

A synthesis of the impacts of climate change on the First Nations and Inuit of Canada

Ashleigh Downing & Alain Cuerrier*

Institut de recherche en biologie végétale, 4101, rue Sherbrooke Est, Montréal (Québec), Canada H1X 2B2; *Jardin botanique de Montréal, Institut de recherche en biologie végétale, 4101, rue Sherbrooke Est, Montréal (Québec), Canada H1X 2B2
E-mails : ashleighdowning@gmail.com, alain.cuerrier@umontreal.ca

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Climate change is impacting multiple aspects of life, many of which resonate with the wellbeing of humankind. Indigenous peoples, including First Nations and Inuit communities around the world are more vulnerable to the risks associated with global warming. In this synthesis, examples of direct and indirect impacts and vulnerabilities on First Nations and Inuit people inhabiting Canada have been provided. Examples from other countries as a reminder that these populations are not alone have also been included. After visiting the topics of biophysical environment, cultural identity, cultural activities, food security and health with respect to First Nations and Inuit peoples conclusion on adaptation within the context of change has been given. The paper stresses also the importance of linking health to cultural identity and land use. To fully grasp the impact of climate change on First Nations and the Inuit, government stakeholders, policy makers, as well as researchers need to understand the connection that these people retain with their land. Reports from the Nunatsiag News related to climate change to reiterate the concerns of Inuit people have been compiled. Graphs, stemming from the compilation, indicate what are perceived as the growing problems linked to climate changes in these communities. In order to take a positive, forward thinking, inclusive action, at the local level science will need to team up with traditional knowledge.

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People all over the world are being affected by climate change and are adapting in order to survive. This is particularly true of indigenous populations who rely more heavily upon natural resources for food, medicine, travel and utility in their daily lives¹. Relatively speaking indigenous peoples have done little to contribute to climate change; however, the lifestyle that has prevented making such impacts is what has left them more vulnerable socioeconomically^{2,4}. Culturally, these populations are used to adapting to a changing environment year to year^{5,6}. However, with such rapid fluctuations, indigenous people are becoming more disconnected from the land as they are unable to predict the timing of natural processes as they used to⁷. They are now facing cultural, health and food security challenges and are in need of finding solutions to adapt. Thus far it has meant more and more reliance on scientific investigation and technology. There are many factors which affect a population's ability to adapt.

Amongst the more heavily impacting is a region's economic capacity⁸⁻¹¹. For example, countries making up Northern Africa will undoubtedly suffer a significant loss due to decreasing water availability in the absence of a monetary security net^{12,13}. These populations will not have the economic backing in order to cope with such events and will, therefore, suffer health and economic consequences aggravating the state of an already troubled region. According to Barbara Stocking, the CEO of OXFAM, rich countries should be leading the way in emissions reduction and also should provide financial support to economically vulnerable countries (2009). Further challenges are expected for "rich" countries such as Canada among others who must also take responsibility for their own First Nations and Inuit peoples already experiencing climate change impacts. Around the globe some 26 million people have been displaced due to climate change and this number is only expected to rise reaching 200 million by 2050⁷. Many groups in Canada such as the Inuit of Nain have already suffered the consequences of relocation for

*Corresponding author

political reasons¹⁴. For indigenous peoples this can lead to a loss of language, traditional knowledge and consequently community wellness¹⁵. It will be important in the face of change to develop culturally appropriate adaptations in order to prevent further cultural loss and health decline in Canadian and other indigenous communities. To ensure this, ongoing community participation is key during the research and application phases^{16,17}. Climate change impacts on the indigenous people living around the world, with special attention paid to the Canadian Arctic will be exploded. Efforts will be made to highlight the efficacies and failures of existing solutions and to identify needs for future initiatives. The paper is thus a synthesis of the literature on climate change and indigenous peoples, integrating some examples from the work done by our team in the Arctic.

Changes in the biophysical environment and indigenous peoples

Increasing temperatures has had an overall impact on all natural processes^{18,19}. For indigenous peoples, this translates into a relative change away from ancestral experience²⁰ (Table 1). What is gained from this experience and passed on is a body of traditional knowledge which is fundamental to the existence of people living a subsistence based lifestyle^{21,22}. This body of knowledge is not archaic but constantly evolving²³. Food security weighs heavily on a person’s ability to predict, prepare and adapt to their environment. However, a general consensus among elders regardless of their origin is that global warming has rendered the use of traditional knowledge less reliable¹. Within as little as one generation elders have seen the unpredictability

Table 1—Summary of observations of environmental change in the Canadian Arctic (as discussed in community workshop)

| Region | Inuvialuit Settlement Region | | | | | Nunavut | | | Nunavik | | | Nunatsiavut |
|---|------------------------------|---------------|---------|-------------|--------|-------------|----------|------------|------------|--------------|----------|-------------|
| Community | Paulatuk | Holman Island | Aklavik | Tuktoyaktuk | Inuvik | Repulse Bay | Kugaaruk | Arctic Bay | Puvimittuq | Kangiqsujuaq | Ivujivik | Nunatsiavut |
| OBSERVATIONS | | | | | | | | | | | | |
| WEATHER | | | | | | | | | | | | |
| Weather is increasingly variable and unpredictable. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Winds not as strong / it is not as windy. | | | Winter | Winter | ● | | | | | | | |
| Winds are stronger / windy days occur more often. | ● | ● | Summer | Summer | | ● | | ● | ● | | ● | ● |
| Prevailing winds have shifted. | ● | ● | ● | | | | ● | ● | | | ● | ● |
| More “whirlwinds” in summer. | | | ● | | | | | | | ● | | |
| STORMS | | | | | | | | | | | | |
| Thunderstorms / lightning events are less frequent. | | | | | | | | | ● | ● | | |
| Thunderstorms more frequent / more extreme. | | | ● | ● | ● | ● | | | | | | ● |
| Thunderstorms / lightning occurring at different times of year. | | | | | | | | | ● | ● | ● | ● |
| TEMPERATURE | | | | | | | | | | | | |
| Winters are warmer. | | ● | | ● | ● | | | | ● | | ● | ● |
| Fewer winter extreme cold temperatures. | ● | ● | ● | | ● | ● | ● | | ● | | | ● |
| Summers are cooler. | ● | ● | | | | ● | | | ● | | ● | |
| Summers are warmer. | | | | | | | | | | | | |
| More summer extreme warm temperatures. | | | ● | ● | ● | ● | | | | | | ● |

of their biophysical environment increased to a point where they have lost the ability to use the tools of the many ancestors that preceded them. For instance, Elders from the Cree Nation of Eeyou Istchee (Quebec) have repeatedly mentioned how unpredictable it is now to navigate on the large Mistissini Lake where the community of Mistissini is situated. Traditional knowledge now more than ever before needs to take the forefront in order for the next generation to understand these changes and adapt to them in a positive way. For people living in the north, biophysical changes, which affect all their cultural activities, tend to be related to precipitation and freeze thaw characteristics of snow and ice^{1,18,20,24-29}. Wind has also been changing and plays an important role in influencing these^{24,30}. In Canada's north snow cover comes later and leaves earlier while ice cover has been thinner and its coverage has reached record lows^{1,24,25,29,31-35}. As a result, permafrost is also melting. Shifting permafrost, rising sea levels and spring runoff has accelerated soil erosion decreasing the structural integrity of community infrastructure^{23,31,32}. Homes, roads, airports, water treatment facilities and natural ice cellars are all affected^{1,36}. On June 8 2008, the community of Pangnirtung on Baffin Island (Nunavut) had two of their two bridges collapsed due to flooding and permafrost melt³⁷. This in turn affected their water supply and sewage system, polluting the bay and arctic char, beluga whale populations, both important cultural species used for food. These traditional foods play a major part in Inuit identity and health^{38,39}.

Soil erosion is also a common problem for people living in warmer climates. In this case erosion can be attributed to a higher frequency and severity of storms as well as overall changes in precipitation and a rising sea level^{1,40,41}. Excess precipitation causes flooding and landslides and a loss in infrastructure while the opposite scenario leads to drought, famine and a loss of food security. Rising sea levels can also lead to salt water intrusion which affects drinking water and agricultural soils once again acting on food and water supplies^{1,42,43}. In these regions, extreme events have always been a part of the biophysical environment throughout history however; climate change seems to be exacerbating the frequency and severity of such events⁴⁴. Natural disasters have other consequences as well, specifically decreases in the health of populations from communicable diseases

such as malaria, dengue fever and diarrhoeal disease⁴⁵. Diarrhoeal disease has particularly serious implications for climate change as it is linked to contaminated water supplies which can be caused by either flooding or drought⁴⁶.

Common to all regions affected by climate change is changes in flora and fauna distribution and behaviour^{19,41,47}. Animals are taking different migration routes, migrating to new territories frequently moving pole-ward or up in elevation^{19,47,48}. Shrubs near the community of Kangirsualujuaq, are changing their distribution⁵¹. In a span of 40yrs, they have covered more than a third of the available surfaces surrounding the community. Further, *Larix laricina* or the tamarack tree, has taken to colonising hillsides. Other studies done in the Arctic have revealed a similar trend for shrub expansion^{49,50}. Through dendrochronology, it has been shown that trees have had greater amounts of radial growth for the last two decades⁵¹. This is due to warmer climate. These expansions of trees and shrubs are impacting and will continue to affect animals, especially caribou if the availability of lichen dwindles due to shading. These lichens as well as mosses are abundant in the north and play the role of "ecosystem engineer". Their role is vital as they create soil organic matter, retain nutrients, and protect permafrost by insulating the ground and reflecting light (many lichens are white)⁵². Trees will also provide shelters for birds, introducing new birds to the north. Elders have mentioned seeing more black bears and the favoured hypothesis is that pole-ward tree expansion has created more suitable dens in the area. Shading due to shrubs may also reduce the berry production of many berry plants. Overall, this means a change in the structure and dynamics of ecosystems surrounding indigenous communities leaving inhabitants unsure of what to expect in the incoming years. What is certain, however, is that all of these biophysical changes will have cultural, health and food security consequences.

Cultural activities/ Cultural identity

The cultural identity herein focuses on the relationship between aboriginals and non-aboriginals in Canada⁵³. Cultural identity is a sense of attachment that is a social identity which is part of a person's self-perspective. This identity is derived from the knowledge that an individual belongs to a social group (or groups) and has an emotional significance⁵³.

The First Nations and Inuit of northern Canada belong to social groups, which have a long history of subsistence hunting and gathering. Therefore, activities surrounding the use of plants and wildlife for food, utility and medicine are the foundation for cultural identity in these populations^{20,23,39,54}, and ultimately many subsistence based nations around the world. Species which shape cultural identity are defined as keystone species³⁸. Identity is also consequently tied to environmental elements particularly the land, water and ice that serves as their home and the provider of foods, tools and curative agents^{16,53,55}. Without the land, Inuit and First Nations tend to lose their identity⁵³. For this reason, climate change has had an impact on cultural activities and consequently the cultural identities of subsistence indigenous populations. Here, efforts have been made to consider namely the Inuit and First Nations of northern Canada in an effort to explore how a changing environment can impact the cultural identity of indigenous groups while offering some examples of similar cultural impacts from around the world. Closely embedded into cultural identity lies the notion of quality of life and well-being therefore, a tie is knotted from people and community to vulnerability and adaptability.

Community members, particularly elders are knowledgeable about the changes that have been occurring in the north. Their experience is in large corroborated with scientific evidence and is considered to be highly reliable^{56,57}. Elders from communities across the north have been noticing decreasing snow accumulation²⁰. In some cases there is a lack of snow because there is less frozen precipitation falling and in other cases it is due to stronger winds or a combination of these. This has been raised by many members of the community of Kangirsujuaq, where winds are sweeping the snow away from the tundra (Nunavik, Quebec). This has led to a decrease in traditional activities such as snowshoeing and igloo building which have already been reduced to recreational pastimes such as during festivities. Igloo building requires a minimum amount of snow, of a certain type which elders say occurs less often now. Traditional travel routes are also impacted by a decrease in snow accumulation as travel by snow machine becomes more difficult and even dangerous^{20,28,29,58}. Indeed, the Inuit have had to postpone the use of snowmobile from November to January along the Hudson Strait, making hunting,

fishing and traveling nearly impossible. A change in the direction of prevailing winds has shifted snowdrifts that were once used as navigational markers. Navigation becomes more difficult and dependent on technology such as GPS. In general, this means people have to take longer routes, do not go out onto the land or don't venture as far from the community^{20,59}.

Winter travel routes often cross areas that are expected to be frozen. Residents have noticed for some time now that fall freeze up comes later and spring thaw occurs more rapidly. A relative decrease in the thickness of the ice and the predictability of that thickness as well as other characteristics has made traveling on these routes risky^{20,28,29,59}. Members of multiple communities have mentioned that 10yrs ago fishing on ice, a traditional activity, required 2 length extension to drill through the ice thickness, now they only need one. It has also decreased the amount of time throughout the year that these routes are available. During seasons without snowcover when all terrain vehicles (ATV) are favoured, melted permafrost impacts travel as there is a risk of mudslides and ground instability^{20,24,58}. Unreliable travel routes have a cascade of consequences, particularly a decrease in the amount of time people spend out on the land. Secondly, permafrost melt has already led to the loss of some important traditional sites such as whaling beaches and graveyards²⁰. Seasonal hunting and gathering calendars are now transitioning; for instance, in Sach's Harbour, community members used to return to ice fishing after the annual goose hunt but since the ice is no longer reliable at that time of year they simply return to their community⁵⁸. A lack of access to the land means that there are fewer opportunities for hunting particularly in areas accessed only by traditional routes or on ice²⁰. It has also led to an increase in these practices in proximity to the community^{20,58}. Some animals are changing in abundance in these areas due to over harvesting having implications for food security, which will be discussed later.

Animal availability and behavior changes are another factor impacting hunting practices^{20,24,48,58} (Table 2). Animals are taking new travel routes, are not as healthy and are changing in abundance. This has decreased the efficiency of hunting practices because hunters need to search out new migration routes/ populations and be more selective about the animals they keep as they are more often diseased or

unhealthy looking. Stories about unhealthy animals or change in meat/furs have unfolded about caribou, polar bear and seals. To increase efficiency hunters have started to go after more readily available game such as musk ox, which are increasing in the face of a decreasing caribou population. This meat is considered of lower quality to community members. Also, musk ox was not hunted before in some parts of Canada, from simply being absent. Thus, it implies a shift in cultural identity. Efficiency is also impacted by the fact that some animals spoil due to warmer temperatures before they can reach the community. Traditional permafrost cellars are falling out of use because these layers are melting and no longer provide reliable freezer storage²⁰. All of this means that there is less traditional food being consumed and the quality of that food is not the same. Another well-known cultural practice among Canadian First Nations and Inuit is berry picking and it is affected by climate change as well²⁰. In many cases the abundance and quality of berries are changing. Some complain they no longer taste the same or are too

difficult to find. A longer growing season and hotter temperatures cause berries to ripen earlier than in the past and it has been said that that they don't last as long before rotting. An increase in biting insects is yet another deterrent of this important traditional practice^{20,24}. The distribution of useful plants such as those collected for medicine could also be negatively impacted⁶⁰. With shifting phenology and global warming, pollination syndromes could change with impacts on the dynamic of the whole plant community. Arctic plants face greater risks because at some point there will be a limit to their northward migration⁶⁰. Used for food and medicine by the Inuit, *Rhodiola rosea* is a good example of a plant threatened by climate change. Inhabiting coastal areas and being vulnerable to competition, rising sea levels and encroaching invasive species could severely reduce the abundance of this important cultural keystone species.

Weather prediction is another significant tool used by First Nations and Inuit, but also by other subsistence peoples all over the world^{30,58,61}. Some

Table 2—Number of incidents related to climate change and global warming reported in the Nunatsiaq News from 1995 to 2008. Incidents and observations have been compiled from archived copies of this Inuit newspaper.

| Year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Temperature | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 | 2 | 0 | 4 | 9 | 6 | 8 |
| Sun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| Snow | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Rain | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 2 | 0 |
| Wind | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Seasonality | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Erosion | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 |
| Glacier melting | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| Melting/thin Ice | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 4 | 1 | 2 | 3 | 10 | 2 | 2 |
| Permafrost melting | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 4 | 7 | 1 |
| Accidents on ice | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 3 | 1 | 3 | 0 |
| Hunting | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 3 | 0 |
| Animal health | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 3 | 5 | 2 | 1 |
| Animals behavior | 0 | 0 | 2 | 0 | 4 | 2 | 1 | 0 | 1 | 6 | 4 | 13 | 5 | 4 |
| Plant phenology growth | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 |
| Changes in the flora | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| Food Security | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Adaptation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| Natural disasters | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 2 | 3 | 2 |
| Scientific observations | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 2 | 1 | 5 | 5 | 4 | 6 | 1 |

scientists believe that for some indigenous peoples this is a resource for understanding and adapting to climate change⁶²⁻⁶⁵. However, it seems that in the Arctic the climate is changing too fast at this time for Northerners to adapt and used their weather predicting abilities⁶⁶. Instead of ignoring this traditional practice community members need to listen to their elders and watch the weather in order to adapt this traditional knowledge otherwise it may die in the face of climate change. Even some of the most knowledgeable elders are no longer confident in using the techniques they have been taught to predict the weather because it has become too erratic. More frequent and severe storms also make the consequences of bad prediction all the more dangerous. Indeed, more accidents have been reported in the media during the last decade (Table 2). Time spent out on the land is affected by this weather unpredictability. Now a dependency upon modern weather forecasting requires technology and is not always accurate and especially not site specific⁵⁸. For most members of Inuit communities, it is not only difficult to predict the weather, it is also that climatic events are more unstable and irregular. In a word, weather is inconstant, which makes it dangerous to go out hunting and fishing, especially for Inuit who travel on bays and neighboring seas or for Cree who reside next to large lakes.

Cultural identity is also shaped by the language a person speaks as it is a product of how and where you were brought up. A decrease in time spent out on the land has grave consequences on the transmission of native language to the youth of previously subsistence peoples. As these languages were developed in a time without modern conveniences the vocabulary is almost entirely related to the land. Some researchers have underlined the importance of that intricate network of relationships that hides in all languages. Language embodies spirituality, land uses, cultural identity, and biodiversity⁶⁷. A subsistence lifestyle also means that these peoples were in excellent physical fitness. This is another part of their identity that is also being lost. This is partly tied to a decrease in the time spent out on the land being physically active and to the consumption of store bought foods²⁰. Social ties and sharing practices are also changing since there is a decrease in the availability and consumption of traditional foods. Preparation of traditional foods needs also to be done with more care. The amount of time it takes to dry fish has changed in some cases from two days to one afternoon. Residents have responded by shielding

their meat from the sun but also have noticed a change in the flesh of fish which they believe to be impacting this practice⁶⁸. Further, meats which are eaten either raw or fermented (*igunak*) in the traditional way pose greater risk of zoonotic disease now as the distribution of these are increasing⁶⁹.

Food security

Indigenous traditional food systems as defined by Kuhnlein and Receveur are *composed of items from the local, natural environment that are culturally acceptable*⁷⁰. From their respective environments the Canadian Dene/Metis, Yukon First Nations and Inuit possess knowledge pertaining to the use of 62, 53 and 129 different species of animals (+fish) and 40, 48 and 42 species of plants for consumption⁵⁴. This represents a significant source of culturally acceptable food which may or may not be utilized depending on westernization of the diet or availability of those resources. As delivery of store-bought food is dependent on weather conditions in remote communities and tends to be expensive and often limited nutritionally by risk of spoilage/availability, it is considered to be a shift from traditional food systems to an increasing reliance on store-bought food a risk to a person's food security^{11,71-73}. Additionally, since the portion of society that is the most dependent on subsistence practices is also the fraction of the population with the lowest cash income, they may not have the resources to maintain their personal food security this way⁷¹. Food security being regular access to nutritious food of acceptable quality and in a quantity that satisfies dietary needs⁷⁴. Anything that modifies this access is ultimately a risk to the health status of the population in question. Traditional foods from Canada's Arctic have been proven to be more nutritious and micronutrient rich than are the store bought foods consumed by indigenous peoples in Canada⁵⁴. Willows, fireweeds and other traditional food plants had more vitamin contents than a lemon kept in the fridge for 3 months⁷⁵⁻⁷⁷. When comparing days on which traditional food was consumed against days where it was not more vitamin D, vitamin E, riboflavin, vitamin B-6, iron, zinc, copper, magnesium, manganese, phosphorus, potassium, and selenium were part of the diet and there were lower amounts of undesirable sodium. Vitamin C was found in lower quantities in the traditional foods that were consumed during the study but still were at acceptable levels thanks to elevated quantities in arctic meats⁵⁴.

As climate change plays a role in the traditional food systems of indigenous peoples it is therefore important to assess the risks it may pose to their food security. Few studies have evaluated the effect of climate change on these systems in a subsistence community context⁷². Depending on the community, local resources can make up a significant amount of a person's diet. The all arctic average for energy intake of traditional foods is 22%, with the Dene/Metis at 21%, the Yukon First Nations at 17%, and the Inuit in the highest bracket at 28%. These percentages increase when looking at persons over the age of 40 or with increasing latitudes^{54,78}. In Nunavut 41% of people received more than half their meat and fish from subsistence practices⁷². Studies in the Northwest territories in cooperation with the Dene and Metis from 16 communities across the Arctic found that traditional foods were consumed on 65% of interview days⁷⁸. When looking at specific game animals we can see that 99% of the Cree of Mistissini ate goose at least twice per month, 80.7% ate caribou meat twice per month and 96% ate moose four times or more per month⁷⁹. A significant reliance on traditional food stuffs is common to indigenous communities across Canada and access to these is vulnerable to climate change in many ways. As more northerly communities tend to be more reliant on traditional food systems and climate change seems to be impacting them more urgently action needs to be taken to more fully understand food security at the local level.

As part of food security we will first consider availability. The primary condition that must be met is a means to go out and collect either by land, sea or ice. As shown above, climate change has increased the unpredictability and severity of bad weather so this contributes to a loss of time hunting or gathering. For example, increases in strength or change in prevailing wind direction has been reported for Nunavik, Nunatsiavut and Nunavut (Tables 1 & 2)²⁰. This can restrict access to big lakes or bays for fishing, seal hunting, whaling²³. In Repulse bay Nunavut, residents are reporting a greater number of windy days throughout the year. In some cases, hunters can enlist the help of technology to overcome such obstacles by using bigger, stronger boats etc, however, this and the additional cost of gas particularly on windy days when boating are an increased economic burden⁶. Extreme cold days in winter have decreased, this having a positive effect on a person's ability to take part in outdoor activities

but a negative impact on the formation of sea ice, a factor which mediates accessibility of game²⁰.

If weather conditions are satisfactory, then a person must consider how they reach their hunting, fishing or harvesting location. Activities which take place on ice such as ice fishing, seal hunting, walrus hunting and travel to hunting grounds on and off-shore locations can be limited by the reliability of the ice and a shortened season^{20,24,29,80}. In Kangiqsujuaq and Ivujivik, freeze up happens up to a month later (December) due to warmer temperatures while in Puvirnituk, the wait could take up until January. Once formed ice tends to be thinner than people remember and breaks up earlier (Tables 1 & 2) Food security may not be compromised here by a shortened ice season, as open water hunting and fishing seasons are increased²⁰. Though, in order to avoid insecurity the migration patterns or availability of animals, and fish must also correspond to this "new" hunting/fishing season. A good example of a substitution took place in Kugaaruk where residents switched to fishing char on the shores of rivers in place of seal hunting over ice, as the conditions were too poor. Often traditional harvest times are chosen based on a long history of environmental feedback. As a substitution of this kind is new the ecological repercussions are unknown so it is important that observations are made locally to avoid devastating a population by harvesting it at a crucial time in its lifecycle⁸¹. A lack of culturally acceptable (also subject to personal tastes) prey during a forced shift from the cultural calendar would likely encourage a reliance on store bought foods at that time of year. Also, it could also be difficult for some to switch from one species to another as it employs different knowledge or skill sets. Further, many who have full time employment and rely on official "hunting breaks", casually referred to as goose break, moose break, etc. to complete their subsistence practices, may not end up having access to animals as these breaks are coordinated with times that game was traditionally hunted. More adaptability given for these breaks may be necessary in the upcoming years. A breakdown in equipment (gps, snowmachine, ATV, boat, etc.) can also cause a shift towards store bought food particularly if there is no financial means for repair⁶.

Winter roads that open up the territory to travel by snow machine suffer similarly shortened seasons. Routes to traditional hunting grounds are longer to avoid dangerous travel and discourage subsistence practices in transitional seasons when the snow is

not fit or the ice is too dangerous (end of fall and start of spring)²⁸. This impacts animal availability and puts more pressure on local populations of animals some of which disappear or migrate away from these areas completely²⁰. In the Inuvialuit Settlement Region, for example, communities have shifted from caribou towards musk ox based on their relative local abundance. Populations of cultural keystone species such as caribou can also be impacted by freezing rain. Cycles of warming and cooling or freezing rain can cause a food shortage (lichens) for caribou herds as it becomes inaccessible under a layer of ice and snow¹¹. A decline in a keystone species such as this one can cause serious food insecurity. One such event took place when the Naskapi were more heavily dependent upon big game. Caribou populations were decimated forcing them to seek out help from their Inuit neighbors. It was said that having to resort to the consumption of fish was humiliating⁸². This example also illustrates how some foods can shape cultural identity and can impact what is considered culturally acceptable food for consumption. This event was termed by Gunn as a cultural anvil. Rapid thaw of sea ice can also change animal dynamics in addition to restraining travel. In Wemindji, spring Canada goose (*Branta canadensis*) migration takes place in early April. The length of time the geese will stay in ideal hunting grounds will be longer if the snowmelt and ice-breakup occurs more slowly. As climate change is increasing, the speed of seasonal breakup would be decreased. Hunting can also be affected by the availability of an animal's food source. For instance, during the fall, migrating geese will only stop by the community if there is a suitable crop of berries to eat on their stop over, otherwise, they fly high and out of the reach of hunters⁸³. Naturally, climate determines berry production and quality⁸⁴.

As plant based traditional foods, berry crops represent some of the most important resources for indigenous groups across Canada⁸⁵. Encroaching shrubs due to climate change, threaten to choke out many areas where berries currently grow due to shading⁵¹. Gwich'in women correspondents mentioned a need to take care of berry patches and to return to them for picking regularly in order to avoid over growth by willows⁸⁴. These women place a large importance on these foods and practices for the health of their community and family. Similarly, the Inuit residents of Nain, Labrador, consider berries to have health benefits. Residents in this community have noticed changes in the time of year when berries

are ripening and the length of time that these berries remain edible before picking. Traditionally, these resources were picked in the fall when temperatures are cooler preserving them for longer. Now they ripen even in august leading to premature rotting. Warmer temperatures can also lead to the rotting of meat during transportation from hunting grounds or in traditional cellars if permafrost is compromised²⁰. The frequency of diseased/unhealthy animals has been compromising the harvest practices of traditional meats²⁰. It takes longer to obtain the same amount of food and more animals need to be killed because more and more animals are seen as unfit for consumption. Animals that are having trouble adapting to the changing climate are likely less healthy and more vulnerable to disease. Increases in disease are also due to the fact that microorganisms limited by cold temperatures are extending their range and vectors which carry them are increasing in abundance and range as well⁸⁶⁻⁸⁸. Some of these are zoonoses, and are a class of parasites of particular concern as they can not only compromise health through threats to food security but also directly as they can be passed from animals to humans. Additionally, more caution will have to be taken when preparing traditional foods by fermenting in order to avoid contamination with *Clostridium botulinum* or botulism. This is because meat is fermented at ambient temperatures and anything above 4°C could promote the growth of this microorganism⁸⁸. Problems with infrastructure (permafrost melting) and flooding can also change the quality of water resources in terms of communicable/infectious disease again having food security implications⁸⁹.

Health

The repercussion of climate change on health can be both immediate and chronic. Immediate are those caused by accidents, natural disasters, exposure to more extreme elements (sun, wind etc.), or the sudden onset of illness like food poisoning for example^{24,88}. More chronic are problems of nutrition like deficiencies, circulatory disease, obesity and others such as sensitivities to newly introduced allergens. It is unknown how many deaths/injuries should be attributed to climate change in the north, but in low income countries worldwide each year there are approximately 150, 000 deaths attributable to this phenomenon⁹⁰. These involve problems of malnutrition, diarrhoeal diseases, malaria and flooding. As previously mentioned, all but

malaria are of immediate concern to the indigenous populations living in Canada. Additionally, socio-cultural problems will likely flourish in the face of an increasing disconnection with the land⁹¹. An unfortunate byproduct of this is an overall loss of well-being, mental health problems, alcoholism, drug abuse and suicide⁹². This decreases what is known as quality of life. It will also reduce the potential for resilience.

Accidental death and injury during ice related activities have been on the rise for several years now^{11,25}, (Table 2; Fig. 1). In 2006, there was an unusually warm year and in some ways has been made into a model of things to come. Several inhabitants in Foxe Basin were reported to have fallen through the ice on snowmobiles losing their machines⁸⁰. To cope with poor ice conditions residents spend additional funds to “go around” trouble spots but this is an increased economic burden that many cannot afford. High gas prices left residents reluctant or unable to make preparations in case they were to run into trouble and resulted in people being stranded out on the land⁸. Unpredictable weather will surely lead to more incidents of this variety potentially encompassing life threatening risk. A loss of traditional knowledge will only exacerbate this as the skills used to read weather and land conditions as well as survival skills are being lost⁵⁸. This will undoubtedly translate to injuries or loss of life during subsistence activities when things go wrong (storm, equipment failure). Of course, higher temperatures will mean fewer people will suffer from cold related injuries in these situations. Global warming can also contribute to more exposure to parasites. With respect to warmer temperatures, people are being exposed to more intense radiation from the sun especially in the summer. Problems related to heat stroke, heat exhaustion, dehydration, and skin rashes and burns are more frequently being treated in northern facilities. Also biting insect populations are increasing. This leads mostly to annoyance but bites can cause infection and they can also become vectors of diseases⁸⁸. Diseases passed from animals to humans this way are called zoonoses. Other vectors of disease include contaminated drinking water. Infrastructural damage caused to water treatment facilities caused by shifting soils (permafrost melt) can decrease water quality and safety. Flooding from rapid snowmelt in the spring can do the same. Excess runoff into drinking

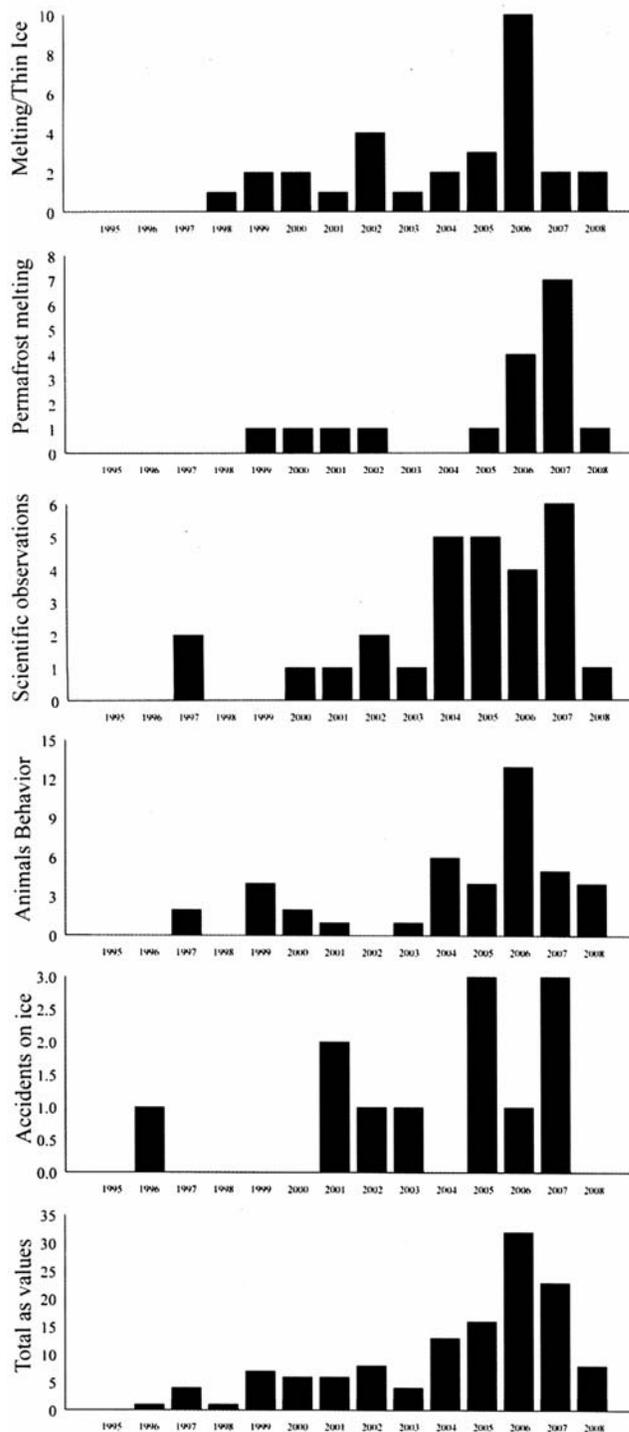


Fig. 1—The six graphs show the increasing number of observations linked to climate change from 1995, where none were reported to 2008. The year 2006 was known to be a particularly warm year. Histograms are based upon Inuit knowledge as reported from the Nunatsiaq News

water reservoirs or overflowing sewage treatment reservoirs can result. Giardiasis and cryptosporidiosis caused by *Giardia lamblia* and *Cryptosporidium parvum*, respectively are types of parasitic zoonotic diseases which can cause outbreaks in this way⁸⁸. Warming temperatures can have negative outcomes on the traditional diet as well. Indeed, climate change may impact fatty acid ratios in the diet and lead, due to bad fat, to increasing cardiovascular problems within a region.

Residents have to be more careful with their meats than ever before. This is partly because meats spoil more rapidly after a kill in warmer temperatures and traditional cellars and methods of preservation don't work as well as they used to²⁰. To reiterate what was previously mentioned, the traditional practice of fermenting foods is becoming more risky as well posing more threat of botulism⁸⁸. Other food borne illnesses to look out for are gastroenteritis from the consumption of halophilic *Vibrio* species in fish and shellfish and paralytic shellfish poisoning. Sick animals have also become more common and pose a risk to the consumer whom it comes into contact with or is ingested by. This is true of tularemia or rabbit fever caused by *Francisella tularensis* which infects hares, rabbits, muskrats, voles, beaver and squirrels some of these being part of the traditional diet and others simply reservoirs. Of course hunters are careful throwing away anything that they perceive to be unhealthy but infection in this case can come from contact during the skinning of an animal^{20,88}. Almost all new or increasing pathogenic threats are due to warmer, wetter conditions and range expansion of microorganisms, vectors and hosts⁸⁷. Lower numbers of healthy prey leads to inefficient harvest practices and potentially a lack of country foods. If implication discussed earlier of food insecurity take effect and residents are not left with regular access to nutritious food in appropriate quantities malnutrition will take hold⁷⁴. Nutrition that is not well balanced can result in one of two types of malnutrition; that which comes from under consumption of appropriate nutrients or over consumption of nutrients. Marginalized nutrition leaves people prone to illness. Too much food, often energy rich macronutrients, can cause obesity, diabetes and cardiovascular disease which are interrelated or a host of other chronic afflictions^{48,92}. A lack of physical exercise from subsistence practices only amplifies these problems.

A shift from traditional food systems to store bought foods has been decreasing the quality of life through health impacts for many indigenous communities around the world including Canadian aboriginals⁹³⁻⁹⁵. Some Canadian indigenous communities like the Cree of Eeyou Istchee suffer from age standardized diabetes⁹⁶. The Inuit who are more subsistence based and therefore consume more country foods tend to have lower rates of diabetes^{54,97}. Country foods can simply be better not just based on the variety of foods available for consumption but because they are nutritionally superior or have medicinal properties. Mountain canberries for instance are eaten as food and also used as medicine by the Gwich'i⁸⁴. According to one informant in Parlee's, study the medicinal properties of mountain cranberries which can be used to treat bladder infections are not characteristic of store bought berries. Many foods in aboriginal and Inuit diets have this double role, including that of *Rhodiola rosea* discussed earlier which is vulnerable like many arctic plants to climate change⁶⁰. This plant has been used to treat fatigue, depression, infections, and to prevent heart problems and strengthen the immune system. More holistic treatment options involving plants from traditional pharmacopoeias would be of benefit but a changing climate may eliminate some of these useful plants altogether. For the many reasons linked to climate change, residents driven towards store bought foods more often will suffer more chronic health consequences.

Chronic are also the socio-cultural problems associated with a shift in cultural identity. Looking at the effect of westernization/acclimation on these communities, we can use this as a model for climate change as there will be a loss of traditional activities, if no processes are put in place to counteract this negative impact. The result has been an overall decrease in well-being for many on a personal level and for everyone at a community level^{55,91}. Poverty and low-self esteem both prevalent in Canadian indigenous communities contribute to high rates of substance abuse which naturally translates to decreased health⁹¹. Moreover, climate change has the potential to augment the level of stress that individuals and communities endure leading to increased health issues. With declining health, indigenous people will experience other stresses, notably at the cultural level. Changes in climate have enormous impacts on health, in addition to

the resulting biophysical stressors, human fitness is closely connected to plant life and wildlife having implications for the mind body and soul.

Conclusions

Everybody's not going to be affected the same way. Everyone will be affected but they will be affected in different ways²³. For First Nation and Inuit people to cope with climate change and other indirect changes multiple tools and solutions are needed, especially for communities that are expanding rapidly. Science and technology are useful but it is traditional knowledge that has kept these people in a flux of adaptation. Communities should look towards this in order to address local problems with local solutions which are better adapted to community needs. It is the “arrogance of humanism” to think that only science will tackle climate change and global warming⁹⁸. Traditional knowledge has much to offer in terms of resilience and adaptability to changes. It offers different perspectives, bringing refreshing views of the world. Science is good however, science and traditional knowledge are better. We need to deconstruct the value of science and place traditional knowledge and science at the same level: at a level where they can interplay together. This will enrich our view of the communities we are trying to help and enrich the solutions we are seeking. Importance of both science and traditional knowledge has been depicted (Fig. 2). There is need to reconnect younger generations to traditional knowledge. The figure illustrates the interrelationship of health, cultural identity, climate change, and traditional knowledge.

Understanding this interconnection defines vulnerability and creates opportunity to address adaptability. The figure shows how important it is to give back pride and empowerment to First Nations and local communities. It increases adaptability by increasing community responsibilities and awareness of changes. Education is a powerful tool and should be used to connect and unify elders and youth. Author’s team has been working with the Cree people as well as the Inuit to bridge the gap between youth and elders and between science and traditional knowledge. Authors accomplished this by organizing flexible workshops that focus on bringing students out onto the land with their elders to learn and reconnect to one another and to the land. Research has shown that a strong connection to the land can serve as a healing tool, especially when elders are actively conveying meaning back to people and their land. The loss of traditional knowledge decreases adaptability to change whether by climate or other factors. It needs to be promoted and enhanced at the community level and stressed in policy development. With tools based upon science and traditional knowledge, communities that have high risk of being relocated will be in a better shape to respond to their new environment. Relocation has impacted Inuit and other indigenous groups, and it will impact many communities in the near future. Reconnecting people to the land will contribute to bringing back wellness. Policy intervention should include: support the teaching and transmission of environmental knowledge and land skills; enhance and review emergency management capability; ensure the

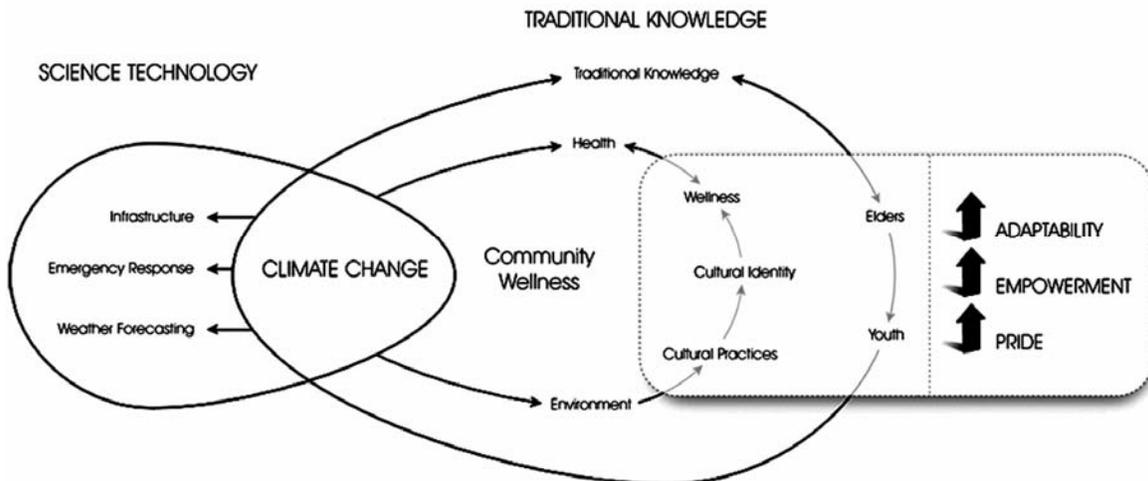


Fig.2—Adaptation to climate change at the local level

flexibility of resource management regimes; provide economic support to facilitate adaptation for groups with limited household income; increase research effort to identify short and long term risk factors and adaptive response options; and protect key infrastructure⁹⁹.

Although we are aware of the overuse and misuse of such concept as holism, we still want to underline that, one needs to use an inclusive approach to understanding changes, vulnerability and adaptation. An inclusive approach is one that links science and traditional knowledge while embracing the all the components of an ecosystem: land with its biophysical processes, plants, wildlife and humans. The human impact of climate change is both direct and indirect. Direct, are the new diseases and potential pollution of their water systems and indirect are the changes to the environment (land slide, permafrost melting), wildlife (shifting abundance and distribution, health, shift in pollinators), plant communities (medicinal quality, abundance, invasive species).

Although climate change is a global problem, communities are experiencing unique changes. For each community to meet with their own problems, policy makers and government stakeholders will have to work closely with the community. Community engagement is mandatory for adaptation to occur and for health to be maintained: health of the people, health of the community and health of the environment. This is no simple achievement, but it is a goal that governments and other players should meet. One needs to acknowledge the importance of cultural identity, traditional knowledge and health. Whether communities are impacted by decreasing snow precipitations in the Arctic or drought in Peru and Africa, they all share the same goal: a healthy place to live and flourish.

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