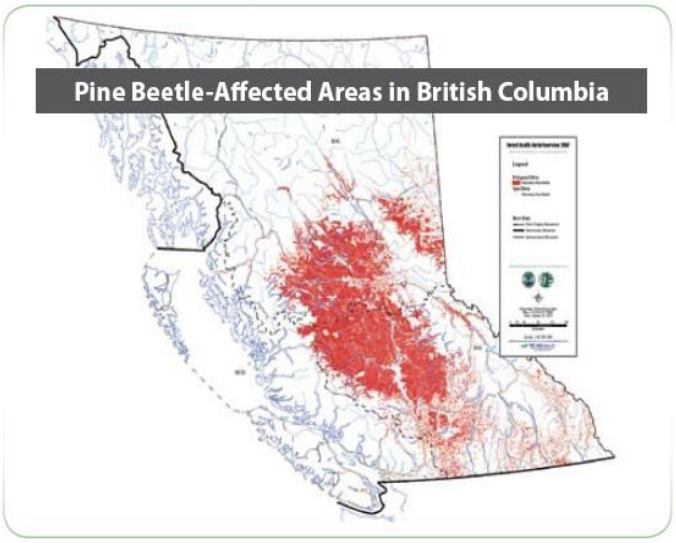

Figure 2: Areas in British Columbia affected by the Mountain Pine Beetle (Source: Livesmart BC, n.d)

This infestation has negatively affected more than 14.5 million hectares of forestland across the interior and has disturbed ecosystems and the economic viability of forest-dependent communities, and has confounded the economy of the province (Woods, 2011; Ministry of Environment, 2010). According to Safranyik and Carroll (2006), extreme winter temperatures have been responsible for curtailing the lifecycle of the mountain pine beetle, however because of the current climatic trends and projections, predictions illustrate that this type of environmental control may no longer be a viable option. Studies suggest that the mountain pine beetle may, because of warmer climates, "expand its range" (The Ministry of Water, Land and Air Protection, 2002, p. 4). Research also indicates that the initial development of mountain pine beetle epidemic coincided with increased trends of warmer temperatures and climate of 2°C - 4°C (Woods et al., 2005; Woods, 2011). Carroll et al. (2003) stressed that the mountain pine beetle population expanded from 1921 - 1950 to 1971 - 2000 because of suitable climatic habitats.

3.3.2 Dothistroma needle blight - *Dothistroma septosporum* fungus

Apart from the mountain pine beetle, increased summer precipitation has resulted in the development of **Dothistroma needle blight** of pine trees. Dothistroma needle blight is caused by the *Dothistroma septosporum* fungus, which is considered a pest to conifer or pine trees within the southern hemisphere of British Columbia. Woods et al. (2005) confirmed that *Dothistroma septosporum fungus* has caused extensive foliar disease and mortality in lodgepole pine plantations located in the northwestern region of British Columbia. According to Woods (2011), Peterson (1973) and Gadgil (1974) stipulated that prolonged moisture in combination with warmer temperatures between 15°C - 20°C are ideal for the development of the fungus and optimal conditions for infestation. Woods, Coates and Hamann (2005), in supporting the work of Peterson (1973) and Gadgil (1974), found that a clear relationship exists between changing climatic conditions and the Dothistroma needle blight infestation. Woods et al. (2005) also indicated that the infestation is expected to continue as long as there is increased summer precipitation. Furness and Nelson (2012) also predicted that the provincial forests will suffer from diseases as a result of increased insect infestation, further biotic damage, migration of species and habitat loss.

In addition to the major economic implications on the forest industry, other consequences associated with the above-mentioned infestations are forest fires. Dead standing pinewood in combination with warmer temperatures is reportedly an ideal condition for wildfires across the province (Pacific Institute for Climate solutions, 2008; Picketts et al., 2012). These conditions will also reduce air quality, increase drought and heat waves, intensify water runoff patterns and escalate the potential for flooding (Pacific Institute for Climate solutions, 2008; British Columbia Government, n.d). Forest fires are also known to significantly damage infrastructure and properties. For example, the wildfires of 2003 and 2009 (Ministry of Environment, 2010) were recorded as "the most dangerous and extensive wildfire seasons" (para. 5) in the province. The wildfires of 2003, which occurred in the town of Kelowna, unfortunately destroyed more than 300 homes and eradicated approximately 260,000 hectares of forestlands and resources (Pacific Institute for Climate solutions, 2008; "Climate change," 2015). Consequently, the estimated restoration cost is at $700 million (British Columbia Government, n.d).

According to the Pacific Institute for Climate solutions (2008), Patriquin et al. (2005) predicted that fire and floods would occur specifically within regions that have been affected by the mountain pine beetle. In fact, predictions indicate that by the year 2045 there will be an increase in the length of the province's fire season of 1 - 2 weeks and an increase in temperatures of 1°C - 2°C (Columbia Mountains Institute of Applied Ecology, 2005). The Columbia Basin Trust shares similar views, and predicts warmer temperatures and lengthier fire seasons in the Columbia Basin. These conditions will increase the risks of floods, forest erosion, droughts and landslides (Columbian Basin Trust, 2003) in the area.

3.4 Sedimentation

In addition, areas affected by landslides or runoffs are also vulnerable to sedimentation, which may affect the quality of water. For example, in 2006, the residents of the Greater Vancouver Regional District were affected by sedimentation in their water supply. Consequently, they were notified of a boil-water advisory. This situation left more than 2 million people affected by high sedimentation load (The Pacific Institute for Climate solutions, 2008).

3.5 Droughts

Droughts are also a common phenomenon during the summer seasons. Changes in climate contribute to increased temperatures, reduced rainfall and less snow resulting in extended and severe droughts (LiveSmart BC, n.d). The province of British Columbia has already experienced intense droughts during the period 2003 and 2009 (Ministry of Environment, 2010). According to the Hunter (2015), dry conditions have been observed across the southern part of the province towards Haida Gwaii, and it has been reported that river levels continue to reside on Vancouver Island. Frequent and more severe droughts are expected to persist contributing to water shortages. This outcome will facilitate increased competition among water users; including, local communities, industry, fisheries, municipalities and recreation sectors (LiveSmart BC, n.d).

3.6 Agriculture and Food Security

Apart from the forest industry, changes in climate and weather also threaten food security across the province, particularly the agriculture and fishing industries.

> *Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life* (Food and Agriculture Organization (FAO), 2006, para.1).

According to the Government of Canada (2015), the agriculture industry contributes more than $100 million Canadian dollars to the country's gross domestic product (GDP) on an annual basis. In fact, Canada has been rated as the "5th largest agricultural exporter in the world" (para. 3). Nevertheless, the agriculture sector, specifically the agriculture sector in British Columbia, remains vulnerable for a number of reasons: 1.) small, family-owned farms seem to be more prevalent throughout the province than larger farms; 2.) there is limited land base for agricultural production; and 3.) the growth and development of the industry emanates mainly from an aging population rather from the youths or the younger generation (Pacific Institute for Climate Solutions, 2013). Such vulnerabilities coupled with the cumulative impacts and uncertainties of

climate change may pose greater risks for the agricultural sector and the local food industry across the province.

Additionally, farmers to date have expressed a variety of concerns in relation to climate change. For example, concerns were raised about increased water shortages, earlier growing seasons of crops, and the rate at which their crops are maturing because of increased summer temperatures. Other challenges highlighted were the exposure of fertile soils to salt water (because of high tides overtopping dikes), and a surge in insect infestations and invasive species due to warmer temperatures ("Climate change," 2015).

Although, increased temperatures may affect the growth of some crops, warmer temperatures may create opportunities for the production of new crops. According to Hunter (2015), farmers raised concerns about irrigation problems and the impacts of high temperatures on the production of the Okanagan cherry. Conversely, farmers in the area are now able to grow Canola. Researchers predict that increased temperatures or warmer climatic conditions could significantly benefit horticulture practices, promote lengthier growing seasons, and could noticeably increase the productivity of crop growth (Zebarth, Caprio, Broersma, Mills and Smith, 1997). Therefore, by 2020, it may be physically possible and economically feasible to produce crops that grow in warmer weather conditions; including, melons, coloured peppers, cereals and potatoes (Zebarth, et al., 1997; Pacific Institute for Climate Solutions, 2008).

Despite the above-mentioned agricultural benefits of climate change, and the fact that changing weather patterns may potentially offer better hunting opportunities due to longer, warmer summers, the overall present and projected impacts are believed to be adverse (Ford, Pearce, Duerden, Furgal and Smit, 2010; Turner and Clifton, 2009). Food insecurity therefore remains a primary consequence due to the impacts of climate change on the agriculture industry across the province and throughout Canada.

Food insecurity has predominantly been observed in poverty-stricken rural communities who depend heavily on the natural environment for subsistence (Downing and Cuerrier, 2011). According to Beaumier and Ford (2010), food insecurity occurs "when food systems are stressed

so that food is not accessible, available, and/or of sufficient quality" (para.1). Statistics illustrate that Nunavut, the youngest territory of Canada, has the highest recorded rate of food insecurity at 36.7%, occurring from 2011 - 2012 (Statistics Canada, n.d). Furthermore, Beaumier and Ford (2010) reiterated that about 56% of the Inuit population, who resides in Nunavut, has been categorized as food-insecure. The Inuit communities survive on a combination of store foods and foods attained from subsistence hunting and fishing activities. However, challenges such as remote or isolated living conditions, high unemployment rates, and poor health are believed to have contributed to food insecurity among these communities (Beaumier and Ford, 2010).

Additionally, the Igloolik, a coastal Inuit community (located in Nunavut) have noticed changes in climatic conditions, which have compromised their food security. The Igloolik community has access to a number of hunting sites on their island; however, this is dependent on the conditions of the sea ice trail from November to July, and boat access in the summer seasons (Beaumier and Ford, 2010). In recent years; however, men who participate in hunting activities have seen first-hand, a decline in the number of the wild animals during these seasons. Women in the community can also attest to the reduced numbers of caribou, seals and walrus meat, which affirms their struggle with food availability on a regular basis (Beaumier and Ford, 2010).

> *When the ice used to be plentiful around here, there was numerous and numerous walrus. That's not so anymore. We have not caught any walrus, near from here around yet this year* (Anonymous) (Beaumier and Ford, 2010, p. 200).

First Nation communities that are positioned along the pacific coastal regions of Canada, also rely heavily on small-subsistence and/or commercial fishing. However, research has shown that unprecedented change in climate and weather conditions continues to impede on the food and economic security of these communities (Weatherdon, Ota, Jones, Close and Cheung, 2016).

Many community members have observed changes in the availability of traditional foods. For example, First Nations have noticed a decline in the abundance of salmon, and have observed changes in their growth and migration patterns (Weatherdon et al., 2016). Downing and Cuerrier

(2011) stressed that for food security to be successful, one has to have the ability to "predict, prepare and adapt to their environment" (p. 58). Although communities have relied in the past on predictability (using traditional knowledge) for survival, global warming, in recent years, has rendered this tool less reliable (Weatherdon et al., 2016; Chapin III et al., 2004; Ford and Smit, 2004). Communities, therefore, have had to learn to adapt in response to the changing weather events to survive, and in order to reduce the impacts of food insecurity. For example, according to Ford and Smit (2004), Fox (2002) stated that the Inuit community, located along the Baker Lake (Nunavut), adjusted the time and location of their hunting practices in response to lower water levels in lakes and rivers. Correspondingly, Furgal et al. (2002)'s work on climate change and health (as cited in Ford and Smit, 2004), stated that the Inuit community in Nunavik adjusted to changes in weather patterns, particularly in ice and snow distribution.

Generally, many researchers have identified food insecurity as primary concern amongst First Nation communities across Canada (Ford, Berrang-Ford, King, Furgal, 2010; Downing and Cuerrier, 2011; Weatherdon et al., 2016; Ford et al., 2009; Beaumier and Ford, 2010). Food insecurity not only affects food availability and food adequacy, but it also affects the traditional and cultural lifestyle of the communities. Referring to an earlier example of the importance of salmon in the Fraser River (p. 8 - 9): Sockeye salmon from the Fraser River not only provides food for the community; it is used for ceremonial and traditional practices. Jacob et al., (2010, p. 860) indicated that people in the communities would catch and preserve Sockeye salmon as an essential part of their "traditional hunter-gatherer harvest activities". In fact, Krishnaswamy et al. (2012) and Ford et al. (2010) reiterated that Aboriginal people and First Nation communities have a strong, deep connection to their land and to their culture, which forms part of their identity. Consequently, these communities rely heavily on the natural environment to preserve their identity.

4.0 CLIMATE CHANGE IMPACTS AND CHALLENGES OF THE UPPER ST'AT'IMC TERRITORY

4.1 Location of the Upper St'atimc Territory

The Upper St'atimc Territory is located in the province of British Columbia. It extends to Churn Creek in the north, French Bar in the south, Big Slide in the east and Fraser River in the west. Moreover, the territory faces west towards the headwaters of the Lillooet River, Ryan River and Black Tusk; and is found in the northwestern region towards the headwaters of Bridge River and in the northeastern region towards Hat Creek Valley (District of Lillooet, 2016; Jacob et al., 2010; St'at'imc, 2008).

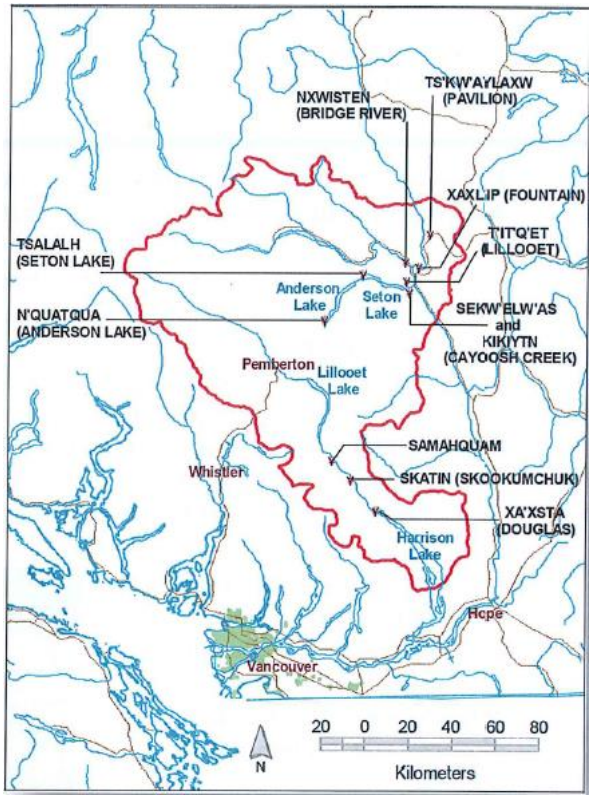

Figure 3: Upper St'at'imc Territory (Source: St'at'imc Government Services, 2013)

This territory comprises of eleven (11) St'at'imc Nation communities that have occupied various traditional sites in British Columbia, extending 11,000 miles^2 across the interior of the province. This area stems from the Pavilion (in the north), to Port Douglas (in the southern region) (Upper St'at'imc Language, Culture and Education Society, n.d). Communities have position themselves along main villages on bench lands located above the Fraser River region, and within the vicinity of Seton and Anderson lakes (Upper St'at'imc Language, Culture and Education Society, 2003). According to Jacob et al. (2010), St'at'imc communities have settled in the towns of Lillooet and Pemberton, and are also located near to the Lillooet and Harrison lakes.

The following presents a list of the Upper St'at'imc communities and their location:

1. Ts'kw'aylaxw (Pavillion);
2. Xáxtsa7 (Port Douglas);
3. Sek'wel'wa'sa (Cayoosh Creek);
4. N'quatqua (Anderson Lake);
5. Xwisten (Bridge River);
6. Xaxl'ip (Fountain);
7. Lil'wat (Mount Currie);
8. T'it'q'et (Lillooet);
9. Smáqwam (Sama'qwam);
10. Sqátin (Skookumchuck); and
11. Tsal'álh (Seton Lake)

(Institute for the History of Science, 2008; St'at'imc Government Services, 2013)

4.2 Weather and Climate of the Upper St'at'imc Territory

The general climate of the Upper St'at'imc Territory is diverse depending on latitude, longitude, and elevation (Ecolibrio, 2013). The coastal mountains hinders the flow of moist air from entering into the territory, while concurrently, trapping cold air from the interior into the coastal regions (Squamish-Lillooet Regional District (SLRD), 2014). As a result of this process, the Upper St'at'imc Territory is generally dry and cold during winter months. However, during the summer season, the climate, specifically around the eastern area of the territory, is generally dry and warm. The climate in the western section of the territory is however, cooler and wetter year round (Ecolibrio, 2013).

A study was conducted in 2013 by Ecolibrio to determine climate trends and projections in the Upper St'at'imc Territory for the T'it'q'et First Nation and Cayoose Creek First Nation communities. Using the Climate WNA (V.470) [6] software and Geographic Information Systems, researchers were able to determine data for historical and projected climate patterns of the region (Ecolibrio, 2013).

According to the research, the annual mean temperature of Lillooet from 1971 - 2000 is 7.3°C. This temperature is generally higher than the 1.5°C average temperature of the T'it'q'et and Cayoose Creek territories. Furthermore, areas of higher altitudes (such as, mountaintops) correspond with colder mean annual temperatures in comparison to areas of lower elevations (such as valleys). It is projected; however, that Lillooet and the entire Upper St'at'imc Territory will experience a 5.2°C warmer annual mean temperature during the 2080s (Table 1).

The projected warming trend for Lillooet during summer months is ~27°C, and the highest warming temperatures during the winter season is expected to be ~18°C. Additionally, the number of frost-free days in Lillooet is expected to surge from 206 days to 263 days annually by the 2080s.

Table 1: Projected Temperature Variables for T'it'q'et and Caynoose Creek Territories (T-S) and Lillooet (Source: Ecolibrio, 2013)

		Mean Annual Tempearture (MAT)		Number of Frost-Free Days		Frost Free Period	
Model/Scenario	Timeframe	T-S	Lillooet	T-S	Lillooet	T-S	Lillooet
	1971-2000	1.5	7.3	117	206	67	146
Run One (HadGEM A1B)	2020	2.8	8.7	145	221	98	168
Run One	2050	5.0	10.8	175	242	138	189
Run One	2080	6.6	12.5	194	263	151	200

The mean annual precipitation of the T'it'q'et and Cayoose Creek territories, from 1971 - 2000, is 974 mm. This is three times the amount of precipitation that is experienced by Lillooet (356 mm) (Table 2).

Additional sources, including the Lillooet's Environment Canada Weather Station, confirmed, however, that the total rainfall per year is 297.1mm with snowfall reaching 32.4cm (SLRD, 2014). According to SLRD (2014), Lillooet's Environment Canada Weather Station stated that precipitation is constant throughout the year with less rain from February to May and more rain during the months of November to January.

Ecolibrio (2013) specified that as elevation increases, precipitation rates also increase. Lillooet is drier compared to the rest of the territory because it is of lower altitude, and because it is positioned in the coastal mountains. It is therefore projected that Lillooet will become drier in 2020s and 2050s, but will have more precipitation during the 2080s (Ecolibrio, 2013) (Table 2).

Table 2: Projected Precipitation related Variables for T'it'q'et and Caynoose Creek Territories (Source: Ecolibrio, 2013)

Model/ Scenario	Timeframe	MAP (mm)[a]		PAR (mm)[b]		PAS (mm)[c]		PAS (%)[c]	
		T-S	Lillooet	T-S	Lillooet	T-S	Lillooet	T-S	Lillooet
	1971-2000	974	356	383	270	591	86	61	24
HadGEM A1BR1	2020	**964**	**344**	422	270	**543**	**74**	56	22
	2050	**934**	**331**	470	279	**464**	**52**	50	16
	2080	986	**347**	605	314	**381**	**33**	39	10

Overall, this project expects that the Upper St'at'imc Territory will experience hotter, drier summers, and warmer, slightly wetter, winters. Winter, spring and autumn will experience more precipitation, whereas summer will receive less precipitation. Researchers project a general decline in annual precipitation and an increase in the mean annual temperatures in the future. Furthermore, the amount of precipitation, as a consequence of warmer temperatures, will fall as snow.

4.3 Lifestyle of the Upper St'at'imc Territory

The St'at'imc way of life emanates from a shared vision of honouring and respecting their relationship with the land (Institute for the History of Science, 2008; Jacob et al., 2010; St'at'imc,

2008). Their vision allows them to respect cultural traditions and beliefs which have been passed on from one generation to another. It also allows them to respect and decide collectively how to manage the land of the St'at'imc Territory and its resources, recognizing that resources, if used sustainably, will provide sustenance to their people for generations to come (Institute for the History of Science, 2008).

According to the Declaration of the Lillooet Tribe dated May 10, 1911, the St'at'imc communities hold "title, rights and ownership" (para. 4) to the territorial land and its resources (St'at'imc, 2011).

> *Ci wa lh kalth ti tmicwa (the land is ours) and We are ucwalmicw (the people of the land)* (St'at'imc, 2011, para. 4).

The St'at'imc communities depend on their natural environment for fishing, hunting, food harvesting, and for medicinal purposes (St'at'imc, 2008; Jacob et al., 2010; St'at'imc, 2011).

4.3.1 Fishing

As rightful owners of the land, the Upper St'at'imc communities are connected to the Fraser River, which is a major river system situated along the northern region of the St'atimc area (St'at'imc, 2008; St'at'imc, 2011). This river system is a rich resource for the communities as it is known to provide fish, their main staple food, to sustain families throughout the year. Four species of Pacific salmon that inhabit the Fraser River and that are important to the communities are: Sockeye, Chinook (*Oncorhynchus tshawytscha),* Coho *(Oncorhynchus kisutch)* and Pink *(Oncorhynchus gorbuscha)* (Jacob et al., 2010).

Salmon has always played a significant role in the lives of the St'at'imc people. Salmon is not only seen as a critical healthy protein-base resource or as an essential part of their diet, but is also seen as a vital part of their culture. Members of the community will catch, store and preserve salmon as a natural part of their traditional hunting-harvesting activities (Jacob et al., 2010; Weatherdon et al., 2016). Such traditions and lessons are passed on from elders to their children at

a tender age (St'at'imc, 2011). Many communities stressed that fishing has been a significant part of their childhood and provides fulfilment to their families. Consequently, fishing activities became a shared experience among community members, which brings people together and connects them to the land. Fish is also used at various functions; including, weddings, funerals and gatherings, such as ceremonies and elders' luncheons (Jacob et al., 2010).

Although First Nation communities along the pacific coast practice subsistence and commercial fishing, necessary for food security, economic stability and culture and spiritual practices (Weatherdon et al., 2016), their culture teaches them to respect the salmon. In doing so, these communities practice "taking only what you need" (p. 866). Other community members state that it is also significant to respect the river and other people who fished at the river. Essentially, respect and sharing is an important aspect of their culture (Jacob et al., 2010). Community members also reiterated the importance of salmon fishing for their subsistence. An individual stressed that it helps the communities to survive during the harsh winter months, another stated that having salmon, reduces the cost for meat and highlights that the fish can also be traded for fruits, vegetables, meat or other necessities (Jacob et al., 2010).

However, communities, throughout the year have noticed changes to the fishing season. For example, fishing has started later in the summer season. Although some community members would commence fishing activities in July, many have started during the month of August or September (Jacob et al., 2010). Jacob et al. (2010), who conducted interviews with First Nation communities along the coast, emphasised that community members were stressed with this change, and stipulated that fishing activities would occur later in the year since the fish would only arrive during that time. In fact, an individual confirmed that "the fish are not there anymore" (p. 865).

Another concern noted by the St'at'imc community is the change to the number or abundance of fish in the Fraser River over the last 10 years (Jacob et al., 2010). Others stated that salmon has become random, for example, some years there are large numbers of salmon observed, whereas other years, the number of salmon declined significantly (Jacob et al., 2010). Others have noticed physical changes to the quality of fish. In some cases, the fish are large and appear healthy,

however, in other cases, the fish appeared smaller, bruised, discoloured and unhealthy. People have even detected sores on the bodies of salmon (Jacob et al., 2010). Many St'at'imc members felt that the fish are overstressed and fear that they would one day become extinct (Jacob et al., 2010).

According to a research conducted by an international team, led by the University of British Columbia (UBC), climate change may lead to a decline in the number of herring and salmon fish for coastal First Nation communities (The University of British Columbia, 2016). The research team stipulates that there could be a decline in fisheries catch by approximately 50% by the year 2050, and First Nations are likely to undergo economic instability, losing between $6.7 - $12 million by that year (Weatherdon et al., 2016; The University of British Columbia, 2016). This study also found that as a result of climate change, 98 species would be affected and it is projected that fish will migrate from their present habitats and move towards cooler waters. Consequently, all coastal communities will most likely experience a decline in catch by "up to 29 per cent for species of salmon and up to 49 percent for herring by 2050" (The University of British Columbia, 2016, para. 8). St'at'imc communities reiterate that changes to the temperature and flow rate of water is currently affecting salmon production and runs (Fraser, 2013). An elder stated "Salmon runs are much later than in years past and the amount of fish is not steady from year to year. The tsaqwem (saskatoon) bushes in bloom used to mean the spring salmon were running and now the fish don't come on time" (para. 3).

First Nations also noted that there have been reduced water levels and a rise in temperatures in rivers. Such temperatures are dangerous to salmon and herring stocks that are trying to swim up the Somass River, which is located near Port Alberni (Indian country, 2016). Weatherdon and her team are especially concerned about the decline in diversity and abundance of fish species and the long-term implications this effect will have on these communities. First Nations may have to resort to other alternatives in order to survive; including, costlier, non-traditional, less healthy store - bought foods, or they may have to hunt other wild animals; such as deer (Pynn, 2016).

According to Pynn (2016), Tracy Winbush, who is an executive member on the First Nations Fisheries Council of British Columbia was amazed by the predictions outlined by the research team and stated that "It's a fearful thought, it really is. Climate change is such a big issue"(para. 6).

4.3.2 Hunting, Medicine and Food Harvesting

Apart from fishing, the St'at'imc are known for their traditional harvesting methods; including, hunting, food harvesting and food preservation (Squamish-Lillooet Regional District, 2014). T'it'q'et and Cayoose Creek are excellent examples of communities who practice these activities in an effort to strengthen food security, and to preserve their culture.

T'it'q'et and Cayoose Creek have small, but also aging populations. In fact, Cayoose Creek population is ranked as the smallest of the St'at'imc communities, whereas Tit'q'et is categorized as third smallest community of the St'at'imc Territory (Ecolibrio, 2013).

Although there is limited commercial agriculture being done in both communities, subsistence gardening has begun. T'it'q'et, with support from the Ucwalmicw Society, has commenced subsistence gardening, specifically of fruits and vegetables (Ecolibrio, 2013). This community relies on specific infrastructure to maintain food security. This infrastructure includes "a community garden, orchard, smokehouse and root cellar" (Ecolibrio, 2013, pg. 43). This project provides the community with organic produce throughout the year, and also helps members to reconnect with the land (particularly, the youth). Approximately 40% of community members participate in gardening either through the Ucwalmicw Society or through their own private gardens (Ecolibrio, 2013).

Cayoose, is also exploring subsistence gardening. However, due to poor conditions such as unsuitable soils and the effects of climate change, the ability to successfully grow diverse crops has been restricted. This community; however, began plant restoration work through Split Rock Environmental. Split Rock Environmental employs and trains members of the Cayoose community in areas of environmental restoration and monitoring (Ecolibrio, 2013; Squamish-Lillooet Regional District, 2014). Cayoose Creek is the proud owner of a plant nursery which supplies plant species (that are native to area) for the purposes of gardening and restoration work. The infrastructure of Cayoose includes "a private orchard, Split Rock nursery, Lillooet seed savers and Lillooet farmers market" (Ecolibrio, 2013, pg. 44).

According to the Squamish-Lillooet Regional District (2014), potential agricultural opportunities for the St'at'imc Territory include the growth and production of sugar beets and/or a vineyard. However, such projects will have to take the St'at'imc culture and priorities into consideration as outlined in the St'at'imc Land Use Plan of 2014.

Although harvesting of wild foods and medicines are important for these communities, they are somewhat restricted by the lack of or stable access to water, especially during the summer months, despite being bounded by lakes and rivers (Ecolibrio, 2013).

As an essential part of agriculture, and as a climate change adaptation initiative, the Lillooet community presently conducts Seedy Saturdays. This type of activity facilitates sharing of local seeds among community members, which promotes collaboration and communication across borders. The Lillooet community is also in the process of establishing a seed bank and a library, which will focus primarily on conserving native, adapted seeds (Ecolibrio, 2013).

Harvesting of wild plants are also important for the T'it'q'et and Cayoose Communities. According to Ecolibrio (2013), 30% - 50% of T'it'q'et community members and about 25% of Cayoose community members participate in the collection of wild plants (Ecolibrio, 2013). Although traditional gathering seems to be a common practice between both communities, the wildfires of 2009, which significantly affected the forest industry (Ministry of Environment, 2010) (described on p. 11 of this report), have made the availability of sites as well as access to collecting sites, difficult (Ecolibrio, 2013). This simply means that community members may have to venture further to access wild foods, and can no longer harvest foods at their preferred locations.

According to Krishnaswamy et al. (2012), sites used for cultural activities including, fishing, hunting, medicine, and food gathering are vulnerable to floods, wildfires and other impacts of climate change. Such impacts could eventually destroy these areas, making them irreplaceable, which may have long-term, overwhelming effects on the identity of First Nation communities. For example, Krishnaswamy et al. (2012) reiterate that 103 First Nation communities have suffered by

the devastating effects of wildfires in the interior of British Columbia. These wildfires were compounded by the built up of dry, dead trees (fuel) because of the mountain pine beetle.

Hunting occurs seasonally by about 30% - 50% of T'it'q'et community members and by approximately 75% of Cayoose community households (Ecolibrio, 2013). It is unclear whether this traditional activity has taken a back seat or whether the number of hunters lessened over time. In comparison, fishing seems to be a more common and frequent activity shared by both communities. Approximately, 50% - 75% of T'it'q'et community members and about 90% of Cayoose community households fish constantly. However, according to the research conducted by (Ecolibrio, 2013), both communities have expressed concerns about the water quality and contaminations levels in the Fraser River and Seton lake which may affect the quality and abundance of fish in the region.

Furthermore, research has shown that changing temperatures are not only affecting the distribution, abundance and habitat of wildlife, which are important to Aboriginal communities, but are also making traditional hunting sites inaccessible (Ford et al., 2010). For example, the Inuit community, positioned at Baker Lake in Nunavut, has had to modify their hunting strategies due to unpredictable weather. As a result of lower water levels in rivers and lakes (which made traditional hunting difficult), the community had to adjust the time and location of their hunting activities (Ford et al., 2010). These changes have resulted in the availability of fewer traditional foods and medicines, which in turn, have implications on the health and well-being of community members (Sanderson et al., 2015).

Additionally, climate change makes it difficult for communities to use traditional knowledge for food harvesting. The Gitga'at Nation occupies the northwestern region of the province and has always been harvesting cockles during the winter season (Reid et al., 2014). However, as a result of warmer temperatures in the ocean, there has been a rapid increase in algal bloom, a phenomenon that usually occurs during the summer months (Reid et al., 2014). The loss of traditional knowledge could be devastating for the Gitga'at Nation, as well as other communities, as it would affect their food security, health and their well-being.

Generally, there is evidence, which suggest that climate change is facilitating food insecurity among communities by restricting access, limiting the availability and reducing the quality of traditional foods (Ford et al., 2010; Ford, 2009; Downing and Cuerrier, 2011). As such, the majority of community members depend heavily on foods purchased from the local grocery or bulk food stores (Ecolibrio, 2013). Although this is an acceptable alternative for some community members (in particular, the youths), others (such as hunting community members) believe that traditional foods are tastier and have cultural importance (Ford et al., 2010). Furthermore, a nutritional healthy diet is of particular concern to community members, since store-bought foods are believed to have a high fat content as compared to traditional foods. Store-bought foods are also perceived to be expensive and unaffordable, especially for those who are living on low incomes or are unemployed (Ford et al., 2010; Jacob et al., 2010). Consequently, both T'it'q'et and Cayoose have decided to resuscitate cultivation and the harvesting activities of wild foods which will contribute to offsetting the high costs associated with store-bought foods (Ecolibrio, 2013).

For more than ten thousand years (10,000), First Nation communities have always proven their resilience to environmental change (including, changing weather patterns); and like Gitga'at Nation and the Inuit Community in Nunavut, they have accommodated these changes over time with the use of traditional knowledge (Weatherdon et al., 2016). However, climate change and its impacts have become rather "unequivocal" and "unprecedented" (IPCC, 2014, p. 2), threatening the food and economic security of these communities.

5.0 CLIMATE CHANGE MANAGEMENT STRATEGIES, PRACTICES AND TOOLS

Recognizing such changes, communities are learning rapidly to adjust to the unpredictability of their environment (Sanderson et al., 2015). According to Turner and Clifton (2009), an elder stated "If nature throws you a loop, you have to deal with that" (p. 182). This simply means that communities need to adapt to unforeseen situations in order to survive. Furthermore, according to Reid et al. (2014), an individual who participated in a climate change workshop stated "We've always been here, we've always adapted. Our forefathers have always done what they've need to do to stay in the area" (p. 410). This statement acknowledges and confirms the ability of the Gitga'at Nation and the Inuit Community in Nunavut to adapt.

Communities, in response to these changes, are moving toward adaptive planning to mitigate their vulnerabilities, and to enhance their resilience against the impacts of climate change (Reid et al. (2014). According to an article published by Our world (2012), Kirsty Galloway, an author from the United Nations University stated that as the impacts of climate change increase, indigenous communities are constantly being forced to adapt and respond in exceptional ways. The International Indigenous Peoples Forum on Climate Change (IIPFCC) also alluded to the recognition of traditional knowledge and its importance to the development of adaptation and mitigation measures to combat the effects of climate change (Our world, 2012).

5.1 Mitigation and Adaptation

The United Nations Framework Convention on Climate Change (2014) identified mitigation and adaptation as policy responses to address climate change. Mitigation fosters efforts to lessen or stabilize the concentrations of Green House Gas (GHG) emissions in the atmosphere. This process is intended to "abate, moderate, or alleviate" (p. 391) changes in climatic conditions through a variety of policy initiatives recognized at the global level (Ford and Smit, 2004; UNFCC, 2014). Mitigation strives to address the root cause of the problem (that is, GHG emissions), and intends to achieve a more certain outcome as compared to adaptation (Baynham and Stevens, 2014).

Adaptation, on the other hand, refers to strategic or planned adjustments in systems, to lessen or moderate the negative effects of climate change, and to benefit from new opportunities (Ford et al., 2010; UNFCC, 2014).

Canada acknowledges adaptation measures at the federal, provincial and territorial levels. Although discussions around adaptation begun, mitigation, to this present day, still dictates the climate political agenda (Ford et al., 2010; Baynham and Stevens, 2014; Ford and Smit, 2004). The Intergovernmental Panel on Climate Change (IPCC) (2014) argues that adaptation and mitigation are harmonizing strategies that can help address climate change; however, no individual option can receive satisfactory results by itself. Researchers also argue that mitigation and adaptation measures, once implemented at various levels, can and should support each other's efforts. Furthermore, both initiatives can achieve sustainable development, without being counterproductive (Laukkonen et al., 2009; Shaw, Colley and Connell, 2007). In fact, according to Cameron (2012), James Ford and his research team specifically stated "a focus on mitigation is myopic" (p. 107). Mitigation alone cannot significantly lessen the vulnerabilities of communities nor can it inhibit changes from occurring because of climate change.

6.0 EXPOSURE, SENSITIVITY, ADAPTIVE CAPACITY AND RESILIENCE

Apart from management strategies, the majority of literature reviewed focused predominately on identifying communities' exposures, their sensitivities, adaptive capacities and their resilience to climate change.

Community sensitivity (vulnerability) refers to the degree to which the community is affected because of exposure to climatic risks (Reid et al., 2014).

Adaptive capacity refers to the capacity of communities to mitigate their exposure to risks, recover from losses that are associated with climate change, and the ability to feat new opportunities through adaptation (Krishnaswamy et al., 2012).

Picketts et al. (2012) stated that adaptive capacity is the ability for communities to efficiently prepare and respond to the effects of changing climate. It is the ability of communities to effectively plan for, adapt or respond to such risks (Ford et al., 2010; Ford et al. 2008; Picketts et al., 2012; Cameron, 2012; Ford and Smit, 2004). Adaptive capacity can refer to, for example, employment and income, level of education and social structures of a community (Reid et al., 2014).

According to Reid et al. (2014) strong social connections, trust, support and strong leadership and knowledge are important facets of the Gitga'at's capacity, which enables them to successfully cope and adapt to the effects of climate change.

Unfortunately, most vulnerable populations are those that have challenging economic situations, suffer from poor health, and live in remote locations. For example, poverty in communities can lead to household sensitivity to climate change by compelling individuals to participate in dangerous activities. Another example is economic instability. Communities that are economically instable may not be able to prevent or recover from climatic disasters (Ford et al., 2010).

Vulnerability can be described through the following relationship:

Vulnerability = Exposure /Adaptive Capacity

(Krishnaswamy et al., 2012; Ford et al., 2008)

Exposure refers to the susceptibility of communities in relation to changing climate and weather conditions (Ford et. al., 2008). Exposure addresses specific questions such as, are communities located in close proximity to the natural disturbance? Are communities directly affected?

Resilience according to Krishnaswamy et al. (2012) is the capacity of the communities to experience disturbances or stresses, while simultaneously maintaining certain functions and structures.

The following portion of this report will outline a cross-section of case studies where adaptive and mitigation response strategies have already been implemented across Canada. These case studies will inform the St'at'imc Territory of successful examples of coping mechanisms, that if implemented correctly, can be used to reduce their sensitivities, and strengthen their resilience against the adverse effects of climate change in British Columbia.

7.0 CASE STUDIES AND DISCUSSION

7.1 Case Study 1: The Gitga'at Nation

The Gitga'at Nation occupies a large area in the northwest region of British Columbia, extending to the southeastern part of Alaska. This community comprises of approximately 700 members; 170 of which occupies the Village of Hartley Bay, also known as the main Gitg'at Village. The remaining members dwell in the port town of Prince Rupert, located 128.75km in the northwest direction (Reid et al., 2014).

Seasonal harvesting activities are an important aspect of the community's cultural practices. These activities; such as, fishing, are physically and spirituality significant, and serves to closely connect the Gitga'at people to one another as well as to their environment (Satterfield, Robertson, Turner and Pitts, 2011). However, community members are observing changes in their environment and are realizing the effects of climate change on their way of life. As such, adaptation has been recognized as a viable, but "critical and challenging" (p. 404) alternative (Reid et al., 2014).

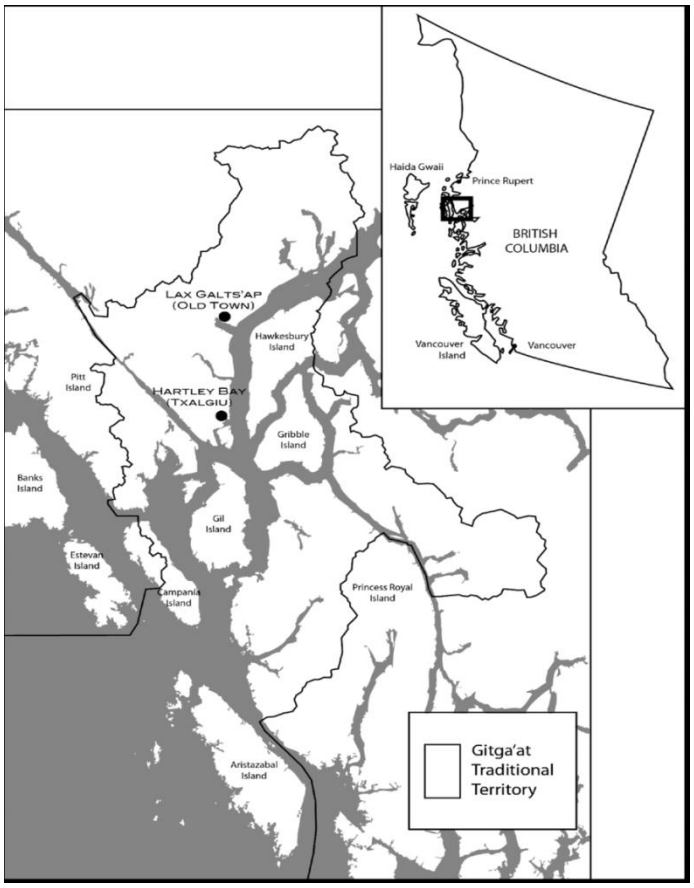

Figure 4: Gitga'at Traditional Territory (Source: Reid et al., 2014**)**

One of the management tools developed by the Gitga'at Nation in 2012 is the initiation of an adaptation planning process, which focuses on climate change (Reid et al., 2014). This process was established to 1.) better understand localized impacts as a result of climate change; and 2.) to prepare a plan to fully adapt to those impacts and changes (Reid et al., 2014).

The multi-disciplinary team that was assembled for this project comprised of researchers, consultants (for planning purposes), and members of the Gitga'at Nation who spearheaded, streamlined and facilitated the process. A strategic four-phase planning process was established which focused predominately on the local knowledge and input of the community. This process facilitated discussions surrounding the effects of climate change and how it will affect the daily lives of community members (Reid et al., 2014). In addition to the community's input, a literature review of socio-cultural indicators (such as employment, health, income and education) was

conducted to better understand the possible impacts of climate change on this group or population (Reid et al., 2014).

Stages of the planning process:

1. **Values Assessment (What matters most?):** Local community values were identified which is critical for planning since these values are used to create and evaluate various adaptation options. The results of the Values Assessment illustrated that the community relies heavily on their environment, especially traditional foods. The key values identified from this phase of the process are: "culturally important foods, culture, environmental resource, self-sufficiency, health, infrastructure" and "pride and cooperation" (Reid et al., 2014, p. 411).

2. **Vulnerability Assessment**: Stage 2 of the process assessed vulnerability in relation to the community's exposure, sensitivity/vulnerability and their adaptive capacity (Reid et al., 2014).

   (a) Community exposure: was assessed by understanding the community's observations in the area. For example, changes were noted in weather patterns, seasons (spring appearing earlier than anticipated) and in storm frequencies. Community members noted that there has been a rise in sea levels, and have observed coastal erosion in the village of Hartley Bay and surrounded camps (Reid et al., 2014).

   The project team also conducted a literature review on past and predicted climate change impacts. For example, research suggests that ocean acidification may become a potential threat to the community as a result of changes to storm surge patterns (Reid et al., 2014). Consequently, ocean acidification may affect the life cycle and reproduction of certain marine species, which the Gitga'at Nation depend on for subsistence and trading purposes. Fish species like that of salmon are also likely to be affected due to changes in water temperature; a phenomenon which is currently being experience by members of the

St'at'imc Territory (Reid et al., 2014; Hinch and Martins, 2011; Jacob et al., 2010; Gayton, 2008; Weatherdon et al., 2016).

(b) Sensitivity/vulnerability: The project team evaluated sensitivity by understanding how climate change would affect the community's values. For example, it may be difficult to access culturally important or traditional foods. Storms, for example, may make it difficult to harvest shellfish. It is also likely that food source such as salmon may become less available due to warmer water temperatures (Reid et al., 2014; Gayton, 2008; Weatherdon et al., 2016).

(c) Adaptive capacity: The Gitga'at Nation, like other communities, have always adapted to changes in their environment. Their ability to adapt is also connected to their "strong social connections, mutual trust and support", "flexibility and strong leadership and ability to plan" (Reid et al., 2014, p. 417). For example, in an effort to preserve traditional knowledge, the local school has been videotaping people in the community (particularly, the elders) who engages in traditional activities; such as, crab harvesting and trapping trees for pitch (Reid et al., 2014). Another example of adaptation is the ability to preserve the red laver seaweed. This type of seaweed is an important staple food for the Gitga'at Nation. The community would practice sun-drying this seaweed; however, because of wetter weather and climate, the community begun drying seaweeds indoors (Reid et al., 2014).

3. **Developing the Adaptation Plan (What can we do about it?):** This stage of the process addressed the development of adaptation options. According to Reid et al. (2014), community members accentuated three main fundamental messages during this phase of the process: "building adaptive capacity; preserving traditional knowledge; and adaptation is everyone's responsibility" (p. 417). These messages were reinforced by several actions (Table 3).

4. **Implementation:** As part of the final stage of this process, the project team initiated meetings with the staff to ensure that the plan was implemented successfully, and did not

remain on the shelf. Adaptation actions were presented to heads of departments and community leaders. This was done to identify and fully understand potential barriers that could impede the implementation process. The project team also wanted to understand how to curb or mitigate such barriers.

The project team and the community recognized the importance of integrating adaptation actions into existing and new processes, and that climate change must remain a priority in the community's way of life. For example, climate change adaptation measures should be considered when making decisions concerning development projects, emergency plans and infrastructure. Furthermore, the team prepared a monitoring and evaluation strategy (to be used by the Gitga'at Nation), which outlines clear timelines, responsibilities and tools used to track and record the progress made (Reid et al., 2014).

The Gitga'at project sought to evaluate the impacts of climate change and the responses of the Gitga'at population, which is, although remote and dispersed (in the village of Hartley Bay and Prince Rupert), connected by traditions and culture. Consequently, not all community members would deal with the same impacts, nor would they have similar vulnerabilities or adaptive capacities. This kind of scenario is similar to that of communities belonging to the St'at'imc Territory.

I believe that the adaptation planning process or tool would be beneficial to the St'at'imc people, if implemented, using the participatory values-based approach. This approach would promote participation and involvement from those who the plan intends to serve, which can help to evade conflicts or pitfalls that may occur during the planning phase. Implementing this approach, would promote a feeling of investment among the St'atimc people. As such, they would feel that their values and perspectives are aired and listened to, thereby providing a sense of ownership and planning in the decision-making process. Moreover, the participatory values-based approach would promote equal weight and recognition to traditional knowledge as well as to scientific and technical knowledge and will, as in the case of Gitga'at Nation, enhance the adaptive capacity of the communities involved.

Table 3 below illustrates Phase 3 of the process - *Developing the Adaptation Plan (What can we do about it?)*. The table shows a list of Gitga'at's Adaptation actions as well as the values that are impacted by those actions.

Theme	Actions	Value impacted
Document and teach traditional knowledge (especially around food)	Cultural skills ''How-To'' library (i.e., documenting cultural skills)	Culturally important food sources, culture, environmental resources, self-sufficiency, and health
	Traditional skills workshops and learning events for all	Culturally important food sources, culture, environmental resources, self-sufficiency, health, and Gitga'at pride and cooperation
	Continue cultural learning in the school	Culturally important food sources, culture, environmental resources, self-sufficiency, health, and Gitga'at pride and cooperation
Increase our food self-sufficiency	Ongoing mapping and surveying of historic and new harvesting sites	Culturally important food sources, environmental resources, self-sufficiency, and health
	Organize communal harvesting, processing, and distribution	Culturally important food sources, environmental resources, self-sufficiency, health, and Gitga'at pride and cooperation
	Ongoing research into traditional and new resource management systems (clam beds, seaweed, cultivation, etc.)	Culturally important food sources, environmental resources, self-sufficiency, and health
	Continue to improve/fortify harvest camps	Culturally important food sources, environmental resources, self-sufficiency, health, infrastructure to enable us to live well, and Gitga'at pride and cooperation
	Build greenhouse(s) and host education workshops	Culturally important food sources, self-sufficiency, health, and infrastructure to enable us to live well
Ongoing climate change research and capacity building	Ongoing research and community education on the effects of climate change for our area	All
	Develop a ''Knowledge Bank'' to document observations	All
	Consider climate change in administration/Council decisions and planning	All
Buildings and infrastructure	Update building standards and recommended materials	Health, infrastructure to enable us to live well
	Conduct an engineering study of general infrastructure readiness to climate change	Infrastructure to enable us to live well
	Pursue energy self-sufficiency through wind, hydro, etc.	Self-sufficiency, infrastructure to enable us to live well
Strengthen community well-being	Revive system of house checks	Self-sufficiency, health, and Gitga'at pride and cooperation
	Investigate ways to improve mental health and resilience (conflict resolution, problem solving, coping skills)	Self-sufficiency, health, and Gitga'at pride and cooperation
	Investigate options for improving cohesion between on- and off-reserve members	Gitga'at pride and cooperation

Theme	Actions	Value impacted
	Create a plan to improve physical exercise and healthy diet programming	Health
Improve emergency preparedness	Review/revise and communicate a community-based Emergency Management Plan	Self-sufficiency and health
	Support emergency preparedness in every home	Self-sufficiency and health
Greater economic self-sufficiency	Training youth and other community members in areas/industries for the "jobs of tomorrow"	Self-sufficiency, and Gitga'at pride and cooperation
	Ensure economic development plans factor in climate change	Self-sufficiency
Build relationships with partners (Nations, towns, groups, etc.)	Build relationships with neighboring Nations and local governments	Environmental resources, self-sufficiency, and Gitga'at pride and cooperation

Table 3: Adaptation Actions and values of the Gitga'at Nation (Source: Reid et al., 2014)

7.2 Case Study 2: Igloolik and Artic Bay, Nunavut Communities

A research team conducted vulnerability assessments within the communities of Igloolik and Artic Bay, Nunavut. These assessments were carried out to determine climate-related risks (current exposure); to identify how these risks are being managed (adaptive capacity); and to assess past and present adaptation initiatives in an effort to cope with future climatic conditions (Ford et al., 2008; Ford et al., 2007).

The research team ensured that the project involved a participatory values-based approach, which facilitated close collaboration with members of both communities throughout each phase of the project. Fieldwork for this project was done with a cross-section of community members, during the period 2004 and 2005, in the form of interviews. Sixty-five (65) interviews were conducted with members of the Artic Bay community and forty (40) interviews were conducted with members belonging to Igloolik (Ford et al., 2006; Ford et al., 2007).

Igloolik, which is positioned on the Igloolik Island, consists of approximately 1,538 people. This island is found off the east coast of the Melville Peninsula; about 320 km north of the Artic circle, and is found in the northern region of the Foxe Basin, Nunavut (Ford et al., 2007; Ford et al., 2008). According to Ford et al. (2007), the island is characterized by its flat topography, similar to that of its mainland region.

Artic Bay is also a coastal Inuit community consisting of about 700 people. This community is found along the northern region of the mountainous Baffin Island, Nunavut, which is approximately 700 km north of the Arctic Circle (Ford et al., 2008; Ford, Smit and Wandel, 2006).

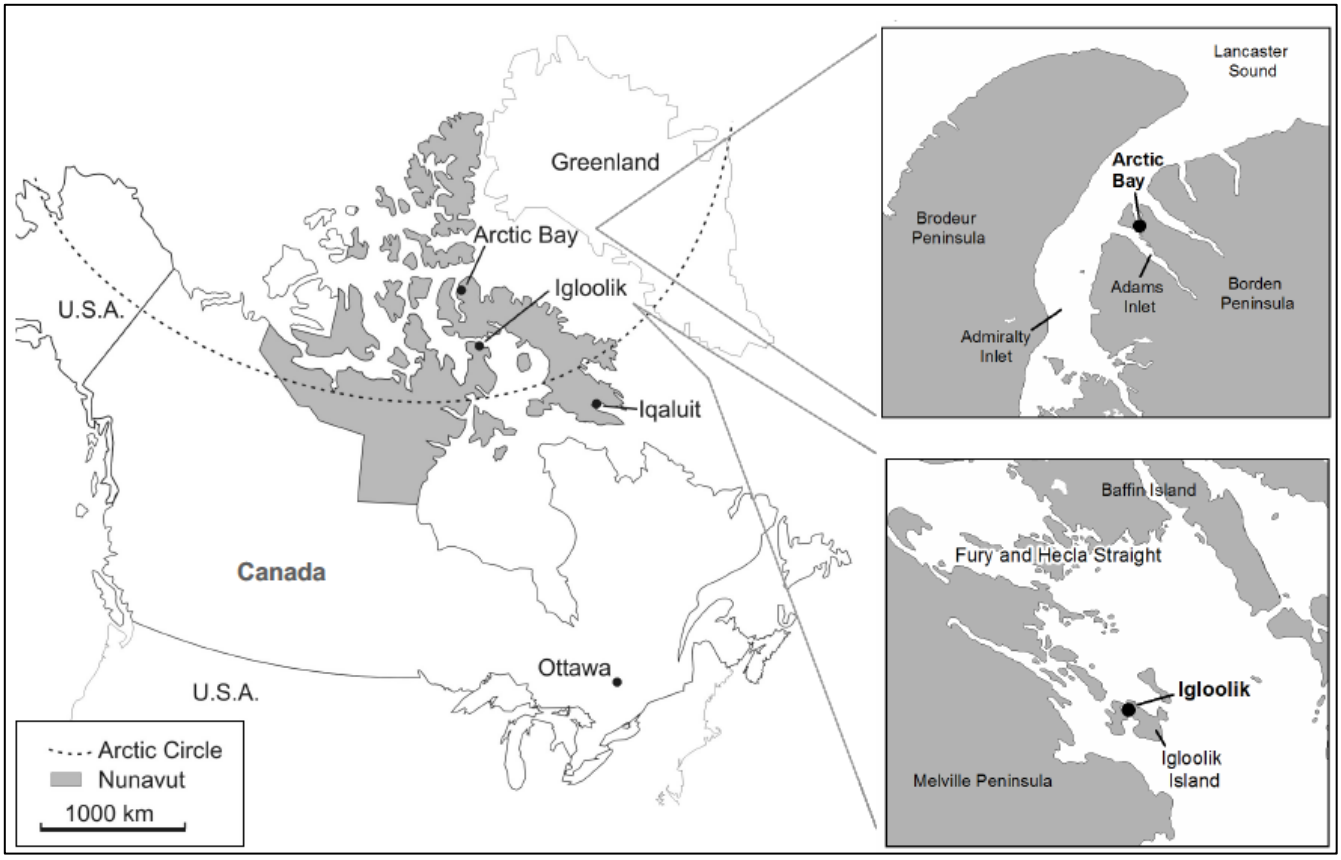

Figure 5: Location of Artic Bay and Igloolik Communities (Source: Ford et al., 2007)

To this present day, both communities, since the 1960s, have expanded rapidly shifting from subsistence activities to mixed economies. Harvesting of renewable resources have always been considered a valued traditional activity and contributes, not only to their food source, but is also of critical significance to their social, cultural and economic welfare (Ford et al., 2008; Ford et al., 2006; Ford et al., 2007).

Travelling and harvesting along sea ice are similar and significant activities for both communities. In fact, some commonly harvested animals include narwhal, ringed seals, caribou, polar bears and migratory birds. These animals are considered "the mainstays of wildlife harvest" (Ford et al., 2007, p. 154) for the Artic Bay and Igloolik communities.

Members of both communities; however, have and are presently experiencing the effects of climate variability and fluctuations since the 1990s which resulted in community members

adapting to and changing their harvesting behaviour and practices (Ford et al., 2008). For example, the Inuit hunters of the Artic Bay have always, prior to performing hunting activities, observed clouds and wind directions, and have made other environmental observations to decide if it was safe to hunt or travel (Ford et al., 2006). However, according to the interviewees, traditional knowledge, because of changing climate, has become less dependable, resulting in hunting activities becoming more dangerous (Ford et al., 2006). Climate change has also amplified less accessibility to hunting sites (Ford et al., 2008). During the interview a community member stressed "Nowadays my traditional knowledge, I can't use this knowledge now" (p. 150); another stated "More lives are in danger because of these unpredictable conditions and changes" (p. 150).

Some observations by community members include changes in the strength and direction of winds, and changes to ice conditions. Both of which are important for narwhal and walrus hunting (Ford et al., 2008). Other changes involving sea ice conditions are later and longer ice freeze-up, thinner ice, early ice break-up, more snow and the emergence of new open water areas. These changes intensify the dangers of using sea ice for travel or hunting purposes (Ford et al., 2008).

Thin on-land snow cover has restricted caribou hunting activities by snowmobile. Members of Artic Bay stated that travelling on areas where the snow is thin has damaged snowmobiles and sleds. During the summer season, caribou trails are muddy because of melting permafrost. Furthermore, later, longer ice freeze-up has resulted a longer wait time before hunters are able to hunt harpoon seals. Additionally, stronger and unpredictable winds have made hunting by boat a dangerous activity (Ford et al., 2006). Such radical changes are not only affecting the food source of both communities but also affect their traditions and culture. For example, hunting seals is not only important for the food supply of both communities, but it also represents a traditional and symbolic facet of the Inuit way of life (Ford et al., 2006).

Adaptive Capacity

The ability of both communities to cope with changing climate and weather depends on their adaptive capacity. Inuit's adaptive capacity relies specifically on their traditional knowledge, social networks, land-based skills, economic and institutional support, and the availability and use

of resources (Ford et al., 2007). For example, traditional knowledge and land-based skills are passed on from one generation to another through experiences and observations. Consequently, hunters for example, would learn about the necessary preparations required prior to hunting. They would also learn how to assess risks, and would learn how to respond in emergency situations (Ford et al., 2008).

Today, responses to climate change are behavioural in nature and include avoiding, mitigating and sharing risks. Although these strategies are traditionally used by Inuit, there are becoming progressively important and are practiced more regularly to combat the effects of climate change, especially as it relates to harvesting (Ford et al., 2007).

Hunters are now making supplementary preparations prior to conducting hunting activities. For example, according to Ford et al. (2006), hunters are taking extra food supplies and gas in the expectation of being beached or stranded (Table 4). Additionally, hunters have been identifying safe locations for shelter during boating activities in the summer season (Ford et al., 2006). A community member stated "Since the weather is unpredictable now you have take extra everything, extra grub and extra gas" (p. 151).

In general, community members are becoming more cautious and risk averse. According to Ford et al. (2006), people are avoiding travelling to dangerous locations or travelling at dangerous times of the year. They also avoid travelling if the weather is believed to be bad or unsafe; or are returning quickly if they observe that the weather conditions have changed, and are overall being more vigilant during daily activities (Ford et al., 2006) (Table 4).

Furthermore, Inuit of Artic Bay has also made technological adjustments which includes the use of the GPS to determine if ice is moving when hunting at the Floe-edge; the use of vhf radio in the event of emergency situations; and the use of satellite images (provided by town offices) which allows the community, prior to travelling, to identify areas that are subject to ice-break-up (Ford et al., 2006). Additionally, the Inuit of Artic Bay also adapted to new hunting practices in response to changing conditions. Hunting times and hunting locations have changed dramatically. For

example, sea ice freezing now occurs later on in the year, delaying the ice fishing season. Consequently, open-water fishing season has been lengthened (Ford et al., 2006).

Inuit of Artic Bay and Igloolik also relied on social networks to adapt to climate change. According to Ford et al. (2006), Woolcock and Narayan (2000) believed that social networks in a community refer to the relations of trust and mutuality that allows people to act in a collective manner. Ford et al. (2006), (as cited in Boas, 1888; Stefanson, 1913; Balikci, 1968) also accentuate that "complex networks of sharing; reciprocity; collective action and exchange characterized traditional Inuit communities" (p. 153).

TABLE 1. Adaptive strategies employed by Inuit in Arctic Bay and Igloolik to deal with climate change and associated costs (adapted from Ford et al., 2006a).

Climate Change Related Risks	Adaptive Strategies	Adaptation Costs
Unpredictability of weather, wind, and ice	• Take extra food, gas, and supplies in anticipation of potential dangers. • Make sure that they travel with others when possible. • Be risk averse, avoiding traveling on the land or water if they expect bad weather. • Use TV and radio weather forecasts to complement traditional forecasts. • Take along new equipment, such as personal location beacons, immersion suits, and satellite phones.	• The cost of purchasing extra supplies is prohibitive for many who have limited income. • Avoiding travel at certain times results in shortages of some traditional foods and the need to purchase more store food. • New equipment is often expensive.
Waves or stormy weather for summer boating	• Wait in the community for adequate conditions. • Identify safe areas where shelter can be found prior to travel.	• Waiting results in reduced harvests and the need to purchase more store food. • Avoiding certain areas can result in higher gas costs and add more time onto hunting trips (a problem for those with full-time jobs).
Snow covered thin ice	• Avoid snow covered areas. • Take extra care while traveling.	• Avoiding certain areas can result in higher gas costs and add more time onto hunting trips (a problem for those with full-time jobs).
Reduced accessibility to hunting areas	• Wait in the community until hunting areas are accessible. • Switch species and location. • Develop new access routes – e.g., overland travel instead of ice travel. • Share country food.	• Waiting results in reduced harvests and the need to purchase more store food. • Not all have the hunting skills to switch species. • New routes can be more time consuming, have higher fuel costs, and be more damaging to equipment.

Table 4: Adaptive Strategies implemented by the Inuit in Artic Bay and Igloolik (Source: Ford et al., 2007)

Today, a high level of interdependence and collectivism exists among the Inuit community members. Such social networks facilitate sharing of food, knowledge, culture, technology and equipment (Ford et al., 2006). Sharing of food among extended family manages risks associated

unpredictable hunting activities, and is important for those who lack time, equipment or money to hunt. This type of sharing also reduces stress or periods of scarcity, which certainly underpins food security (Ford et al., 2008). As such, the success of one person may be beneficial to others who participate in the sharing network (Ford et al., 2006).

Sharing of equipment offsets the expense of purchasing equipment (such as, GPS or radios) especially for those who cannot afford it (Ford et al., 2006). Sharing of knowledge strengthens the institutional memory of the Inuit community. Knowledge and experiences about risks and adaptive measures or strategies are shared within the community during hunting trips, or over the radio. This information is used to provide guidance, which is transmitted from one generation to another (Ford et al., 2006).

Climate change creates new, unexpected situations, and so far the Inuit community is learning make ad hoc changes to benefit from these situations. For example, whenever ice freeze-up is late, the community would extend its fishing season. As ice freezing commences, the community would resume their on-ice activities. Additionally, if hunting of caribou fails during a particular season, the community will substitute harvesting of this species with other species; including, walrus or seals (Ford et al., 2008). Adaptation in this form allows individuals to cope with the inaccessibility of specific species, to manage with variations in animal numbers, and enables them to take advantage of new opportunities (Ford et al., 2008).

Economic and institutional support is also critical in the management of climate change impacts. The Nunavut Department of Environment and the Nunavut Tunngavik Incorporated currently offer Harvester Support Programs. According to Ford et al. (2008), funds from the Government of Nunavut and relevant Inuit institutions play a vital role in mitigating the effects of climate change. These programs would also help to strengthen communities' resilience to such effects (Ford et al., 2007). For example, funds from the Government would finance the purchase of equipment, including VHF radios and personal locator beacons, to help hunters cope or recover from losses as a result of climate change exposures (Ford et al., 2007). The government also provides money to harvesters, if there is a hunting accident involving lost or damaged equipment. This type of support is especially important since there is a high unemployment rate in both communities (Ford

et al., 2007). However, Ford et al. (2007) argues that the Harvester Support Programs may face increased pressures if climate change continues to persist at its current rate.

In an effort to promote and preserve their culture, heritage and values, the Igloolik implements a Land-based Skills Training Program, which is currently being offered by the Igloolik's Inullariit Society (Ford et al., 2007). Experienced hunters and elders from the community would train youths to develop their navigating skills, to load sleds, to predict weather, and to recognize snow formations (Ford et al., 2007). Youths are also trained in the safety of firearm use and vehicle management. This training program is essential for youths as it imparts lessons on safety that are necessary for hunting and travelling activities. Youths are also thought to be patient, to be respectful to their elders and the environment, and to be persistent. These are important values and attitudes needed in order to survive in the Artic (Ford et al., 2007).

In terms of wildlife management, climate change is expected to negatively affect the quota system by creating demands for unregulated species. For instance, ringed seals and caribou are believed to be vulnerable to the effects of changing climate and weather (Ford et al., 2007). Consequently, it is necessary for communities to establish guidelines and/or strategies to manage wildlife resources adequately. The Inuit community in Nunavut; for example, has established a co-management agreement comprising of hunters, the Trappers Organization, the Nunavut Wildlife Management Board, the Department of Fisheries and Oceans and the Nunavut Tunngavik Incorporated (Ford et al., 2007). This type of agreement is specific to the allocation of narwhals in the Nunavut region, and creates flexibility in the Quota system. For instance, if harvesting activities fail in one year (maybe because of unsuitable weather or ice conditions), then the following year's harvest or hunt will make up for the lost income or lack of food (Ford et al., 2007). Therefore, communities are allowed to either carry over their total allowable harvest from the preceding year or borrow from the following year's limit, which is approved by the Nunavut Wildlife Management Board (Armitage, 2005).

While the above-mentioned adaptation measures/strategies have been established or implemented, there are certain challenges to consider. For instance, although the transfer of knowledge and land-based skills are important for the younger generation, less commitment or interest in harvesting

has been observed from the youths in the community (Ford et al., 2007). The lack of interest is due to educational requirements, reliance on wage employment, and a shift in social norms. Consequently, certain skills required for successful hunting have been lost; including, navigation; dressing appropriately for hunting and travelling; knowledge of the different types of equipment to take on trips; and the ability to confidently predict unsuitable weather conditions (Ford et al., 2007).

According to Kral, Idlout, Minore, Dyck and Kirmayer (2011), "intergenerational segregation" (p. 432), is also becoming a common singularity among Inuit communities. Kral et al. (2011) stresses that interests and activities among the youths have been separating from those of their elders. In fact, the social networks of communities have been affected due to the decline in the practice of traditions and cultural values. Furthermore, money has become an important issue and has created division and tension among extended families in the community; as a result, non-monetary practices, including sharing, now involve money (Ford et al., 2007).

Furthermore, not everyone could afford technological adaptations, and according to Ford et al. (2007), The Department of Sustainable Development - Government of Nunavut (2002) states that such developments or adaptation measures may create divisions or inequalities among communities.

This case study demonstrates that a community's adaptive capacity is facilitated by their knowledge, social networks, land-based skills, economic and institutional support, and the availability and use of resources (Ford et al., 2006; Ford et al., 2007). However, challenges exist which include the break-down in traditional knowledge and interests, especially noticeable in the younger generations; as well as increased vulnerabilities of social networks, due to rising inequalities in relation to resource access (Ford et al., 2006). It is also important to note that vulnerabilities will vary across groups or communities. The situation; for example, of each community in the Upper St'at'imc Territory may differ depending on their social, economic and cultural conditions, as well as their level of exposure to climate change impacts. Even though variations in sensitivities exist, research has predicted that programs (such as the Harvester Program), if modified to the needs of the community, have the potential to maintain social

networks, sustain funding (to facilitate the development and implementation of adaptive initiatives), and have the capacity to promote flexible harvesting practices among youths.

It is therefore recommended that the communities of the St'at'imc Territory establish similar programs to reduce climate change effects. For example, co-management agreements with the federal government can be established to sustainably manage the quota allocation of specific species being hunted. Furthermore, communities can initiate the establishment of a Land-based Skills Training Program that will train youths to better predict weather conditions and further their navigation skills. This program can also develop the art of harvesting and gardening, and will enable participants to master the use of specific equipment and technology; including, firearms, vehicle management and GPS, which is essential for hunting and travelling. The Harvester Program can strengthen the resilience of communities in the Territory by recovering from losses due to climate change impacts. These programs can also address rising inequalities by providing financial and knowledge aid; and can facilitate youth participation by strengthening the intergenerational connections within each community.

7.3 Case Study 3: Stellat'en First Nation

The Stellat'en First Nation community is located in the northwest region of British Columbia. This community is positioned 160 km west of Prince George and is found in the western end of Fraser River, in close proximately to the Endako and Stellako rivers (Sanderson et al., 2015). According to Lee-Johnson (2008), 524 people are members of the Stellat'en community. These individuals are also known as Stellaquo.

The traditional landscape of the community spans to about 7000 km^2, 85% of which, is covered by forest. The forest portion of the land contains mainly conifer trees, such as lodgepole pine, spruce and subalpine fir and some leafy plant species, including aspen and willows (Sanderson et al., 2015). According to Sanderson et al. (2015), Danard and Murty in 1994, confirmed that the area experiences dry, warm summers and cold, snowy winters. As with most communities in Canada, the Stellaquo maintains a close spiritual relationship with the land and relies on the environment

for their survival. For example, Stellaquo uses traditional knowledge to practice the art of hunting and harvesting. As such, they depend on a wide variety of plants and animals for food and medicinal purposes.

The Stellako and Nautley Rivers are two of the most important water resources for the Stellat'en community. These waterways support the production of salmon, trout and white sturgeon fish species. However, the community is particularly concerned that climate change could implicate the health, reproduction and habitat of these species because of increased water temperatures, and changes in flow rates of the rivers (Sanderson et al., 2015; Picketts, Dery and Parkes, n.d). The community has also witnessed other changes to their environment, including the mountain pine beetle infestation and an increased number of wildfires in the area (Safranyik et al., 2008). Consequently, during the period 2008-2009, the Stellat'en community, in collaboration with academics, decided to prepare a plan to reduce the carbon footprint of the community (Sanderson et al., 2015).

The methodology for the plan was divided into the following three (3) sections:

1) **Western Science**: Quantitative information relating to changes and fluctuations in climate were recorded. Meteorological data was gathered from two Environmental Canadian Stations. Information of average air temperatures, rainfall, snow and precipitation were taken from the National Climate Data and Information Archive of Environment Canada (Sanderson et al., 2015). The team also examined the characteristics of the water budget for both rivers. A water budget or water balance, as it is also known, addresses inputs, outputs, and changes in the quantity of water by breaking down the water cycle into various components (Unites States Geological Survey, 2014). The water budget also estimates the quantity of water found in each component and analyses the flow of water (Unites States Geological Survey, 2014).

2) **Traditional Knowledge**: In an effort to solicit climate change related knowledge and experiences from the Stellaquo members, the team initiated a community participatory-based approach. This initiative resulted in meetings, which ensured that residence from the community was listened to in a respectful and cultural manner (Sanderson et al., 2015).

This action-oriented approach involved conversing with the elders, chief and council to discuss their thoughts on climate change; conducting an open-ended survey to identify issues and discuss recommendations to resolve those issues; integrating a session for youths and elders to address climate change issues; collating data from interviews and surveys to identify themes; and designing and conducting workshops to share knowledge, re-define and discuss themes and outline next steps (Sanderson et al., 2015).

The research team deliberately focused on the strengths of the community rather than emphasizing their vulnerabilities and/or risks. According to Sanderson et al. (2015), this approach not only highlighted issues and concerns, but it also allowed the community itself to identify suitable actions and possible solutions.

3) Knowledge Intersection: Two workshops were held to facilitate the exchange of knowledge and experiences between indigenous residences and academia or western sciences. The first workshop includes presentations on climate science and hydrometeorology; and indigenous knowledge on climate change and water. Results of the research project were subsequently shared at the second workshop, and future action strategies or measures were elaborated during this session (Sanderson et al., 2015).

General observations made by community members (in relation to climate change) include less water in the rivers, less rainfall and reduced snowfall. During the summer months, community members have observed low stream flow in rivers; increase natural disasters, including fires, floods and tornadoes; warmer temperatures, increased emissions, resulting in poor quality of air; less traditional foods and medicines; and increased dependence on store-bought foods, which the community feels may implicate their health (Sanderson et al., 2015). The community was particularly concerned about the impacts of climate change on their water resources. As such, the following recommendations were developed through focus group discussions, interviews and surveys:

- The community thought that it was necessary to revisit their lifestyle and further embrace and integrate their traditional values and culture into their daily lives. A member of the community stated “We need to change how we live” (Sanderson et al., 2015, p.147). This

includes showing respect to all living things, each other and the environment. Members of the community stated that this is done by strengthening their language through education or supporting the practice of language and cultural education. Furthermore, education relating to climate change impacts and human behaviour on land and water resources, should be addressed.

- The community also felt that individuals and the community at large should behave in ways that are less impactful to the environment. For example, community members should be encouraged to reuse and recycle materials (Sanderson et al., 2015).

- Other actions include the establishment of a community food garden, (which is currently being done by the T'it'q'et Community); the purchase of bicycles for rental; and the creation of a hotline for ride sharing within the community. The community also purchased a wood chipper, which is used to chip wood affected by the mountain pine beetle. The chipped wood is subsequently used as a compost in the garden to provide nutrients to plants (Sanderson et al., 2015)

The research clearly demonstrates that the Stellat'en First Nation community has experienced similar challenges to that of the Upper St'at'imc Territory. These challenges include increased water temperatures and changes in flow rates of rivers, the infestation of the mountain pine beetle and forest wildfires. The Stellat'en community have since made admirable steps towards mitigating their carbon footprint. Communities of the Upper St'at'imc Territory, through funded projects and in collaboration with scientists and academia, can conduct similar research to investigate gaps in traditional and western practices. This process will facilitate the exchange of knowledge and experiences between community members and academia. It will also initiate suitable actions, specific to the Upper St'at'imc Territory, via focus group discussions, interviews and surveys.

7.4 Case Study 4: The Vulnerability of Igloolik, Nunavut Food System

The Food and Agriculture Organization of the United Nations stipulates that food security exists when "people…have access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (2006, para. 1). However, in order for the objectives of food security to be recognized, the following pillars or dimensions should be fulfilled concurrently (Capone, Bilali, Debs, Cardone and Driouech, 2014):

- *Physical availability of food;*
- *Economic and physical access to food;*
- *Food utilization; and*
- *Stability of the above-mentioned three dimensions*.

It is believed that the dimensions of food security are susceptible to the changes in climatic conditions, and as a result, food systems are thought to be vulnerable to climate change (Food and Agriculture Organization, 2006). Several studies have been conducted which have explored the implications of climate change on food security, including the Igloolik coastal Inuit community (located in Nunavut) mentioned on page 14 of this report. Harvesting traditional foods plays an important role in the lifestyle of this community. However, there is growing concern that harvesting activities such as, hunting and fishing, are sensitive to the impacts of changing weather and climate, resulting in vulnerable food systems (Ford, 2009). These food systems are critically significant to the community because they represent "dynamic interactions between and within the biogeophysical and human environments" (Gregory, Ingram and Brklacich, 2005, p. 2139). These interactions result in the "production, processing, distribution, preparation and consumption of food" (p. 2139), thereby sustaining food security. The Inuit food system comprises of two important components: 1.) traditional foods; and 2.) store-bought foods (Figure 6).

Traditional foods are continuously being harvested by the Igloolik community. Some of the wildlife harvested includes ringed seals, caribou, beluga whale and a variety of berries (Ford, 2009). Consumption of traditional foods remains an important cultural, social and economic facet of the Inuit food system. According to Ford (2009), Poppel et al. (2007) a researcher who

conducted food surveys in Nunavut, states that approximately 41% of the individuals who participated in his research consumed more than 50% of their meat and fish from traditional harvesting activities. Harvesting would occur in close proximity to the community or would involve extended trips to various hunting locations, depending on the following factors: the species being hunted, the time available, season or time of year, and the skill-set of the hunters (Ford, 2009). Hunting is mostly practiced by males in the community, whereas the females are responsible for processing the harvested meat. Foods are subsequently distributed within community. However, it is important to note that food-sharing practices differ across regions and communities (Ford, 2009).

Store bought foods, on the other hand, have played a significant role in the diets of the Inuit community members over the past fifty years (Ford, 2009). This is especially true for the younger generation. However, preference for store-bought foods has led to a nutrient poor, high fat, high sugar, and generally unhealthy diet, resulting in the rise of prominent diseases such as, obesity and diabetes in community members (Pynn, 2016; Ford et al., 2010; Kuhnlein, Receveur, Soueida and Egeland, 2004).

Generally, there are at least two stores in the community, which supply a variety of fresh and processed foods. However, these stores depend on air service or sea-lift transportation to attain fresh and non-perishable food items. Air service transportation usually occurs on scheduled times, and sea-lift transport may occur only once annually during the summer period in ice free conditions (Ford, 2009). Both means of transport are susceptible to climate change. For example, sea-lifts are vulnerable to sea ice and rapid changes in weather patterns, and air transportation is sensitive to bad weather (including, blizzard, fog, snow and high winds). Consequently, since both means of transport are vulnerable to fluctuations in weather conditions, significant problems could occur for produce that are close to their expiry dates (Ford, 2009).

Research also illustrated the presence of interdependence within the Inuit food system (Figure 6). For example, as an adaptation strategy, communities of Artic Bay and Igloolik in Nunavut rely more on store-bought food whenever traditional foods, such as wildlife, are not easily available, accessible, or are of poor quality (Ford et al., 2007). This is also true when equipment to facilitate harvesting activities is in need of repair or should be replaced. On the other hand, community

members would rely more on traditional foods during periods when there is limited accessibility to money or increased prices of store-bought food (Ford, 2009). Alternatively, with the increased cost of gasoline, which makes hunting an expensive activity, individuals may be forced to consume nutrient poor store-bought foods, or people may be forced to consume less (Ford, 2009).

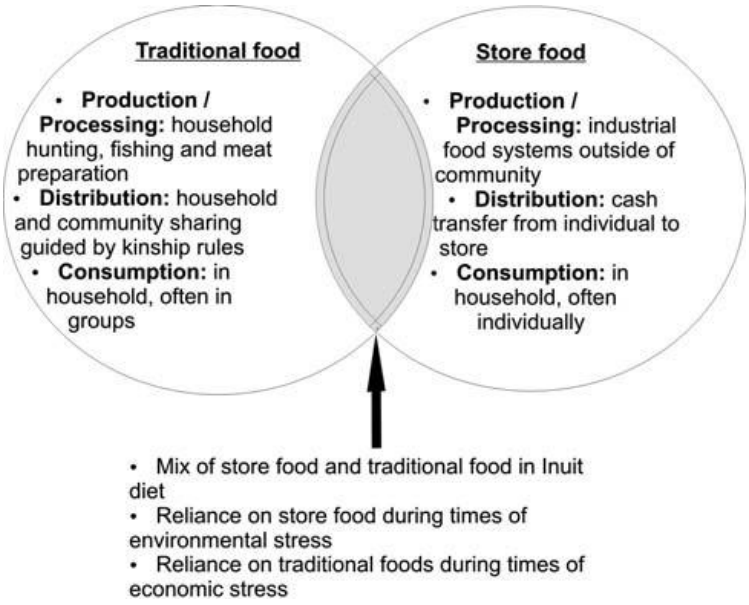

Figure 6: Components of the Inuit Food System: Traditional and Store-food Components (Source: Ford, 2009)

Studies illustrate that there is a high occurrence of food insecurity among Inuit community members (Statistics Canada, n.d; Beaumier and Ford, 2010). Food insecurity exists because of many social and economic factors (Figure7). These factors include lack of income, the high cost of harvesting and purchasing store-bought foods, and reduced transfer of traditional knowledge, including hunting skills etc. (Beaumier and Ford, 2010; Indian and Northern Affairs Canada, 2003; the Inuit Circumpolar Council, 2012). Furthermore, evidence suggests that climate change also affects food security in Nunavut. The roads in Nunavut are limited and less well-structured and maintained; as a result, communities rely on the frozen ocean and land to hunt. However, as a consequence of warmer temperatures and changes in precipitation, ice may become unsuitable, and the land may not have adequate snow cover, making it impossible to hunt (Ford, 2009; Ford et al., 2010). Additionally, traditional foods, including wildlife, may become sensitive to such changes in weather and climate, which affects their migration times, health, and availability. This

in turn will negatively influence hunting activities for these communities (Ford, 2009; Ford et al., 2010; Ford et al., 2007).

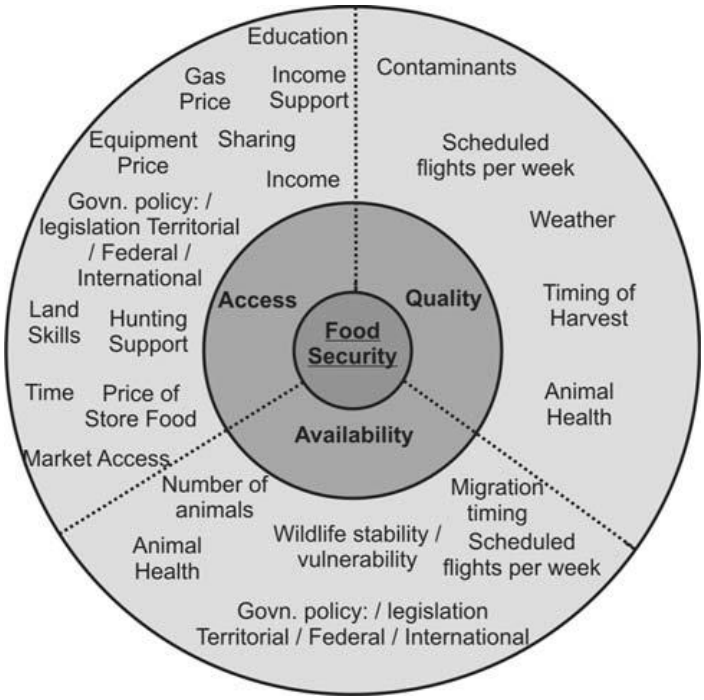

Figure 7: Factors that affect Food Security for Canadian Inuit Communities (Source: Ford, 2009)

Ford (2006) developed a conceptual model, which addressed the implications of climate change on food security for Inuit communities in Canada (Figure 8). Ford (2009) explored the susceptibility of the food system to climate change, taking into consideration exposure sensitivity and adaptive capacity.

In terms of exposure sensitivity, the effects of climate change can be either direct or indirect. For example, climatic changing conditions may alter migration times, affecting wildlife populations, which in turn would constrain harvesting activities (Ford, 2009). Climate change can also affect communities indirectly in a number of ways. For example, the inability to properly use trails to access hunting grounds, thus reducing harvesting of traditional foods; the disruption of air and sea transport to attain store foods, resulting in delays and food reaching their expiry dates upon arrival; and the inability to successfully produce, process and share foods among household members or throughout the community (Ford, 2009). Adaptive capacity is the second component

in the model and it addresses the ability of a system (or in this case, individuals and households) to adapt to climate change (Ford, 2009). However, it is important to note that adaptive capacity of the Inuit food system is determined by a wide range of factors including, economic wealth, availability of technologies, social institutions and infrastructure, characteristics of the food system and the nature of exposure sensitivity (Reid et al., 2014; Ford, 2008b). The vulnerability model was used to access a connection between climatic conditions and food security by exploring how the Inuit community experienced and responded to climatic effects of 2006. Ford (2009) selected 2006 since it was an atypical year known for sea ice and other climate change-related conditions, especially in the Nunavut region.

Ford implemented his research by conducting focus group and semi-structured interview sessions with Inuit community members, resource managers and local health representatives. This was done to record the community's experiences in relation to their food system for that year and to identify adaptive strategies used to address exposure sensitivities related to climate change (Ford, 2009). Data was also gathered from the Igloolik Oral History Project (IOHP). The IOHP is a database consisting of information retrieved from more than five hundred (500) interviews with local residents on diverse topics (Ford, 2009).

During the focus group discussions, Inuit elders stated that summer ice periods became "unprecedented" (p. 92) resulting in negative impacts on walrus hunting. However, in reviewing data from the IOHP, there was no indication of aberrations of this magnitude from 1986 to the 20th Century (Ford, 2009). The sea ice conditions in 2006 also affected the ability to conduct harvesting in the area. For example, the ocean freeze-up would occur in October (mid to later part), and as such, individuals would use the frozen ocean for transportation purposes and to conduct harvesting activities. However, in 2006 the freeze-up came later than usual (during the month of November), which was followed by ice break-up due to warmer temperatures (Ford, 2009). As such, walruses migrated further south due to the lack of ice.

The walrus is an important traditional food for the Inuit community during the summer and fall seasons. It provides a variety of nutrients, such as vitamin A and protein. Participants revealed that the late freeze-up also inhibited the ability of community members to travel because the ice was

considered thin, and travelling on it to the mainland seemed dangerous. Furthermore, due to the lack of snowfall, snowmobiles were unable to access caribou hunting grounds (Ford, 2009). This delayed, and in some cases, reduced the ability to harvest, not only walruses, but also other animals, including caribou, fish, and ringed seals (Ford, 2009). Consequently, the overall availability and access to traditional foods in the region had been severely affected, and in 2006, the Inuit community reverted to substituting wild meat with store-bought foods (Ford, 2009).

> *This fall has been long because we spend a lot of time on [Igloolik] island. Usually we go out hunting earlier in the fall but haven't been able to go to the mainland for a while. We have not been able to get new meat because of this [late freeze up]* (Ford, 2009, p. 93)

For those with strong connections to their land and the environment, using store foods was not an equivalent trade off. In fact, participants stated that they preferred traditional foods over store-bought foods as it is believed to be of better taste, is culturally significant, and it provides nutritional benefits when consumed (Ford, 2009).

As part of the community's strategy to adjust to these changes, and especially for members who did not have adequate funds to purchase food, individuals depended on their families for the following: to share store-bought food; community members used food banks; others purchased inexpensive, poor quality store foods; and some participants even revealed that they would skip meals to make ends meet (Ford, 2009). Beaumier and Ford (2010), who conducted a study to identify and characterize the determinants of food insecurity among Inuit women, confirmed that 40% of women have not eaten adequately at least once per day; and 76% of women revealed that they have skipped meals and have cut meal sizes to ensure that other family members attain sufficient food (Beaumier and Ford, 2010).

In addition to food sharing, other adaption strategies documented in 2006 include travelling further to access hunting grounds and fishing lakes; delaying harvesting activities until there was ice freeze-up; and pursuing walrus along coastline areas (Ford, 2009).

Ford's study concluded that neither climate change nor human stresses in isolation were responsible for food insecurity in the Inuit community during 2006 (Ford, 2009). Ford emphasised that consequences worsened when both variables interacted. For example, the Inuit in Igloolik have been struggling with the rising price of gasoline and other items. Additionally, thin sea ice conditions further exacerbated this problem, which overwhelmed the capacity of the community to adapt adequately to the situation, compromising the accessibility and availability of food (Ford, 2009).

Additionally, the implications of food insecurity could be moderated or reduced by having less dependence or minimal importance on a particular traditional food source (Ford, 2009). For example, if there less importance placed on walrus meat in the younger generations, the effects of climate change on the access and availability of this type of meat would have limited impacts on the food security of this community.

The Upper St'at'imc Territory can use this case study as a guide to seek out drivers that are responsible for food insecurity within their communities. It is noteworthy to mention that those who will be involved in conducting this study should not isolate the variables of climate change and human stresses. As outlined clearly by Ford (2009), "neither climate-related conditions nor human stresses alone would have resulted in compromised food security" (p. 96). Therefore, the interaction of both variables exaggerated or magnified their consequences. It is also important to note that the nature of exposure sensitivity or vulnerability will differ for each community across Canada. Furthermore, the dependence on traditional foods verses store-bought foods will also vary across regions and communities. This study, provided by Ford in 2009, simply provides a snapshot of the variables responsible for food insecurity at that particular time.

7.5 Case Study 5: Northeastern Graham Island, Haida Gwaii (Queen Charlotte Islands)

Haida Gwaii is positioned off the northern coast of British Columbia (Government of Canada, 2007). This area is an archipelago, consisting of approximately 150 islands, with a land mass spreading to about 10,000 km^2 (University of British Columbia Press, 2005). This area was formally known as Queen Charlotte Islands; however, since the enactment of the Haida Gwaii Reconciliation Act, the official name of the islands became Haida Gwaii, meaning "Islands of the People" (British Columbia Adventure Network, 2016, para. 3). The indigenous people or Haida inhabited these islands for thousands of years and their culture, art and mythology played significant roles in their lifestyle (University of British Columbia, 2005; British Columbia Adventure Network, 2016). Today, these islands are known for their natural beauty and for the rich, traditional culture of the Haida people (British Columbia Adventure Network, 2016).

The Graham Island is the largest island in the northern part of Haida Gwaii (Government of Canada, 2007). However, communities that inhabit the island are sensitive to the impacts of climate change given their remote location and the island's vulnerable landscape, extreme weather fluctuations, and the communities' heavy reliance on restricted natural resources for economic subsistence (Dolan and Walker, 2007). The island is ranked as one of "Canada's most sensitive coastlines to climate change" (Government of Canada, 2007, p. 358). For example, the island is sensitive to extreme rising annual sea levels, coastal erosion, storm surges and high unpredictable winds (Government of Canada, 2007). Graham Island has also experienced several challenges resulting in the decline of jobs within the forestry sector; restrictions to fishing privileges within the fishing industry; cutbacks in funding at the federal and provincial levels; and loss of hundreds of individuals, as a direct consequence of closure to the Canadian Forces Base Masset (Government of Canada, 2007; Dolan and Walker, 2006).

Historically, the islands depended on natural resources for employment. However, studies illustrate that the Haida Gwaii community, because of the aforementioned challenges, had a record of low employment rates and unstable incomes, which contributed to high vulnerability and limited adaptive capacity (Government of Canada, 2007).

Although this study did not document the adaptation or mitigation strategies currently being implemented by the Haida community itself, Connor, 2005 and Walker et al., 2007 (according to the Government of Canada, 2007) identified and assessed attributes that were necessary in building the adaptive capacity of the community to mitigate the impacts of climate change. A participatory approach method was used to incorporate local or traditional knowledge, experiences and perceptions (Government of Canada, 2007).

Infrastructure and transportation play a significant role in adapting to the effects of changing climate. For example, according to the community, the islands are vulnerable to damages from coastal winds and storms, power outages, ferry and air services disruptions, food supply shortages, and highway closures (Government of Canada, 2007). Institutions and governance can also affect adaptive capacity. The BC government and the community, because of outstanding negotiations, have yet to establish a Land Resource Management Plan, which is necessary to onset coastal planning initiatives in the Haida Gwaii Islands (Government of Canada, 2007). Another important determinant of adaptive capacity is social capital, which represents relationships and networks that support shared goals and values of the community. For example, strong community unity, participation in community services and support networks are all considered high social capital in the Haida Gwaii Islands (Government of Canada, 2007).

Adaptation, according to Connor (2005) and Walker et al. (2007), should focus primarily on mitigating the vulnerabilities associated with critical infrastructure. For example, the continued maintenance and protection of coastal roads, including Highway 16, transmission lines and services; rezoning, specifically around areas that are prone to erosion and flooding (Rezoning still needs to be included into current and future plans and activities); and developing, enhancing and diversifying the local economy. Although the community is dependent on natural resources (forests and fish) for economic stability, the Haida Gwaii nation should explore other initiatives in the fields of tourism, arts and crafts, culture, food harvesting and stockpiling, to enhance their resilience. Furthermore, enhancing political and institutional networks will further strengthen the overall adaptive capacity of the community towards the long-terms effects of climate change (Government of Canada, 2007).

Factors that increase vulnerability[1]	Factors that enhance adaptive capacity[2]
• Geographic isolation • High exposure to climate variability hazards and sea-level rise	• Strong attachment to Haida Gwaii • Connectedness with nature • Frontier mentality • Experience with environmental changes and hazards
• Low formal education levels (cf. Holman and Nicol, 2001)	• High informal education, local knowledge, traditional ecological knowledge • Haida culture and rediscovery • Diverse skills (hunting, gathering, etc.)
• Limited provision of essential services (health care, social services, education) • Generational health impacts (alcoholism, abuse, apathy)	• Strong community cohesion and support networks (e.g. family ties, volunteer groups) • Increasing volunteerism and local involvement in essential services (e.g. women's shelters, community health programs)
• Poor dissemination and awareness of emergency plans	• Established evacuation protocols and tests • Increased communication between communities
• Frequent power outages • Short-term food shortages	• High coping capacity with power shortages • Local food gathering and hunting • Food stockpiling and preserving
• High unemployment • Dependence on unstable natural resource sector • Low, long-term economic stability	• Household income diversification/subsidization (multiple jobs, arts, food gathering, tourism) • Seasonal jobs (fisheries/crabbing, mushrooms, tourism/charters) • Increased resilience to economic hardships
• Lacking official land-resource and/or land-use management plans[3]	• Ongoing development of integrated LRMP incorporating Haida Land Use Vision and resident values
• Local, regional and federal political tensions	• Increasing local involvement and Haida governance in decision-making process

Table 5: Local Attributes of Vulnerability and Adaptive Capacity to Climate Change Impacts in Haida Gwaii (Source: Government of Canada, 2007)

This case study is similar to Case Study 2 (Igloolik and Artic Bay, page 37) and Case Study 4 (Vulnerability of Igloolik, Nunavut Food System, page 49), in that the adaptive capacity of the Haida Gwaii community relies specifically on a variety of comparable factors. These factors include the availability and access to technologies, infrastructure and transport services; Land-based Skills Training program; local or traditional knowledge; social networks; economic and institutional support; and the ability to enhance their economy through diversification (Smit and Olga, 2003).

It is recommended that the communities of the Upper St'atimc Territory collaborate with research teams or external consultants, and using the participatory approach outlined by Connor (2005) and Walker et al. (2007) determine, not only the specific sensitivities at the community level, but also define existing and potential attributes that will enhance the adaptive capacity of each community. Table 5 above can be used as a guideline to facilitate this purpose.

Other attributes of adaptive capacity are risk perception, awareness and preparedness (Government of Canada, 2007). Although, there is a low level of formal education within the Haida Gwaii community, members possess high informal traditional education and a diverse Land-based skill set. This type of informal education facilitates awareness to risks, and enables communities to be adequately prepared for unexpected or unprecedented events (Dolan and Walker, 2006).

Dolan and Walker (2006) also stressed that in order to assess adaptive capacities of communities, it is important, not only consider the inherent resiliencies of the communities (experiences with adaptation), but to also reflect on other social elements. These social elements include discrimination; social processes that may reduce or limit their access to resources; differential rights; and their involvement in decision-making processes (Dolan and Walker, 2006). Another important argument made by Dolan and Walker (2006) relates to administering vulnerability assessments in order to determine the adaptive capacity of a community. When a vulnerability assessment is required, the research team should focus primarily on the local or traditional knowledge of the community members. In this way, scientific insights or perceptions are framed within a local context (Dolan and Walker, 2006).

7.6 Case Study 6: Adaptation to Extreme Heat or High Temperatures

Apart from the physical environment, research has shown that climate change can potentially affect the health and well-being of individuals, both directly and indirectly (World Health Organization (WHO), 2003; Public Health Agency of Canada, 2014). According to the World Health Organization (2003), direct impacts arise as a result of being expose to changes in extreme weather conditions; such as, heat waves and cold winter; extreme events including, floods and droughts; and high levels of air pollutants and aeroallergens, for example moulds and spores. Furthermore, climate change may have indirect impacts on food productivity, and may affect the transmission of various infectious diseases (World Health Organization, 2003; Health Canada, 2008).

The Upper St'at'imc territory, specifically, the T'it'q'et Community has expressed concern in relation to the impacts of high temperatures or extreme heat on community members, primarily, the elders. Extreme heat events are "periods of abnormally hot and often humid weather, are dangerous to some and can result in increased rates of heat-related mortality and morbidity" (Health Canada, 2011, para. 9). This section of the report will identify adaption measures or strategies that can be implemented by the St'at'imc Territory to address heat-related problems because of climate change.

Extreme heat, can among other things, result in heat stroke, dehydration, skin rashes, loss of consciousness and may amplify other health-related conditions such as asthma, allergies, cerebral, respiratory, and cardiovascular illnesses (Government of Canada, 2014; Assembly of First Nations, 2006; Public Health Agency of Canada, 2014; Lynn, MacKendrick and Donoghue, 2011). Extreme heat can severely affect vulnerable groups, including infants and children, the elderly and individuals who suffer with fundamental health illnesses (Heath Canada, 2012; Assembly of First Nations, 2006). High temperatures or extreme heat poses health risks to individuals, especially among those who are chronically ill, those who are socially deprived, or isolated and individuals who are using specific medications (Government of Canada, 2014). The Public Health Agency of Canada also stated that age, access to cool spaces or air conditioning, housing conditions and characteristics of the neighbourhood or the community (such as, income

and environmental conditions) are other factors that can influence sensitivity to heat-related risks (Public Health Agency of Canada, 2014).

7.6.1 Housing and extreme heat conditions

Studies illustrate that First Nations' homes are likely to be more susceptible to the impacts of changing climate and weather because of reduced income levels or lower levels of economic development (Houser et al., 2000). The Assembly of First Nations (2006) also reiterates that the construction of First Nations' houses is poor, and that these homes generally do not have the flexibility and capacity to adjust to climate fluctuations.

Furthermore, First Nations' homes are generally not energy efficient and commonly experience overcrowding (Assembly of First Nations, 2006).) It has also been confirmed that many homes in rural communities lack adequate heating and cooling systems (Houser et al.,2000). While the presence of air conditioners would attempt to mitigate the effects of extreme heat conditions and improve electricity; shifting toward a more indoor lifestyle can facilitate resilience to the effects of climate change (Lynn et al., 2011; Houser et al., 2000). In addition to this, occupants renting on-reserve houses require permission from the Chief and Council to make changes to their homes, and as a result, there are limited or no incentives for community members to maintain and renovate their homes. On the other hand, those who possess ownership status of homes are financially responsible for changing or renovating their homes (Billy, 2016 personal communication; Assembly of First Nations, 2006).

In addition to housing requirements, a portion of the homes in communities is trailers, which may lack appropriate heating and cooling systems or "weatherization" (LaDuke, Gough, Goldtooth, 2009, p. 53). Because of the aforementioned, exposure sensitivity of communities increases, and communities may even become a financial liability due to weather damage (LaDuke et al., 2009).

7.6.2 Housing and Mold or Mildew

Another health issue in many homes is mold. Mold or mildew is the result of water damage due to leaking or floods. Leaks occur as consequence of faulty structures or broken pipes, roofs and

windows. In many homes, poor or inadequate ventilation also facilitates mold growth. Consequently, this does not permit effective or complete removal of moisture from homes. Similarly, many homes are poorly insulated, which allows dampness or moisture to be trapped, intensifying mold growth (Centers for Disease Control and Prevention, 2014; Assembly of First Nations, 2006).

The primary concern with the presence of mold is the development of health problems. According to the Centers for Disease Control and Prevention (2014), the Institute of Medicine, in 2004, found adequate evidence that links respiratory illnesses such as, asthma, coughing, wheezing, sneezing and congestion of nose and chest, to the indoor exposure of mold.

In addition to the factors mentioned above, communities' homes are also subjected to "complex funding, allocations and reporting rules that already serve to limit First Nations health and well-being" (Assembly of First Nations, 2006, p. 17). Because of these merging issues, there are limited opportunities for First Nations to respond to housing problems related to climate change.

Health Canada (2011) stresses there are two main Urban Heat Island (UHI) Reduction Strategies that can be implemented to lessen the effects of high temperatures or extreme heat. These strategies, for the benefit of the St'at'imc Territory, can be adapted to suite the community needs**:**

1. **Increase surface reflectivity**: increasing the solar reflectance (Albedo) is the ability of materials to reflect sunlight on a scale from zero (0) to one (1), reducing the ability of absorbing radiation.

- Cool or White Roofs: A cool or white roof is designed to absorb less heat and reflect more sunlight than a standard roof. In fact, the United States Department of Energy (n.d) confirmed that during the summer season, dark or standard roofs could reach temperatures to about 65.56 °C. However, a cool roof is able to stay 10 °C cooler under similar conditions. These types of roofs are made of highly reflective paint, reflective tiles, shingles, or sheet covering. According to the White Roof Project (n.d), solar reflective white coating is used to paint roofs that reflect up to approximately 90% of sunlight, in comparison to standard roofs, that only reflect about 20% of sunlight.

Cool or white roofs are beneficial in many ways (Bizikova, Neale and Burton, 2008; White Roof Project, n.d; United States Department of Energy, n.d):

- They help to minimize damage by cooling buildings from the harsh effects of ultraviolet radiation and daily temperature fluctuations which may lead to rapid contraction and expansion;
- Cool roofs are also known to reduce roof temperatures which may lengthen the service life of roofs;
- They facilitate a cooling effect to indoor areas that are not air conditioned; including, garages and patios;
- Since these roofs provide a cooling effect during the summer periods and offers thermal insulation during the winter season, there is limited reliance on electrical systems, such as air conditioners and heaters. Thereby, reducing energy consumption and fuel cost.

For community members who intend to make renovations to their homes, the following changes may help to mitigate the effects of extreme heat and to remove mold or mildew. These adaptation measures were extracted from Bizikova, et al. (2008):

- The construction of internal door systems: such systems will facilitate the preservation of cool and warm air during the summer and winter months respectively;
- Roof beams: the installation of roof beams that overhang at each side of the home will not only provide shade, but would also maintain cooler temperatures inside the home;
- The construction of deep balconies and terraces to house plantings which will in turn provide shade and facilitate cooling;
- Floor vents: these vents allow individuals to control the flow of fresh air that enters into their homes;
- Windows facing the sun can be covered with aluminium fins to reduce solar heat and promote shading;

- Air extraction ducts can be installed to cool surrounding spaces. For example, dark coloured air extraction ducts can absorb heat and help air to rise out of the building, where as light coloured air ducts can draw fresh air into the house from the roofs; and
- Installation of mechanical cooling systems for instance, chilled beams and air conditioning systems.

Other adaptation strategies that can be implemented as a community are:

- Heat Health Alert Systems:

According to Bizikova, et al. (2008), Penny and Wiedtz (2007) confirmed that the Toronto Public Health, in collaboration with the Toronto Atmospheric Fund, have established a Heat Health Alert System. This system allows the city to make predictions in relation to climate-related health risks. Whenever climate risks are pre-determined, the alert system is triggered. Warnings are then communicated through all the media outlets; including, radio, television and internet; bottled water is provided to homeless individuals; shelters allow people to stay indoors; house calls are initiated to individuals who are at risk; and air conditioned buildings, such as libraries and community centres, provide relief to the public from heat exposure.

The Upper St'at'imc territory can use the City of Toronto Heat Health Alert System as a guideline to establish a similar alert system (on a smaller scale) to adapt to climate change.

The Upper St'at'imc Territory can:

- Create designated cooling centres within each community. Communities can designate public spaces that are air conditioned as cooling spaces; including, Community Health Centres, Recreation Centres and libraries, etc.;
- Educate and spread awareness about climate change-related health effects in the form of public awareness materials; such as, brochures, flyers, local media and at community events and meetings;

- Ensure that bottle water is readily available to individuals during the hot summer months, especially for those who are at risk;
- Establish, within their community centres, an information line, to answer any heat-related questions;
- Ensure that staff employed at health centres across the territory is specially trained to deal with health related matters as a consequence of climate change. This includes, heat exhaustion and heat stroke; and
- Continue to protect and maintain blue spaces including, rivers, lakes and ponds. These spaces help to cool rising temperatures through evaporation.

2. **Increase vegetation cover:** Vegetation cover controls rising temperatures using diverse vegetation in the form of forests or green open spaces such as parks. Creating green spaces reduces rising temperatures, through "evapotranspiration and shading" (Bizikova, et al., 2008, p. 52) and helps to purify the atmosphere, and generally improve the quality of life. For example:

    - Community members throughout the territory can participate in tree planting exercises, where trees are planted along streets, roads and in residential areas. Planting of trees can promote cooling; and
    - Individuals are also encouraged to develop and maintain community gardens and farming which can also help to reduce rising temperatures.

The table below presents a summary of the six (6) case studies that were discussed throughout this report. It outlines the challenges, and adaptation response strategies implemented by First Nation communities across Canada in effort to adjust to the effects of climate change. This table also provides the Upper St'at'imc Territory with examples of how these adaptation strategies or coping mechanisms can be applied to and implemented by their communities. This initiative of integrating successful adaptation measures into the lifestyle of the St'at'imc communities will aid to reduce their vulnerabilities, and strengthen their resilience against the adverse effects of climate change.

Case Study 1	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
The Gitga'at Nation	The Gitga'at Nation has observed changes in their environment; including, ocean acidification due to fluctuations in storm surge patterns. Ocean acidification may affect the life cycle and reproduction of certain marine species that the Gitga'at Nation harvests for subsistence and trading.	A four-stage Adaptation Planning Process, which focuses primarily on soliciting local knowledge and experiences from the community on climate change impacts (pg. 31-33).	Implementing this plan will provide the Upper St'at'imc Territory with documented evaluations of the impacts of climate change that currently affects the lifestyle of the St'at'imc people. If implemented using a participatory values-based approach, this plan will promote participation and involvement and will ensure that communities' values and perspectives are aired and listened to, thereby providing a sense of ownership and planning in the decision-making process. This plan will identify key values of each community in Upper St'at'imc Territory and will assess vulnerabilities in relation to each community's exposure and sensitivity. This plan will also examine the ability of the communities to adapt to the impacts of climate change. It is however, noteworthy to mention, that not all communities would deal with the same impacts, nor would they have similar vulnerabilities or adaptive capacities. One of the primary challenges of the Upper St'atimc Territory is to maintain food security. Some of the action responses initiated by the Gitga'at Nation that can be implemented by the communities of the Upper St'atimc Territory are: 1.) **Documenting and teaching traditional knowledge,** particularly in the areas of fishing and farming; 2.) **Increasing food sufficiency** by researching, mapping and surveying previous, as well as, new harvesting sites and conducting regular community harvesting, processing and distribution activities; and 3.) **Promoting education and awareness on climate change** by developing a knowledge bank to document observations.

Case Study 2	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
Igloolik and Artic Bay, Nunavut Communities	Some of the challenges experienced by the Nunavut communities are unpredictable weather conditions and reduced accessibility to harvesting locations.	The communities of Igloolik and Artic Bay have incorporated a number of adaptation measures to cope with the effects of climate change. Community members have: 1.) Changed their behaviours to either avoid or mitigate potential risks (e.g., taking extra food, gas and supplies on trips or generally avoiding travelling in bad weather); 2.) If harvesting of a specific species fails, this species is substituted with another; 3.) Shared equipment to offset the expense of purchasing equipment; 4.) Shared food to offset risks of unpredictable hunting activities; and 5.) Established the Culture Preservation Program; the Wildlife Management Program; and the Harvester Support Program (pg.42-43) to mitigate community sensitivities.	Communities of the Upper St'at'imc Territory can develop similar programs to those that are currently being implemented by the Nunavut communities. Since one of the primary concerns is to maintain food security for future generations, the Upper St'at'imc Territory can: **1.) Change behaviour patterns:** **1a.) Fishing:** Community members have noticed that fish species have started to arrive later during the summer season, and as such, communities need to re-adjust their fishing activities to the later part of the year since fish would only arrive at that time. 1**b.) Harvesting**: The Upper St'at'imc Territory should incorporate the notion of substitution into their harvesting activities. If the preferred species is not available or inaccessible, alternative species can be harvested to sustain food security. **1c.) Sharing of food among extended families or within the community:** sharing of food is also encouraged to control or manage unpredictable issues associated with harvesting and climate change. **2.) Lands Skills Harvester Training Programs** **2a.) Training youths:** communities can train youths to better predict weather conditions; to better learn harvesting and gardening techniques; and to master the use of specific equipment and technology, including firearms, vehicle management and GPS, which is essential for hunting and travelling. **2b.) Establish Harvester Programs:** The Upper St'at'imc Territory can establish similar Harvester Programs to those of the Nunavut communities. These programs can be developed in collaboration with the Government. The BC government, in this case, can help harvesters to recover from losses due to climate change effects.

Case Study 3	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
Stellat'en First Nation	The Stellat'en First Nation community has experienced a number of wildfires in their area because of the mountain pine beetle infestation. The community has also expressed concern over the health and reproduction of several fish species (including, salmon, trout and white sturgeon) as a direct consequence of increased temperatures of two primary waterways, the Stellako river and the Nautley river.	The Stellat'en community, in collaboration with an academic team, prepared a plan to reduce their carbon footprint. This plan constituted collecting quantitative data, soliciting climate change-related knowledge and experiences from the members of the community, and establishing the exchange of knowledge between the locals and the academic team. After implementation, the community: 1.) Changed its lifestyle and further embraced and integrated their traditional values by strengthening their language and culture; and 2.) Behaved in ways that are less impactful to the environment. For example, the community promoted recycling of waste materials, developed a community garden, and established a bicycle rental program and a ride-sharing program. (pg. 47-48)	The Upper St'at'imc Territory has experienced similar challenges to that of the Stellat'en community. As such, it is recommended that communities of the Upper St'at'imc Territory, **through funded projects, and in collaboration with scientists and academia, conduct a similar research to assess the gaps in traditional and western science**. This can be done through focus groups discussions, interviews and surveys. Similar to the plans established for the Gitga'at Nation and the Stellat'en community, the plan for the St'at'imc people should incorporate: 1.) **Education and awareness programs**, specifically targeting climate change impacts; and 2.) **Traditional programs to strengthen the language, culture and general lifestyle of the community**. Furthermore, this plan would allow the communities to develop actions that are specific to their area in relation to the effects of climate change (such as, the bicycle rental or ride-sharing programs). It is however important to note that those benefiting from this plan may not notice results within a short timeframe, but changes maybe observed over a longer duration of time.

Case Study 4	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
The Vulnerability of Igloolik, Nunavut Food System	Ford's (2006) study, which focused on discussing the implications of climate change for food security in Inuit communities, highlighted that unpredictable weather conditions significantly affected the ability of the Igloolik community to harvest important traditional foods in the region. These foods include walruses, Caribou, fish and ringed seals.	Ford (2006) implemented his research by conducting focus group and interview sessions with Inuit community members, resource managers and local health representatives. This was done to document experiences, and to identify adaptive strategies used to address exposure sensitivities related to climate change. Some adaptive strategies that were implemented are: 1.) purchasing and sharing of store bought foods; 2.) establishing and using food banks; 3.) travelling further to access hunting grounds and fishing lakes; 4.) delaying harvesting activities until there is ice freeze-up to hunt walruses and other wildlife; and 5.) Changing behaviours so that there is reduced importance and reliance on walrus meat. (pg. 52-55)	Communities of the Upper St'at'imc Territory can use this case study as a guide to identify the drivers responsible for food insecurity. Community members can: **1.) Change behaviour patterns:** **1a.) Implement the element of food sharing among extended families or other community members** as in Case Study 2. This will particularly help those who lack sufficient funds to purchase food; **1b.) Adjust harvesting and food preservation activities to a later time** to strengthen food security; **1c.)** If the preferred traditional food is not available or inaccessible, **alternative food can harvested,** sustain food security. **2.) Establish easily accessible food banks and use when necessary**; and **3.)** T**rain youths through the Land-based Skills Harvester Programs** (similar to those implemented by the Nunavut communities). These programs will equip youths to better predict weather conditions and learn harvesting techniques so that they will be able to travel further to access **alternate hunting grounds and fishing locations.**

Case Study 5	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
Northeastern Graham Island, Haida Gwaii (Queen Charlotte Islands)	The Haida residents of the Graham Islands are concerned about their remote location, the island's vulnerable landscape to weather fluctuations; such as, damages from coastal winds and storms, power outages, ferry and air services disruptions, food supply shortages, and highway closures. They are also concerned about their economic instability, which resulted from reduced employment in the forestry sector, restricted fishing privileges and cut backs in funding at the federal and provincial levels.	Although this case study did not specifically present adaptation or mitigation strategies that are currently being implemented by the Haida community, the research team outlined several attributes that are necessary in building the adaptive capacity of this community: 1.) Continued maintenance and protection of coastal roads; transmission lines and services; 2.) Re-zoning specifically around areas that are prone to erosion and flooding; 3.) Developing innovative ways to enhance and diversify the local economy in the areas of tourism, arts and crafts, culture, food harvesting and stockpiling to enhance their resilience; and 4.) Enhance political and institutional networks (For the complete list of factors that enhance adaptive capacity (pg. 57-59)	Implementing the participatory approach method outlined by Connor (2005) and Walker et al. (2007) will enable communities of the Upper St'at'imc Territory to determine sensitivities at the community level. Communities will also be able to define existing and potential attributes that will enhance their adaptive capacity: **1.)** Communities of the Upper St'at'imc Territory are similarly located in a remote setting, depending significantly on each other. As a consequence, community members should build their adaptive capacity by **strengthening community cohesion and support networks and by enhancing the attachment to their land;** **2.)** As a result of weather fluctuations and its location, The Upper St'at'imc Territory is vulnerable to erosion and flooding. **It is therefore important to maintain and protect roads and infrastructure, and transmission lines and services and rezone areas that are prone to erosion and flooding;** **3.)** Community members of the Upper St'at'imc Territory are also concerned about their economic stability since there has been a downturn in the forestry sector. **It is recommended that the communities in this region explore other diverse initiatives (such as, multiple jobs, food gathering and stockpiling, tourism, arts and craft, and seasonal jobs) to sustain their economic viability;** and **4.) Enhancing political and institutional networks:** this type of collaboration will strengthen relations at the government and the local community level, which will further enhance negotiations and support funding initiatives.

Case Study 6	Challenges of the Community	Adaptation Response Strategies	Application of Adaptation Response Strategies to the Upper St'at'imc Territory
Adaptation to Extreme Heat or High Temperatures	The Upper St'at'imc territory, in particular, the T'it'q'et Community has expressed concern in relation to the impacts of high temperatures or extreme heat on community members, specifically the elders. Extreme heat may result in heat stroke, dehydration, loss of consciousness, respiratory other heath related illnesses.	Not Applicable	Studies have shown that there are two (2) primary strategies that can reduce the effects of high temperatures or extreme heat: **1.) Increase surface reflectivity:** **1a.) Install Cool or white roofs:** cool or white roofs reflect more sunlight than standard roofs and absorb less heat, thus promoting a cooling effect in the homes; **1b.) Cover windows facing the sun with aluminium fins**: This is done to reduce heat and promote shading; **1c.) Construct floor vents**: floor vents will control the flow of fresh air entering into homes; **1d.) Construct deep balconies and terraces:** Balconies and terraces can house plants, which will in turn provide shade and facilitate cooling; and **1e.) Install cooling systems** such as, chilled beams or air conditioners **1f.) Establish a Community Health Alert System:** This system can make predictions or alert the community when temperature rises beyond its perceived tolerance level; ensures that air conditioned buildings or centres are available for public use; provides bottled water to the public, especially those at risk; and ensures that staff at centres and hospitals across the region are trained to deal with health-related matters as a consequence of climate change. **2.) Increase Vegetation Cover** **2a.) Conduct community tree planting activities**: tree planting can be done along streets, roads and in residential areas; **2b.) Establish Community gardens and farms.** Both of which reduces the general temperature of the area and promotes cooling. (For the complete list of recommendations see pg. 62-65)

Table 6: Application of How Adaptation Response Strategies implemented by First Nation communities across Canada can be applied to the Upper St'at'imc Territory

8.0 CONCLUSION

Climate change is a complex phenomenon that is evident in many dissimilar ways across various geographic regions, and affects the environmental, social and cultural facets of life (Turner and Clifton, 2009). Unfortunately, indigenous people (including, First Nations and Inuit communities) in comparison to people living in the urban areas are more sensitive to the effects of climate change. This is true on account of their challenging economic situation, their remote or isolated living locations, their close connection to the land, and in general, their social and political marginalization (Krishnaswamy et al., 2012; Ford et al., 2010).

It is noteworthy to mention that the research team in four (4) out of the six (6) case studies presented in this report, implemented community-based participatory methods or participatory values-based approaches as forms of adaptation strategies. Although this type of strategy or measure is considered a grass-roots based approach, it promotes participation and involvement from the communities itself. It empowers the communities to be able to understand what climate change is all about, to identify their sensitivities, and to be able to make informed decisions that will affect their well-being and livelihood.

Participation in the process also ensures that the values and perspectives of community members are aired and listened to, proving a sense of ownership in the process. Community-based participatory approach also facilitates the exchange of knowledge and experiences between community members and academia or western sciences, promoting equal weight and recognition to traditional as well as scientific knowledge, as in the case of the Gitga'at Nation. Participation in the form of workshops, focus group and interview sessions would also serve as a significant tool for communities to learn and enhance their capacities, and to formulate their adaptive strategies and priorities.

However, it is important to note that community-based participatory approach, similar to those discussed in the case studies, may entail continued access to funds and human resources in order

to be successful. Another significant challenge, according to McClymont Peace and Myers (2012), is the duration or length of funding required; as well as, the delays in the release of funds to the communities due to extended bureaucratic processes. In most cases, the communities are unable to commence their research projects unless funding is received. Such delays may extend into the field season, where valuable information cannot be collected, compromising the quality of research being conducted. As such, it is imperative for local communities (such as those living in the Upper St'at'imc Territory) to inform the provincial and federal governments and Non-governmental organizations of their initiatives. It is also important for both parties to prioritize research projects and adaptation strategies and work together in an efficient and effective manner to implement such initiatives.

According to Ford's Study on the Inuit food system, it is important for future and current research teams and communities of the Upper St'at'imc Territory to recognize that neither climate change nor human stresses were responsible for food insecurity in the Inuit community (2009). The interaction of both variables amplified the consequences for the community. Furthermore, the level of exposure sensitivity, as a consequence to changing weather and climate, may vary between communities. This is affected by the social, economic and cultural conditions, the adaptive capacity of each community, as well as the level of exposure to climate change impacts and the nature of such impacts.

In addition to social networks, traditional knowledge and land-based skills, economic and institutional support and technology and infrastructure, risk perception, and awareness and preparedness are also other attributes of adaptive capacity that should be considered when implementing similar community research initiatives. Furthermore, Dolan and Walker (2006) reiterated that researchers should not only consider the inherent resiliencies of the communities, but should also reflect on other social elements; including, discrimination, differential rights, limited ability to access resources, and their participation in decision-making processes.

The recommendations offered in report does not represent an exhaustive list of adaptive strategies, but can be used to initiate discussions among First Nations of the Upper St'at'mic Territory, government representatives, and academia. Implementation of adaptation strategies or initiatives should not be viewed as a one-time event, but should be perceived as an on-going, evolving

activity. As new projections of climatic impacts become known, new adaptation measures should be researched, tested and implemented to enhance community resiliency (Krishnaswamy et al., 2012).

It is also important to acknowledge that no community is entirely safe from natural disasters and disturbances; however, a resilient community is one that is able to mitigate its sensitivities and adjust to fluctuations from such hazards, while at the same time, functioning effectively.

SECTION 2

Climate Change and the Bridge River Power Development

1.0 INTRODUCTION

The majority or 90% of the electricity that powers the province of British Columbia stems from falling water. The availability of water is however inevitably influence by the effects of changing climate and weather (Jost and Weber, n.d). According to a study conducted by Huntington (2006) and Shrestha, Schnorbus, Werner and Berland (2012), climate change is expected to intensity the water cycle, affecting the quantity and availability of water resources. There is also evidence, which suggests that climate change has already affected, and will continue to influence hydrological processes and conditions. Some of these changes, however, fluctuate between locations and times or seasons (Rosenzweig et al., 2007; Kundzewicz et al., 2008; Shrestha et al., 2012). It is therefore imperative to understand the potential effects of this phenomenon in its entirety in order effectively sustain the supply of hydroelectric power for future generations (Jost and Weber, n.d).

1.1 British Columbia Hydro and Power Authority (also known as BC Hydro)

The British Columbia Hydro and Power Authority (also known as BC Hydro) was established by the provincial government as a Crown Corporation in the early 1960s (British Columbia Hydro and Power Authority, 2016; BC Hydro, 2016) via the passing of the *Hydro and Power Authority Act, 1996, c. 212* (British Columbia Hydro and Power Authority, 2016). BC Hydro is one of the largest electricity utilities, comprising of "31 hydroelectric generating stations, two gas-fired thermal power plants, and one combustion turbine station" (World Wide Fund for Nature Canada, 2014, p. 9). The Corporation was established specifically for the sole purpose of power generation (BC Hydro, 2016). With the capacity of generating approximately 12,000 megawatts, BC Hydro provides electricity to about 95% of the province's population (BC Hydro, 2016).

1.2 The Bridge River Power Development (Bridge-Seton Hydroelectric System)

The Bridge River Power Development, also known as the Bridge-Seton Hydroelectric System, is one of BC Hydro's generating systems that has been integrated into the provincial grid exclusively to manage the flow of water in the southwestern location of British Columbia (St'at'imc Eco-Resources, n. d). BC Hydro passes flows from the Bridge River and Seton River watersheds, and receives water from the Cayoosh Creek watershed (World Wide Fund for Nature Canada, 2014; BC Hydro, 2011). Both rivers flow from the coastal mountains, and subsequently join the Fraser River, located near the town of Lillooet. These watersheds presently lie within the vicinity of the traditional territory of the St'at'imc Nation (BC Hydro, 2011; St'at'imc Eco-Resources, n.d) (Figure 8 below).

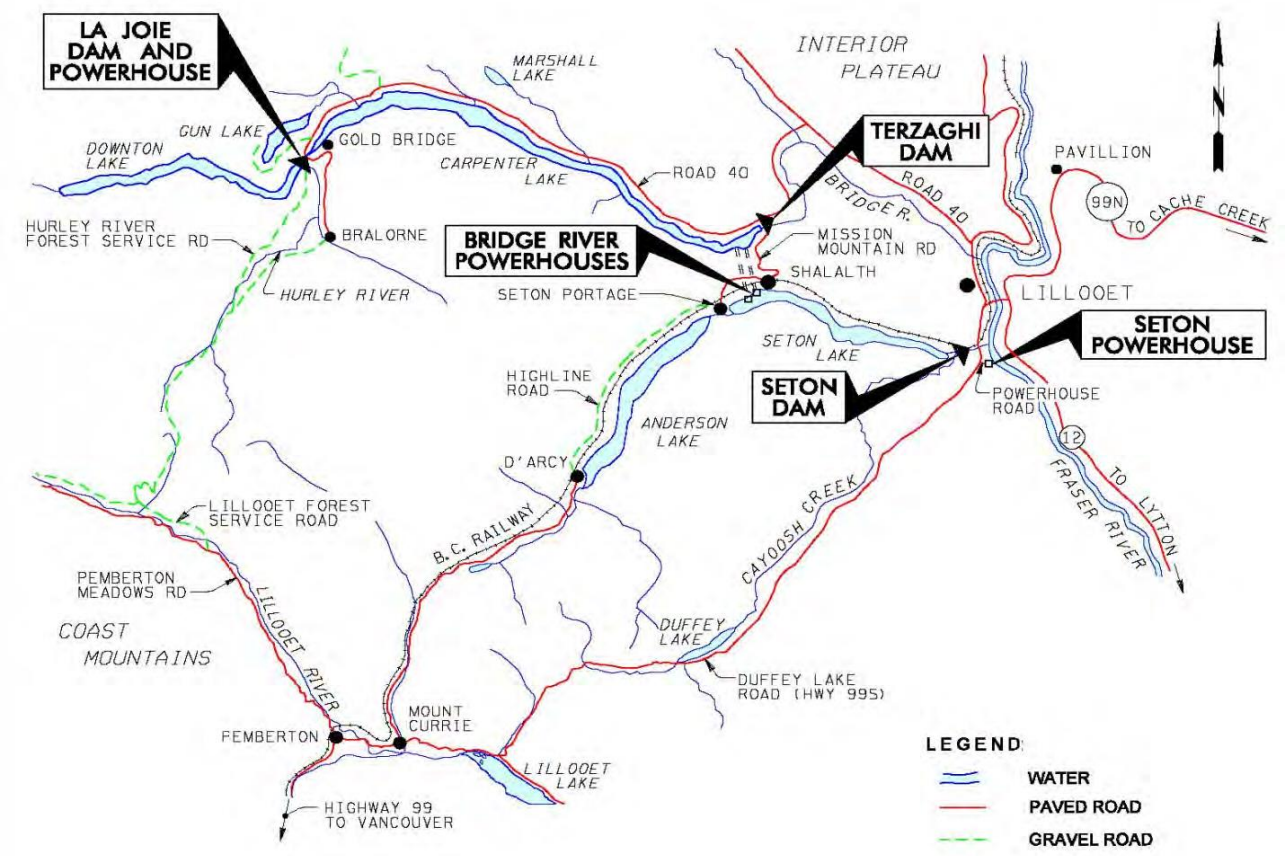

Figure 8: The Bridge River Power Development or Bridge-Seton Hydro-electronic System (Source: St'at'imc Eco-Resources, n.d)

The Bridge River Power Development is a complex system, and comprises of the following facilities (Figure 8):

- Three (3) impoundment dams: La Joie, Terzaghi and Seton;
- Three (3) reservoirs: Downtown lake, Carpenter lake and Seton lake; and
- Four (4) generating stations: La Joie, Bridge No.1, Bridge No.2, and Seton (WWF Canada, 2014; BC Hydro, 2011; BC Hydro, n.d).

The distance between La Joie and Terzaghi dam is divided into three (3) sections:

- Upper Bridge River: This portion emanates from headwaters to the Downtown lake reservoir;
- Middle Bridge River: This section covers from La Joie dam to Carpenter lake reservoir; and
- Lower Bridge River: This segment extends from La Joie dam to the Fraser river, covering about 41km in length (WWF Canada, 2014; BC Hydro, 2011).

Operation of the Bridge River Power Development, according to World Wide Fund for Nature Canada (2014) and BC Hydro (2011)

Water from the Carpenter Lake reservoir diverts to the Bridge Generating Stations (Bridge No1. and Bridge No.2), and is released through two (2) tunnels into Seton Lake reservoir. Additionally, water from the Carpenter Lake reservoir (at Terzaghi Dam) is released into the Lower Bridge River.

Seton Lake reservoir (which is impounded by the Seton Dam), also obtains water from the Seton River, and water is diverted from the Cayoosh Creek.

Water streaming from the Seton Lake reservoir is directed along a 3.7 km power canal to the Seton Generating Station, where it is discharged into the Fraser River.

The Seton Dam facilitates the release of water from the Seton Lake Reservoir directly into the Seton River. Water is then discharged into the Fraser River upstream of the Seton Generating Station, and downstream meeting the Lower Bridge River.

The Bridge River Power Development System was initially created in 1927 for the primary purpose of power generation (World Wide Fund for Nature Canada, 2014; St'at'imc Eco-Resources, n.d), and has the capacity of generating 533 megawatts, contributing up to 8% of the province's electricity (World Wide Fund for Nature Canada, 2014). However, since the facilities of BC Hydro's hydroelectric system are located within the territory of the St'at'imc First Nations, BC Hydro and St'at'imc have been working in close collaboration over a number of years. This initiative ensures that all interests and issues in relation to fish, wildlife and cultural and heritage sites affected by the operation are fully addressed (BC Hydro, n.d; BC Hydro, 2011). For example, during the early 1990s, high inflows of water resulted in spillage from the Terzaghi Dam, which contributed to bank erosion, disruption of spawning gravel, and displaced or breached fish (World Wide Fund for Nature Canada, 2014).

As a result of the aforementioned, a settlement agreement was established among BC Hydro, St'at'imc First Nations and the province of British Columbia (St'at'imc Chiefs Council/Nation Hydro, 2010). This agreement was signed on May 10, 2011 and ensures that the eleven (11) St'at'imc communities living within the vicinity of the hydroelectric system are compensated for their grievances over the impacts of the hydroelectric system. This agreement secures financial and economic benefits, and ensures mitigation of impacts related to the construction and operation of facilities (St'at'imc Chiefs Council/Nation Hydro, 2010; World Wide Fund for Nature Canada, 2014; Penner, 2011). The settlement agreement also permits future operational certainty to the province and to BC Hydro (St'at'imc Government Services, 2012; World Wide Fund for Nature Canada, 2014).

Following the settlement agreement, the Bridge River Water Use Plan (WUP) was formulated. This plan, in conjunction with the *Water Sustainability Act, 2016, c.15* highlights how water control facilities will be operated (BC Hydro, 2011). The purpose of the WUP is to balance the interests of generating electricity in a safe and responsible manner, while concurrently, supporting interests and values of the St'at'imc people (BC Hydro, n.d). These interests include facilitating the abundance and diversity of fish species that pass through the system, and protecting cultural and spiritual sites from erosion and exploitation (BC Hydro, 2011). While the settlement agreement and the Water Use Plan were developed autonomously, they remain inter-connected.

Both documents facilitate transparency and legitimacy, and enhance mutual trust among all parties that are involved in the process (World Wide Fund for Nature Canada, 2014).

Furthermore, the St'at'imc Eco-Resources program (SER) was established as part of the St'at'imc Government Services to enhance program delivery and capacity-building initiatives between BC Hydro and the St'at'imc Nation. As a result, the SER was awarded 16 monitoring programs, which followed the completion of the WUP in 2011(St'at'imc Government Services, 2016). Monitoring opportunities for this program cover the preparation of annual progress reports and sponsorships of bi-annual technical workshops to promote the exchange of information (St'at'imc Government Services, 2016). The SER program, through project management, ensures that all economic needs (power production), as well as social needs (wildlife, fisheries, recreation and traditional knowledge), are met effectively (R. Louie, 2016, personal communication).

2.0 CONCERNS RELATED TO THE IMPACTS OF CLIMATE CHANGE ON THE BRIDGE RIVER DEVELOPMENT

The following section discusses the primary concerns expressed by The St'at'imc Eco-Resources Program and the St'at'imc sub-committee in relation to the impacts of climate change on the Bridge River Development System:

According to the St'at'imc sub-committee (P. Klawer, 2016, personal communication), BC Hydro has been unable to pass flows through the Bridge River Power Development System in accordance with the *Water Sustainability Act, 2016,c.15* without variances from the Water Comptroller.

Consequently, the St'at'imc Eco-Resources and the St'at'imc sub-committee have raised concerns about spill events occurring at the Lower Bridge and Seton Rivers of the Bridge River Power Development System, resulting in fish being stranded, displaced or even killed (Fish and Wildlife Compensation Program, 2011; BC Hydro, n.d). In addition, BC Hydro was unable to follow the flow certainty provisions that are stipulated under agreements signed between BC Hydro and the St'at'imc Nation. As a result of the aforementioned, discussions were held between BC Hydro and

St'at'imc, and a Variance Order was issued to address concerns related to dam safety, and unpredictable high inflows (R. Louie, 2016, personal communication).

In moving forward, BC Hydro and St'at'imc will determine the operating regime (water flows) that will be use for the next 15 years. However, in order to determine such changes, the potential impacts of changing weather and climate must be carefully considered.

Generally, historical records have shown that the province of British Columbia became warmer over the last century. The average annual temperature of the province has risen by 0.5 °C - 1.7°C (LiveSmart BC, n.d; Jost and Weber, n.d) and the annual average precipitation has climbed by 12 percent each century (Environmental Reporting BC, 2015). Jost and Weber (n.d) also confirmed that annual inflows into BC Hydro's reservoirs have increased over a period of 35 - 47 years. However, it is noteworthy to state that such trends are small and may not be statistically significant (Jost and Weber, n.d).

In recognition of the province's goal of reducing one third of Green House Gas (GHG) emissions by 2020, BC Hydro has prepared a Climate Change Adaptation Strategy. This document has two main objectives: 1.) to "maintain a low-carbon electricity supply for our customers; and 2.) to leverage that supply to support provincial GHG reduction targets and policies for a low carbon economy" (p. 6). This strategy addresses potential impacts; such as, rise in temperatures and changes in precipitation patterns. It will also enable BC Hydro to fully adapt its facilities to accommodate unavoidable events (Jost and Weber, n.d).

Consequently, BC Hydro, have been collaborating with other institutions; such as, the Pacific Climate Impacts Consortium (PCIC) and the Western Canadian Cryospheric Network (WC^2N), to determine how climate change has affected, and would potentially affect water supply and reservoir inflows (BC Hydro Power Smart, 2009). This group of esteemed scientists has also been conducting research to investigate how such changes in water resources can potentially affect the hydroelectric facilities of BC Hydro and its ability to generate power (Jost and Weber, 2012).

2.1 Glacier Recession or Retreat and Hydroelectric Power Generation

One of the primary concerns of BC Hydro and St'at'imc is glacier recession. Glaciers throughout Canada have been shrinking significantly since the Little Ace Age or the nineteenth century (Chernos, 2014; Moore and Demuth, 2001; Schiefer, Menounos, and Wheate, 2007). In fact, glacier retreat in the twentieth century or over the last three (3) decades has become more unpredictable and prevalent, which has correlated with the rise in global temperatures (Chernos, 2014; Stahl, Moore, Shea, Hutchinson and Cannon, 2008).

According to Jost and Weber (2012) and Stahl et al. (2008), visual changes to glacier cover strongly indicate that the effects of climate change on the water cycle are evident. Studies have shown that for about 20 years (1985 to 2005), glaciers across British Columbia have lost approximately 11% of their mass area (Jost and Weber, 2012). Holdsworth (2016) states that glaciers in British Columbia loose about 22 million cubic meters of water annually. It is also important to note that more of their mass area is lost during the summer season (because of melting ice), than is gained during the winter season, from snow precipitation (Jost and Weber, n.d).

Glaciers are beneficial to the water cycle in many ways. For example, melting glacier ice helps to maintain stream flow in rivers during hot summer seasons and also assist in regulating water temperatures in downstream rivers. In addition, the latter contributes to sustaining an ecological habitat for cold-water species like salmon (Stahl et al., 2008; Brown, Hannah and Milner, 2005). In short, glaciers are generally important in sustaining water supplies and are an important source of freshwater. Glaciers therefore play a significant role in the generation of hydroelectric power. Projections generally stipulate that glaciers will continue to retreat as temperatures rise. As glaciers melt, streamflow will initially increase, but will ultimately lessen as glaciers shrink in mass (Jost and Weber, n.d). In 1985, for example, glaciers in the Mica Basin covered about 1,268Km², representing 6.1% in total surface area. However, by 2005, glacier cover decreased by 181km², representing 5.2% of the total basin area (Jost and Weber, 2012). Studies illustrate that 40% to 60% of the glacier cover will disappear by the year 2050. Research also predicts that glacier cover will further retreat by 85% - 90% by the year 2100. In fact, by 2100, research

forecasts that all glaciers in the area or region will disappear (Jost and Weber, n.d; Jost and Weber, 2012)

The Bridge Glacier, a known outlet of the Lillooet Ice field, is located in the western vicinity of the town of Lillooet, at the headwaters of the Bridge River (Fraser, 2016). This area is about 180 km northwest of Vancouver in British Columbia's southern Coast Mountains (Bird, 2014; Allen and Smith, 2007).

Historical records suggest that the Bridge Glacier remained moderately stable between the period of 1972 and 1991. However, subsequent to 1991, the glacier began to recede about 100 meters annually. Recession accelerated considerably to 600 meters per year between 2004 and 2012 (Fraser, 2016). According to Fraser (2016), the Bridge Glacier, over a period of forty (40) years, has retreated about three and a half kilometers (31/2 km) in mass. Research conducted by Allen and Smith (2007), indicates that after 1979, the terminus (toe or snout of the glacier) has been retreating 41 meters per year up valley. Presently, this part of the glacier has been floating in Bridge Lake, a proglacial lake, since the early1990s (Chernos, 2014; Allen and Smith, 2007; Ryder, 1991; Bird, 2014). The mass area of Bridge Glacier has reduced dramatically in size from 88 km^2 in 2002 to 64 km^2 in 2010 (Allen and Smith, 2007; Bird, 2014). To reiterate, recession in this manner, means that the glacier has lost more mass during the summer seasons than it gained during the winter periods.

According to Kimmett (2012), University of British Columbia's (UBC) Geography Professor, Dan Moore described the Bridge Glacier as being a battery for the BC hydro system, and generally emphasized that glaciers play vital roles in operating hydroelectric systems. Professor Moore stated that the Bridge River flows 100 kilometers from the mouth of the Bridge Glacier through the Coast Mountains. Water is subsequently passed to the three-(3) impoundment dams (La Joie, Terzaghi and Seton). These impoundment dams then regulate water inflow to the four generating stations, (La Joie, Bridge No.1, Bridge No.2, and Seton) resulting in the production of approximately 8% - 9% of the province's electricity or 492 megawatts (Bird, 2014; Kimmett, 2012).

While it is not clear at this stage how the recession of the Bridge Glacier will affect electricity production, scientist fear that BC Hydro may not be able to maintain sufficient supply of

electricity required to power the province in the future (Kimmett, 2012). According to Matthew Beedle, a Phd candidate at the University of Northern British Columbia, glaciers usually recharge each winter; however, "in a warming climate, you don't get that recharge….so we're just drawing from that reservoir" (Kimmett, 2012, para. 15) Beedle stated that it is also "a critical time for salmon coming upstream" (Kimmett, 2012, para. 16).

Stahl et al. (2008) and Moore, Allen and Stahl (2007) conducted research that assessed the vulnerability of streamflow to climatic fluctuations and glacier cover for the Bridge River Basin. The results of their studies revealed as temperatures continue to rise; glaciers would continue to retreat for decades to come. Rivers fed from glaciers will experience a shift in pattern from a glacial regime with high flows to one of reduced stream flow, or experience stream flow recession during the hot summer periods (Stahl et al., 2008; Moore et al., 2007). It is therefore evident from this study that climate change and glacier recession will have substantial implications on the water supply and aquatic life. Stahl et al. (2008) and Moore et al. (2007) also indicated that in its current state, the Bridge Glacier is out of equilibrium with present climate and weather conditions. Furthermore, projections indicate that this glacier would continue to shrink by 20% in mass area, over the next 50-100 years, even if the current climate conditions were sustained (Stahl et al., 2008; Jost and Weber, 2012). This process would there significantly influence the hydroelectric generation capacity of the Bridge River Development System.

Moreover, a study that conducted by École Polytechnique Fédérale de Lausanne (EPFL) University projected that by the year 2035; there will be a decline in power generation from Swiss hydro, from 40% to 60% (Kimmett, 2012). This occurs as energy demand rises and precipitation decreases. It was also highlighted that countries such as, Bolivia, Peru and Columbia are currently experiencing the negative effects of glacial retreat on their hydroelectric power system (Kimmett, 2012).

2.2 Dam Safety and the Bridge River Power Development System

According to the 2015/16 Annual Service Plan Report, BC Hydro has also raised concerns about Dam Safety, especially as it relates to La Joie Dam. Presently, there are 79 dams dispersed in 41 sites across the province of British Columbia (Ridbey, 2016). In an effort to manage dam safety

issues and hazards in its hydroelectric generating facility, BC Hydro has implemented a Dam Safety Program (Ridbey, 2016).This program ensures that inspections and monitoring activities are conducted on a daily basis. The Dam Safety Program specifically manages the safety "of physical features and structures that retain the reservoirs and control passage of flows through, around and beyond dams that are operated by BC Hydro, thus protecting both the public and the corporation" (Ridbey, 2016, p. 3).

BC Hydro also commissioned a seismic $10 million, six-year assessment, which critically evaluated risks at Bridge River and at BC Hydro's Power Development facilities (Fraser, 2014). This study solicited the experience and knowledge from twenty-five (25) international experts.

Several major projects emanated out of this study; one of which was the assessment of La Joie Dam (Ridbey, 2016; Fraser, 2014). The stability, seismic performance and appurtenant structures of this dam were evaluated over a period of several years. These investigations, which followed further analyses, were completed in 2016 (Ridbey, 2016). The evaluation concluded that the dam suffered a leakage due to an existing, deteriorated shotcrete, installed in 1972. As a result, the dam requires upgrades to mitigate this issue. In its current state, the study revealed that if a major earthquake occurs, La Joie Dam will be damaged considerably (Rigbey, 2016). Subsequent to these results, and following discussions with the First Nation communities and the Comptroller of Water Rights, an Interim Dam Safety Risk Management Plan was developed and issued in January of 2016.

For BC Hydro to legally operate the Downtown Reservoir it was agreed that the maximum reservoir elevation level would be reduced from 749.8m to 734.0m at La Joie Dam until all upgrades to the Dam are made (P. Klawer, 2016, personal communication; Rigbey, 2016; Fraser, 2014). This initiative will reduce spillage, take the load and pressure off the dam, and mitigate seismic risks. BC Hydro has also offered to purchase eleven (11) homes, situated along the flood pathway of the dam, in an effort to reduce potential risks (Vancouver Sun, 2014). Nevertheless, Rigbey, 2016 emphasized that there might be potential water management challenges for the Lower Bridge Water Section (of the hydroelectric facility), emerging from this agreement.

In summary, projections stipulate that the province will become generally wetter and warmer by 2050. Precipitation is expected to increase between 0% -18 % (Jost and Weber, 2012), and will be

the highest during the fall, winter and spring seasons (Jost and Weber, n.d). As such, BC Hydro can expect an increase in its watersheds during these periods. There will also be an increase in water supply during this time to generate hydroelectric power (Jost and Weber, n.d).

Projections also indicate that by the same year (2050), all regions of the province would become 1.4°C - 3.7°C warmer (Jost and Weber, 2012). Similarly, other studies illustrate that by 2100, the average temperature across the province will increase by 1°C - 4°C (Gayton, 2008; West Coast Environmental Law, 2012; Ministry of Water, Land and Air Protection, 2002). However, a consequence of rising temperatures is glacial recession or glacial retreat. Research indicates that as glaciers continue to retreat at such accelerated rates across the province, glacial fed rivers will experience a shift in pattern from a glacial regime of high flows to one of reduced stream flows during the hot summer periods. Glaciers that retreat in this manner would lose more mass during the summer seasons than it would gain during the winter periods.

We can therefore speculate that this phenomenon would have substantial implications on the water supply, which concurrently, will affect the hydroelectric generation capacity of BC Hydro. Correspondingly, temperature rise in rivers can also be detrimental to fish species, such as sockeye salmon, and their habitats. Research indicates that salmon prefers cooler temperatures of about 15°C or less in order to survive and reproduce (Gayton, 2008). Various researchers have linked warmer temperatures to lower reproductive rates (Hinch and Martins, 2011; Jacob et al., 2010), a general decline in the abundance of salmon, and have noted unhealthy changes to the physical appearance of this fish (Jacob et al., 2010). Consequently, since salmon has always been a significant part of the lifestyle and traditional culture of the St'at'imc people, climate change and the issue surrounding glacial retreat and BC Hydro operations will have indirect consequences on food security of the Upper St'at'imc Communities.

Consequently, BC Hydro continues to collaborate with the Pacific Climate Impacts Consortium and other institutions to further conduct hydrologic impact research studies on their watersheds (BC Hydro Power Smart, 2009; Jost and Weber, n.d). In an effort to further facilitate this process, various researchers have indicated that BC Hydro needs to assess how vulnerable or sensitive its operation system is to the effects of climate change. It was recommended that BC Hydro conduct further studies (if they have not already) to address potential glacial recessions using hydrological

simulations. In addition, BC Hydro should implement projects that address inflow scenarios by using operation and planning models (Jost and Weber, n.d; Stahl et al, 2008).These studies can be used to illustrate projections over longer time scales or periods (for example, decades).

In addition to the reconstruction of La Joie Dam, and maintenance of suitable elevation levels in reservoirs (to adequately manage spills and flows), BC Hydro has been monitoring the impacts of their operations on fish and fish habitats near specific waterways (rivers, streams and reservoirs) (BC Hydro Power Smart, 2016). Consequently, the facility has been using an environmental management system to mitigate potential effects. For example, fluctuations in water levels at reservoirs and changes in plant life can affect the food chain fish species. As such, BC Hydro has implemented fertilization programs to assist in the production of food to support fish populations (BC Hydro Power Smart, 2016). BC Hydro has also implanted fish ladders and screens at certain sections of the facility. These installations currently help fish to travel freely upstream or downstream throughout the system (BC Hydro Power Smart, 2016).

BC Hydro also collaborated with the St'at'imc Nation and have developed a Water Use Plan Monitoring Program. This initiative enables the St'at'imc Eco-Resources program to conduct monitoring activities related to the Bridge River Power Development facility, over a 10-year period, from 2012 to 2022 (St'at'imc Government Services, 2016).

It is therefore evident from the examples provided above that BC Hydro is committed towards mitigating or resolving challenges associated with their operations. Therefore, it is recommended that BC Hydro continue to effectively collaborate in partnership with leading experts, and institutions to address current and potential climate change impacts. It is also necessary for BC Hydro to conduct regular monitoring programs and maintenance of the hydroelectric system. These initiatives can enable BC Hydro to strategically balance the interest of generating electricity in a safe and responsible manner, while concomitantly supporting the interests and values of the St'at'imc people in relation to food security, culture and traditions.

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