Impacts of Climate Change on Northern Ontario Communities

2009

Ontario Centre for Climate Impacts and Adaptation Resources
OCCIAR

Focusing on Municipal Infrastructure and Tourism

Ontario Centre for Climate Impacts and Adaptation Resources

OCCIAR is a university-based resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation. The Centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development of tools to assist with municipal adaptation. The Centre is also a hub for climate change impacts and adaptation activities, events and resources.
http://www.climateontario.ca

Acknowledgements

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Workshop Report

Impacts of Climate Change on Northern Ontario Communities
Focusing on Municipal Infrastructure and Tourism

October 20, 2009

Ontario Centre for Climate Impacts and Adaptation Resources
at
MIRARCO

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Analysis

The sectoral climate change scan for the Municipality of Sioux Lookout was deemed to be very successful. Participation from the tourism sector was low but other attendees were able to offer comments informing vulnerability to climate change, adaptive capacity and adaptations that may have already transpired at private tourism operations. The level of interest was high and all attendees were keen to learn more about climate change and to share their experiences and knowledge pertaining to impacts and adaptation.

Summarized climate data for the Sioux Lookout Airport meteorological station dating back to 1939 were reported in a delegate information package (Appendix A). Mean, maximum, and minimum temperatures show increases of 1.1 to 1.2^{0}C over the 60 year period. Seasonal temperature data (winter and summer) indicate that winter months appear to be warming to a larger extent. Precipitation values over the same time period are shown to have increased slightly (100mm) which represents approximately 15% relative to average values over that time period. The summer season appears to have seen larger increases in precipitation relative to the winter period. Spring and fall precipitation values were not compiled.

Projections of climate data, specifically for temperature and precipitation, show increasing trends over both the short and long term as well as for all scenarios of future GHG emissions. Periods into the distant future (2080’s) show larger or continued increases in temperature (relative to the 2020’s period). Extreme temperature values appear to be strongest in summer while minimums appear to increase mostly in the spring. Projections of average precipitation show larger increases in spring and the largest decreases in fall. Annual changes in average precipitation are expected to remain the same for the short term but increase under more intense GHG scenarios. Projections of climate data were sourced from Environment Canada’s Climate Change Scenarios Network (www.cccsn.ca). Modeled futures were derived from the Canadian Global Climate Model CGCM3T47. Projections of climate data from global models cover an area of 3.75degrees latitude/longitude which is approximately 400km x 400km in land area. Due to the limitations of these projections to achieve suitable local resolution, the meeting did not include a strong focus on climate projections.

Workshop attendees commented on the apparent increase in weather variability, and noted shortfalls in weather monitoring stations in their area. Less predictable weather translated into more challenges at the municipal level and changes to local terrestrial species. A connection was immediately made linking the change in weather and climate to its impacts on natural and built systems. Local monitoring of weather and climate may be insufficient for the area as monitoring responsibilities are left to MNR officials. Meeting attendees inquired about weather patterns for the area: where they come from and what that meant to local conditions in Sioux Lookout. Aside from variability, it was noted that microclimates and extreme events can be very localized. The need for increased monitoring was noted in order to better understand these local weather events and also to be able to have more accurate forecasting as extreme weather events approach the area. Some meeting attendees mentioned the need for a more complete climate data set, particularly wind data which might aid in the development of wind power generation.

With reference to the hazard/impact table in the delegate package, meeting attendees were able to comment on how historic climate has impacted specific areas of municipal infrastructure. Impacts from historic climate variability and extremes were reported. Due to the close proximity of the community to forest areas, forest fire management became a focal point during part of the meeting. Regardless of the responsibilities of MNR staff to control and battle forest fires, the municipality has some responsibility. Emergency services along with the municipal fire management coordinator commented on how the community is vulnerable to forest fires including risks posed by smoke. Community members can participate in a Fire Smart program offered by MNR to reduce their vulnerability to forest fires. Previous reactive adaptive measures included 'stay and fight' measures while current methods/measures, mostly driven by concern for public safety and liability risks, place evacuation as a reactive measure.

Recent reductions in the demand for power due to reduced saw mill operations have meant a positive benefit to greenhouse gas emissions. Tourism was most notably affected by large fluctuations in water levels on local lakes. Extremely high water levels in the spring create a situation where tourism business owners (and other lakeshore property owners) are very vulnerable to flooding. **These high lake water levels places infrastructure, ecosystems and human health at increased risk under a new climate regime.** It was unclear as to whether high spring lake levels are controlled by damns in the area.

Sioux Lookout is considered to be a hub for transportation for a large part of northwestern Ontario. The municipality services not only its own residents but also provides services and resources to many First Nations people from reserves north of the town. A total of 10-12 First Nations communities depend on Sioux Lookout for health, education, information technology and many other government services. The private sector also benefits from the town's many visitors. Thus, risks posed by climate change could extend to other communities that lie north of the area.

Although many of the First Nations communities in Northern Ontario lie in the far north and the winter roads network is primarily in the far north, Sioux Lookout is dependent on a robust and well-maintained winter roads system. **A shortened season due to warming and/or variability in climate threatens the winter roads in northern Ontario and ultimately a part of the economy of Sioux Lookout.** Meeting attendees noted spending on enhancement of the winter roads system by MNDM and the Federal government and questioned whether decisions to extend the network have included the recognition of climate change. The winter roads also offer only one way into and out of town thus increasing the importance of a strong network with adequate monitoring and maintenance.

Sioux Lookout's location on the provincial power grid makes it vulnerable to losses in power. One single 40km transmission line feeds into Sioux Lookout from an area near Dryden. Without any redundancy in the supply, threats to the single line translate to losses of hydro. **Considering the transmission lines are more than 40 years old, the existing stresses from age combined with potential climate stresses render the transmission infrastructure vulnerable.** Backup generation is the responsibility of individuals, business owners and the municipality for essential services. It was also thought that local power generation may be beneficial if storage can be made efficient and cost effective.

Threats to the tourism sector were numerous as noted by meeting attendees. The impacts of climate change on lake water levels and local ecosystems were considered to be most important. Invasive species, both terrestrial and aquatic, were recognized as potential threats to a successful tourism industry. Again, winter roads were noted as particularly important in order to maintain a visitor population who engage in tourism and recreation in Sioux Lookout. Environmental conditions and climate/weather monitoring were noted as severely lacking yet most important for feeding into early warning systems (extreme events) and identification of longer term climatic changes.

Shortened and warmer winter seasons leave winter tourism vulnerable to climate change. Current marketing efforts to attract more visitors for winter sports, leisure and recreation may be viable options for the short term as southern location suffer the loss of natural snow cover but the long terms implications may weaken the conditions necessary for viable winter tourism. There was discussion around altering the marketing efforts to attract snowmobilers and others who depend on the natural snow pack and colder temperatures to a less dependent, more eco-friendly marketing focus.

Meeting attendees saw benefit in encouraging local tourism outfitters to change to a more eco-friendly mode of operation (alternate green energy) with potential assistance coming from the Green Energy Act and/or the Northern Ontario Growth Strategy.

Human resource capacity was noted to be a prohibiting factor when it comes to environmental planning and action. While larger cities have more people to take responsibility for environmental issues, small communities often have an easier time garnering political support. Municipal staff often handle tasks and responsibilities of more than one position within small municipalities. The common challenge for many Ontario communities of trying to balance the budget without increasing municipal taxes makes it difficult for major infrastructure upgrades.

Similar to many other Ontario communities, the Sioux Lookout sewage treatment plant may be required to handle increasing amount of storm water if extreme events and/or warming lead to flooding. Municipal representatives also noted that regular maintenance for roads (snow removal, repairs) and the airport facility (snow removal) is crucial to the provision of auto and air services. The Sioux Lookout airport, with its large annual passenger-load, requires substantial maintenance. More snowfall in the future would imply increased costs to remove snow and maintain transportation routes to and from the community. Current road design was thought not to be adequate for the current climate much less the anticipated future climate. The municipality and its engineers cite the current building codes as the guiding document for new infrastructure with little deviation taking place to allow for adaptive measures such as over-designing. Many upgrades to infrastructure are done in light of the need for upgrading and not as a result of proactive adaptation to climate change.

Tourism operators and cottage owners alike often experience high spring-time water levels on local lakes. Control over these high water levels, inflows and outflows, is uncertain but it appeared that little has been done to try to regulate the levels in any way. In light of the risks posed by increased water levels in local lakes and subsequent flooding due to shifts in climate, the Municipality of Sioux Lookout and local tourist camps and cottagers will have to adapt or try to affect changes to current lake level policy. The lack of capacity to affect those policy or regulatory changes in the area may increase future threats and risks.

As noted previously, much support was given to increasing the ability to monitor weather and climate in the area, either through the municipality or through the MNR. More monitoring locations would allow for identification of localized weather extremes thus enabling an early warning system to be put in place. Long term data sets would also allow the area to track climatic shifts as they are occurring in Northern Ontario.

A discussion about the development of municipal or private sector energy conservation initiatives and/or GHG reduction efforts led to comments about human resources within the community. Initiatives such as these require resources that are not easy to find either on staff or within the community. A newly struck Sioux Lookout Environment Committee will bring attention to issues of sustainability and climate change within the community. The mandate of the committee is as follows:

> **To provide leadership, education, and action on environmental best practices, with emphasis on identifying local aspects of adaptation to and mitigation of climate change and to make recommendations to Council on attaining the goal of Environmental Sustainability.**

Methods to reduce the consumption of energy and water are being considered by the Environment Committee as well as ways to encourage active transportation i.e. walking and biking throughout the municipality. The new waterfront revitalization project has incorporated means to reduce vehicle traffic and idling (turnabouts) and build green spaces that will provide trees and naturally landscaped areas to reduce hardened surfaces, capture rainfall and, in a small way, capture CO_2. The municipality is also in the process of assessing the viability of a recycling plant for the area.

Meeting attendees commented on the seemingly increasing methods employed by the Provincial and Federal governments to encourage municipalities to develop and implement environmental or sustainability plans. Funding mechanisms appear to be attempting to incorporate sustainability into the application or devote entire funds to the development and implementation of such environmental plans, including GHG quantification and reduction programs. In this context, it is important to capitalize on these programs for support as smaller communities often do not have sufficient funds to develop such environmental initiatives.

Efforts to switch to more energy efficient operations in tourism, as within many other sectors, is often driven by cost savings rather that environmental benefits. The business case that accompanies environmental program development often has longer term payback periods thus reducing the appeal of such capital expenditures. The tourism sector cited cost savings as the main driver in switching to 4-stroke outboard motors and not the benefits of emissions and particulate matter reductions. The appeal of 'greener' operations often drives tourism marketers to promote these infrastructure upgrades as an environmentally conscious decision and not a business-profit decision.

Future tourism marketing efforts for Sioux Lookout may include promoting less fossil fuel dependant activities and more eco-friendly attractions and adventure tourism. Trail system development, specifically from Dryden to Sioux Lookout is one way to encourage low-impact, low-carbon activities such as hiking, walking and biking. The development of local recreation and leisure facilities such as parks and playgrounds will also encourage local people to remain in

Sioux Lookout for vacation and at the same time, appeal to visitors to undertake low carbon, outdoor activities.

Interest and awareness of the impacts of climate change and the importance of adaptation planning was noted during the meeting in Sioux Lookout. Attendees, as well as Mayor and council, appeared to be keenly interested in learning more about the topic and what it means for their community. Areas of focus included the impacts of climate change in winter roads, the resources required to develop and implement climate change (or environmental) plans and the desire for additional support for the 'conversion' to greener operations, both in tourism and in municipal operations. With these resources in hand, the municipality seems to have the will and commitment to move forward on efforts to combat climate change. Although more difficult to accomplish in a smaller community, provincial and federal support mechanisms would enable communities in northern Ontario to cope with climate change through adaptation and assist in the development and implementation of measures to reduce GHG emissions. Provisions within The Municipal Act will allow progressive communities to develop and institute innovative ways to reduce GHG emissions and build resilience within their communities without the risk of facing litigation for positive steps towards environmental sustainability.

Appendix A - Delegate Package

Impacts of Climate Change on Northern Ontario Communities Focusing on Municipal Infrastructure and Tourism

Thursday May 7, 2009

Sioux Lookout

Ontario Centre for Climate Impacts and Adaptation Resources
at
MIRARCO

Climate Change

Climate is naturally variable and has changed significantly over the history of the Earth. Over the past two million years, the Earth's climate has alternated between ice ages and warm interglacial periods. There are a number of climate variability drivers, from changes in the Earth's orbit, changes in solar output, sunspot cycles, volcanic eruptions, to fluctuations in greenhouse gases and aerosol concentrations. When considered together, they effectively explain most of the climate variability over the past several thousand years. These natural drivers alone, however, cannot account for the increase in temperature and accompanying suite of climatic changes observed over the 20th century.

Climate change may manifest itself as a shift in mean conditions or as changes in the variance and frequency of extremes of climatic variables. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850) (IPCC 2007). There is growing recognition that planning for these changes may pose challenging problems for natural resource managers (IPCC 2001). There is confidence in the ability of climate simulation models to provide natural resource managers with useful projections of future climate scenarios to support planning and management across a range of space and time scales.

Globally, two broad policy responses to address climate change have been identified. The first is mitigation, which is aimed at slowing down climate change by emitting less greenhouse gases in the atmosphere or capturing it through various sequestration methods. The second is adaptation, which is aimed at adjusting resource uses and economic activities in order to moderate potential impacts or to benefit from opportunities associated with climate change. The primary focus of this workshop is on the latter approach.

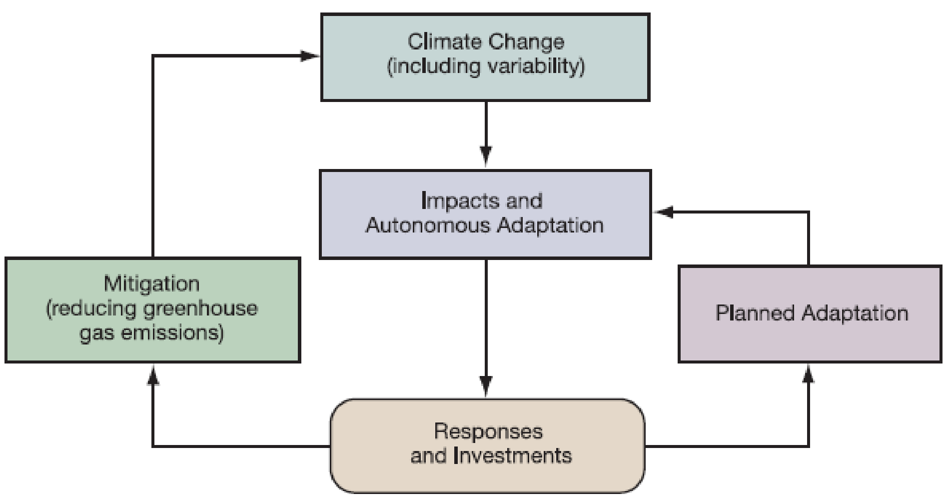

Figure 1: Adaptation and mitigation in the context of climate change (*modified from* Smit et al., 1999 cited in Lemmen et al., 2008).

Impacts and Adaptation

There is broad consensus among international scientists that climate change is occurring, that the impacts are already being felt in regions all around the world and that they will only get worse. “Impacts due to altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change” (IPCC 2007).

Even after implementing measures to reduce greenhouse gas emissions, some degree of climate change is inevitable and is already having economic, social and environmental impacts on communities. Adaptation limits the negative impacts of climate change and takes advantage of new opportunities. It is not an alternative to reducing greenhouse gas emissions in addressing climate change, but rather a necessary complement. “Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions” (IPCC 2007). Reducing greenhouse gas emissions decreases both the rate and overall magnitude of climate change, which increases the likelihood of successful adaptation and decreases associated costs. Adaptation is not a new concept as many approaches have already allowed us to deal with our extremely variable climate. The nature and rate of future climate change, however, poses some new challenges.

Developing an effective strategy for adaptation requires an understanding of our vulnerability to climate change. “Future vulnerability depends not only on climate change but also on development pathway” (IPCC 2007). Vulnerability is determined by three factors: the nature of climate change, the climatic sensitivity of the system or region being considered, and our capacity to adapt to the resulting changes. The tremendous geographic, ecological and economic diversity of Canada means that the 3 factors mentioned above, and hence vulnerabilities, vary significantly across the country. In many cases, adaptation will involve enhancing the resiliency and adaptive capacity of a system to increase its ability to deal with stress.

Adaptation responses include biological, technical, institutional, and economic, behavioural and other adjustments that reduce vulnerability to the adverse impacts, or take advantage of positive effects, from climate change. Effective responses to climate change require an integrated portfolio of responses that include both mitigation and adaptation. At this workshop, the focus is on adaptation.

The Northern Ontario Growth Plan in the Context of Climate Change

Background

The Ontario Centre for Climate Impacts and Adaptation Resources is a university-based, resource hub for researchers and stakeholders searching for information on climate change impacts and adaptation. The centre communicates the latest research on climate change impacts and adaptation, liaises with partners across Canada to encourage adaptation to climate change and aids in the development of tools to assist with municipal adaptation.

The mandate of the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) is to:

- effectively communicate the science of climate change including its current and future impacts;
- encourage the development and implementation of adaptation strategies in order to reduce climate vulnerability and increase resiliency;
- create and foster partnerships with stakeholder groups;
- and support the work of Ontario's Expert Panel on Climate Change Adaptation;

within the Province of Ontario and beyond. The Centre will also be a hub for climate change impacts and adaptation activities, events and resources.

As a component of the Northern Ontario Growth Strategy, OCCIAR will be compiling a report on the implications of climate change for northern Ontario. One part of that report will be an assessment of the climate challenges that northern communities are already facing and will continue to face into the future with respect to changing climatic conditions.

OCCIAR will be conducting a community based climate impacts scan in 2 communities in northern Ontario, one being Sioux Lookout. The scan will consist of a one-day, facilitated meeting with key personnel from 2 sectors, municipal infrastructure and tourism. This meeting will engage participants to discuss their views on climate change, how it may be affecting their sector and what options they have to build resilience into their systems into the future.

Combined with historic and future climate data, key questions related to current stresses in the context of climate change, on both the human and built systems, will be forwarded prior to the meeting and will form the basis for discussion throughout the day. Facilitators will guide the discussion to answer these questions to gain an understanding of how current system stresses will be exacerbated by changing climatic conditions. If time permits, suggestions on adaptive strategies will also be invited.

Once completed, results from the scan will be shared with meeting participants.

Meeting Agenda

On behalf of the:

Ministry of Northern Development and Mines,

Municipality of Sioux Lookout

Ontario Centre for Climate Impacts and Adaptation Resources

You are invited to join us in a one-day meeting to discuss

Impacts of Climate Change on Northern Ontario Communities Focusing on Municipal Infrastructure and Tourism

Thursday May 7, 2009

8:45 AM	Introductions and Meeting Objectives
9:00 AM	Climate change, historic trends and future projections for Sioux Lookout
9:30 AM	Climate change and impacts on Municipal Infrastructure
9:45AM	Current weather and climate challenges with Municipal Infrastructure
10:10 AM	**Break**
10:25 AM	Projected impacts in the context of future and implications
10:55 AM	Adaptive Capacity and barriers to adaptation
11: 15 AM	Options for adapting
12:15 PM	**Catered Lunch**
1:00 PM	Review of climate change, historic trends and future projections
1:30 PM	Climate change and impacts on Tourism
1:45 PM	Current weather and climate challenges in the tourism sector
2:10 PM	Projected impacts in the context of future and implications
2:30 PM	**Break**
2:45 PM	Adaptive Capacity and barriers to adaptation
3:15 PM	Options for adaptation
4:15PM	**Closing remarks**

Facilitated by Al Douglas (Ontario Centre for Climate Adaptation Resources)

Sioux Lookout

Although Ontario is relatively well adapted to present climatic conditions, it may not be ready for the impacts resulting from changes in average and extreme climatic conditions. Recently, Ontario has experienced climatic events such as such as drought, flooding, heat waves and warmer winters. These have resulted in a wide range of impacts including water shortages, lower Great Lakes water levels, declines in agricultural production, power outages and outbreaks of water-borne diseases.

Northern Ontario has already experienced flooding due to intense rainfall events, rapid snowmelt and ice jamming in the spring. In 2002, northwestern Ontario received 400 mm of rain over a 48 hour period. The expected increase in frequency and magnitude of these events will certainly exceed current thresholds and will lead to stresses on our human and natural systems. Good planning requires consideration of climate variability and how it will impact current and future operations in all sectors.

Although Ontario is generally well equipped to adapt to climate change, this adaptive capacity is not uniformly distributed across the province. Indicators such as: economic resources; availability of, and access to, technology, information and skills; and the degree of preparedness of infrastructure and institutions (Smit, et al., 2001) are all necessary in developing and acting on a climate change adaptation strategy.

It is imperative that decision-makers understand current vulnerabilities and the extent of future change to make well-informed adaptation planning decisions. Without this, insufficient actions or actions that inadvertently increase vulnerabilities could be made.

Historic Climate and Climate Trends

The following is a compilation and summarization of weather and climate data for the Sioux Lookout area. Data were obtained from Environment Canada.

Daily Weather

Daily climate data from the Sioux Lookout A weather station, obtained from Environment Canada, was averaged to obtain monthly values for temperature and precipitation (Environment Canada, 2008). Seasonal climate values (winter –DJF and summer – JJA) were calculated by averaging the monthly data. In the following section, temperature and precipitation data, for the years 1939 to 2008, are displayed annually and seasonally (summer and winter) with line charts (Figures 2 to 13) and includes: mean, maximum and minimum temperature and annual precipitation.

Mean temperature is defined as the average of temperature readings taken over a specified amount of time; for example, daily mean temperatures are calculated from the sum of the maximum and minimum temperatures for the day, divided by 2 (Environment Canada, 2008). Maximum temperature is the highest or hottest temperature observed for a specific time interval and minimum temperature is the lowest or coldest temperature for a specific time interval (Environment Canada, 2008). Precipitation includes any and all forms of water, liquid or solid that falls from clouds and reaches the ground and is expressed in terms of vertical depth of water which reaches the ground during a stated period (Environment Canada, 2008). Total precipitation (mm) is the sum of all rainfall and the water equivalent of the total snowfall observed during the day (Environment Canada, 2008). According to Environment Canada (2008), most ordinary stations compute water equivalent of snowfall by dividing the measured amount by ten; however, at principal stations it is usually determined by melting the snow that falls into Nipher gauges. This method normally provides a more accurate estimate of precipitation than using the "ten-to-one" rule (Environment Canada, 2008).

Annual - Historical Climate Data for Sioux Lookout

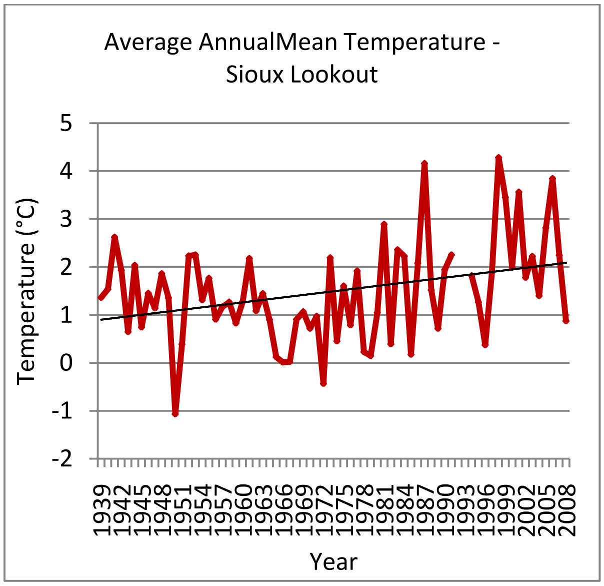

Figure 2: Average annual mean temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.2°C over the 70 years of record.**

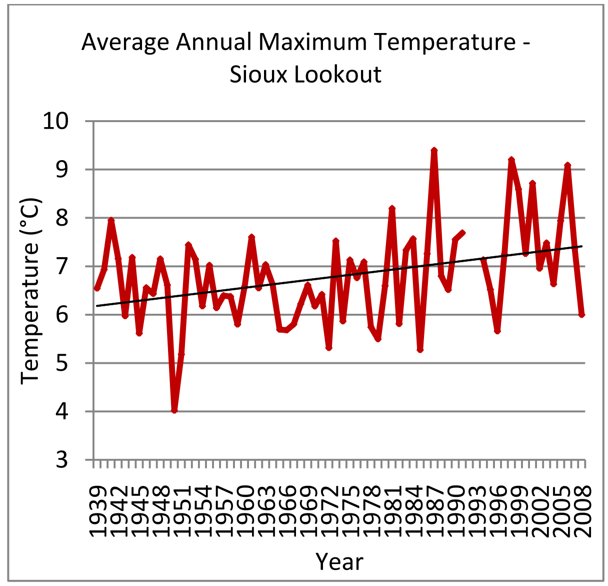

Figure 3: Average annual maximum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.2°C over the 70 years of record.**

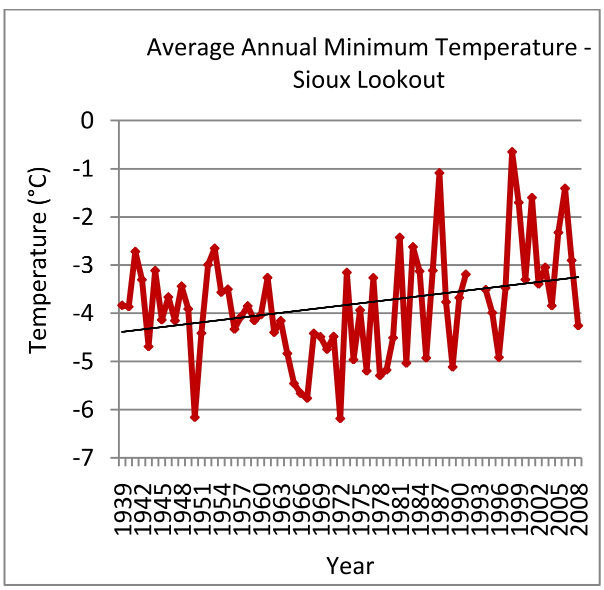

Figure 4: Average annual minimum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.1°C over the 70 years of record.**

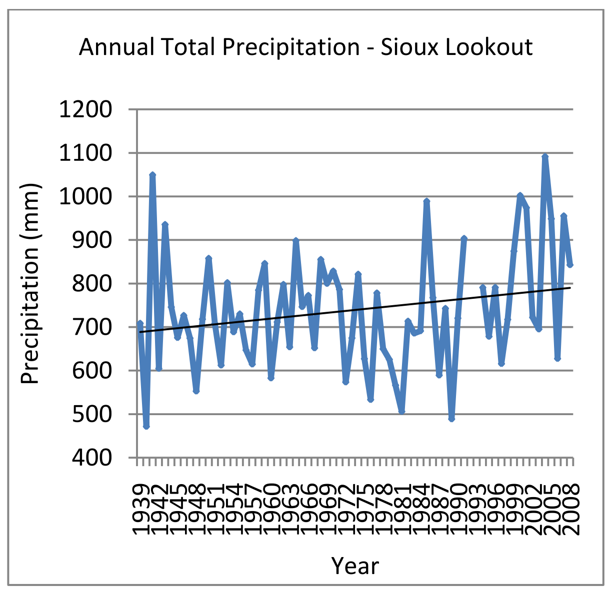

Figure 5: Annual total precipitation (mm) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the precipitation at this location has increased by 100 mm over the 70 years of record.**

Winter - Historical Climate Data for Sioux Lookout

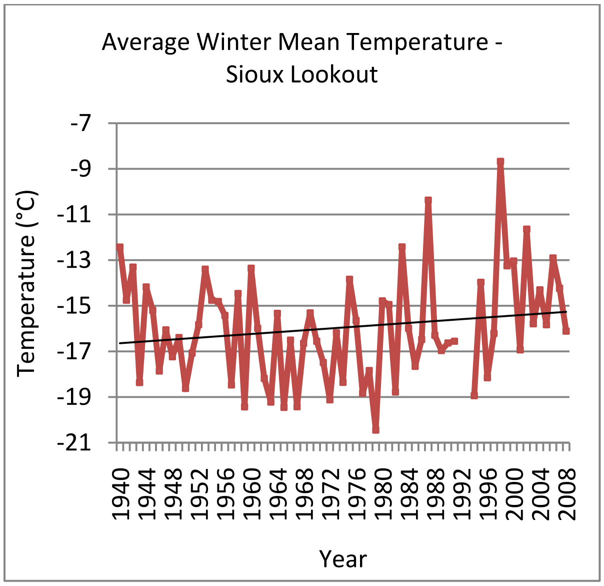

Figure 6: Average winter mean temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.4°C over the 70 years of record.**

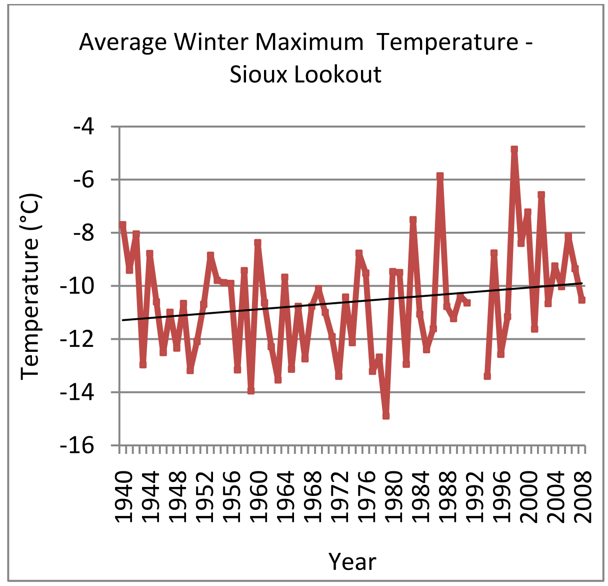

Figure 7: Average winter maximum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.4°C over the 70 years of record.**

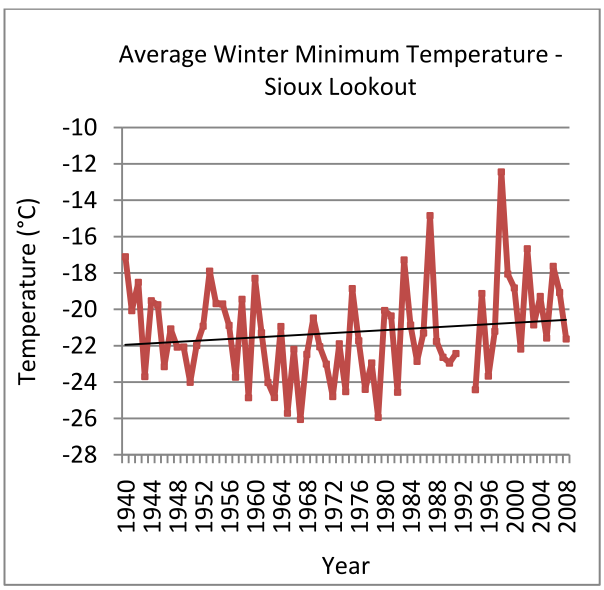

Figure 8: Average winter minimum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.4°C over the 70 years of record.**

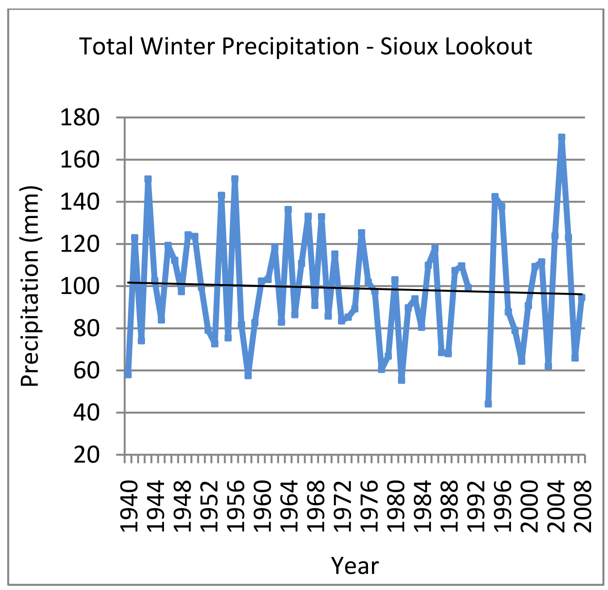

Figure 9: Total winter precipitation (mm) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the precipitation at this location has decreased by 6 mm over the 70 years of record.**

Summer - Historical Climate Data for Sioux Lookout

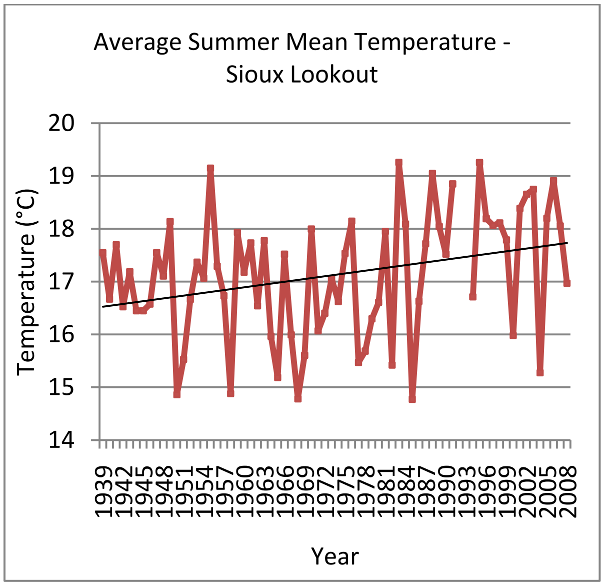

Figure 10: Average summer mean temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.2°C over the 70 years of record**

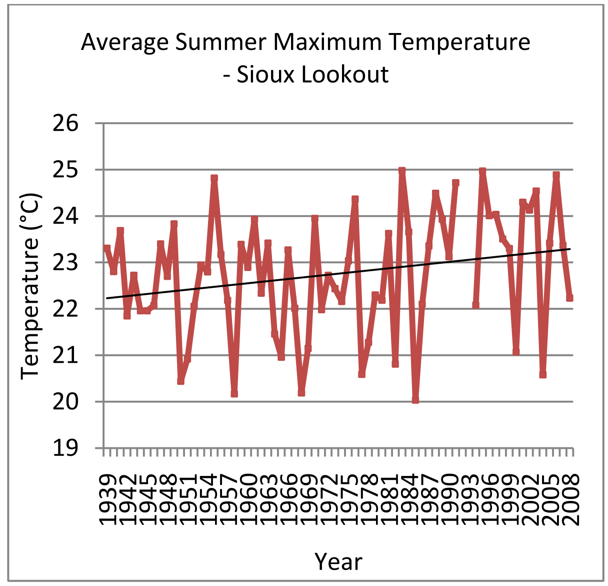

Figure 11: Average summer maximum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.1°C over the 70 years of record**

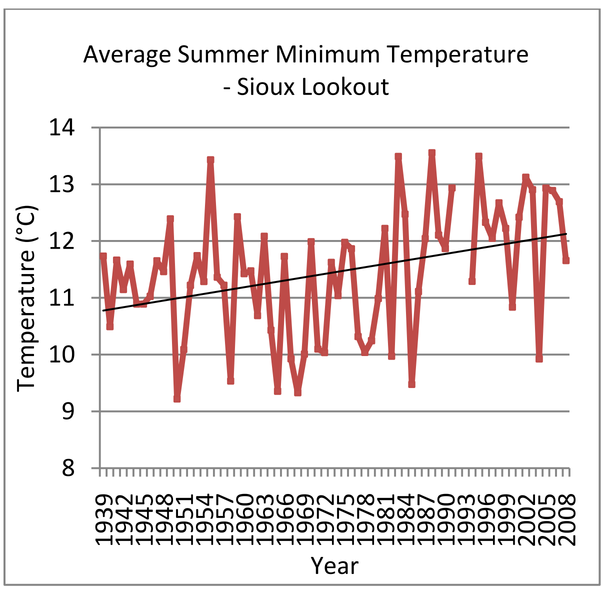

Figure 12: Average summer minimum temperature (°C) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the temperature at this location has increased by 1.3°C over the 70 years of record**

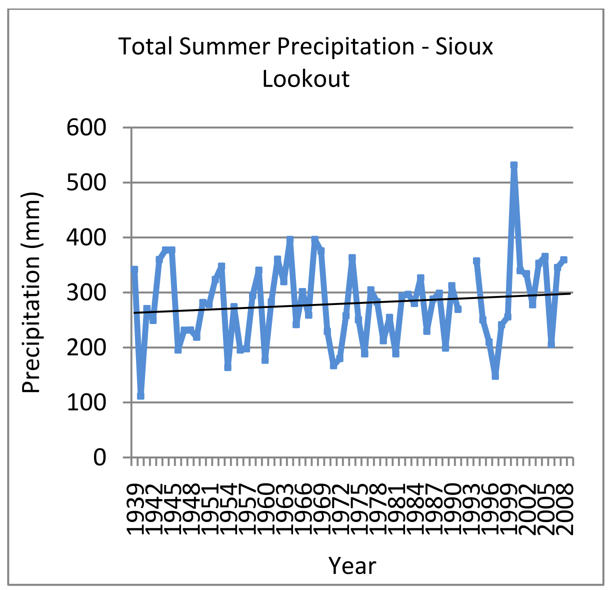

Figure 13: Total summer precipitation (mm) from 1939 to 2008. Data from Sioux Lookout A (Environment Canada, 2008) **shows that the precipitation at this location has increased by 40 mm over the 70 years of record**

Future Climate Projections

Future climate projections were obtained from Environment Canada's Canadian Climate Change Scenarios Network (CCCSN). The CCCSN describes climate change as a difference over a period of time (with respect to a baseline or a reference point) and corresponds to a statistical significant trend of mean climate or its variability, persistent over a long period of time (Environment Canada, 2007). Reference periods of typically 3 decades long (1971-2000) are of sufficient length to adequately represent the climate of the period, and can be used to compare fluctuations of climate between one period and another (Environment Canada, 2007).

Projections from Global Climate Models (GCMs) exhibit a great deal of climate variability. Because of this, the IPCC (2001a) has recommended using at least 30 year averaging periods for GCM output (Environment Canada, 2007). Output generated by climate models are typically as follows: the 2020s (2010-2039), the 2050s (2040-2069), and the 2080s (2070-2099) (Environment Canada, 2007).

The climate scenarios produced for Sioux Lookout were created using the Third Generation Coupled Global Model (CGCM3), version T47. The T47 version has a surface grid whose spatial resolution is roughly 3.75 degrees lat/long and 31 levels in the vertical (Environment Canada, 2005). Data is displayed for the B1, A1B and A2 emission scenarios and is compared to the period of 1971-2000.

Emission scenarios (B1, A1B and A2) are described as follows (IPCC, 2007 cited in Environment Canada, 2007).

A1FI, A1T and A1B

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century (8.7 billion) and declines thereafter (7 billion by 2100), and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity-building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B; where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population (15 billion by 2100). Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1

The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

Temperature

Table 1: Change in mean temperature, extreme maximum temperature and extreme minimum temperature data compared to 1971-2000 for Sioux Lookout, Ontario. Projected values are obtained using AR4 (2007), CGCM3T 47 – Run 1 for each of the emission scenarios A2, A1B and B1 (Environment Canada, 2007).

	AR4 (2007), CGCM3T47 - Run 1						
	Observed Data	**SR-B1**		**SR-AIB**		**SR-A2**	
		Change in Mean Temperature (°C) Data					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	-15.9	1.4	2.4	1.3	3.4	1.4	2.7
Spring	1.9	1	2	1.2	2.2	1.1	2.3
Summer	17.1	1.4	2	1.8	2.6	1.9	2.9
Autumn	3.1	1.8	2.2	1.9	2.7	1.7	2.8
Annual	1.6	1.4	2.1	1.5	2.7	1.5	2.6
		Change in Extreme Maximum Temperature (°C) Data					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	9.3	2	2.7	1.3	3.1	1.3	2.3
Spring	33.9	2.1	2.4	2.4	3.2	2.1	3.4
Summer	37.8	-0.1	0.3	0	0.9	0.5	1.4
Autumn	35	1.7	2.4	2.4	3.1	2.4	3.2
Annual	37.8	-0.1	0.3	0	0.9	0.5	1.4
		Change in Extreme Minimum Temperature (°C) Data					
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	-45	1.8	2.7	1.3	3.1	1.1	2.3
Spring	-35.3	1.5	3	1.3	2.8	1.5	2.3
Summer	-2.1	2.3	2.8	2.9	3.5	2.5	3.8
Autumn	-35.4	1.6	1.6	1.3	2.5	1.5	2.3
Annual	-45	1.8	2.7	1.3	3.1	1.1	2.3

Precipitation

Table 2: Change in precipitation, extreme maximum precipitation and water surplus and deficit data compared to 1971-2000 for Sioux Lookout, Ontario. Projected values are obtained using AR4 (2007), CGCM3T 47 – Run 1 for each of the emission scenarios A2, A1B and B1 (Environment Canada, 2007).

	AR4 (2007), CGCM3T47 - Run 1						
	Observed Data	**SR-B1**		**SR-A1B**		**SR-A2**	
	Change in Precipitation (mm) Data						
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	91.2	-4.5	8.8	16.7	22	12.9	26.3
Spring	139.8	73.9	81.2	14.6	37.4	19.6	31.4
Summer	270.9	-18.4	-21.4	-1	18.3	2.4	13.9
Autumn	212.2	-53.2	-40.3	-13.6	-2	-25	2.3
Annual	714	-2.1	28.5	16.8	75.8	10	74
	Change in Extreme Maximum Precipitation (mm) Data						
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Winter	177.1	-1.8	27.9	42.4	50.8	33.5	59.9
Spring	372.2	161	178.1	9.6	62.2	19.4	47.9
Summer	533.6	-64.9	-78.1	-43.3	-10	-36.4	-13.2
Autumn	486.3	-138.1	-107.1	-49.1	-26.5	-76.1	-15.9
Annual	1569.2	-43.8	20.8	-40.4	76.6	-59.6	78.7
	Change in Mean Water Surplus/Deficit (mm)						
	1971-2000	2011-2040	2041-2070	2011-2040	2041-2070	2011-2040	2041-2070
Surplus	247	4	25	8	42	3	44
Deficit	57	24	28	17	11	14	19

Climatic Hazards

The following table summarizes the possible climatic hazards and extremes related to climate change and the potentially impacted areas and vulnerabilities for municipal infrastructure and tourism.

Climatic Hazards/Extremes	Potentially Impacted Areas/Vulnerabilities	
	Municipal Infrastructure	Tourism
• **Increase in temperature** • **More frequent and intense storms** • **Increased evaporation** • **Increased winter temperatures** • **Prolonged periods of drought** • **Heat waves** • **Increased air pollution** • **Shorter winter seasons** • **Decreased precipitation** • **Increased rainfall intensities** • **Increased vector and rodent-borne disease** • **Reduced water levels in lakes and streams** • **Floods** • **Overall weather variability** • **Cumulative effects of climate hazards** (e.g. heavy snowfall followed by warm winter temperatures combined with rain) • **Windstorms** • **Hail** • **Increased freeze/thaw cycles**	• Water treatment systems and water quality (e.g. sterilization) • Water distribution systems (e.g. pumping) • Energy generation and transmission • Transportation networks (e.g. roads, winter roads, air strips/runways, rail lines, ports, harbours, bridges) • Water shortages (e.g. both surface and ground/well water) • Storm-water and sanitary system infrastructure (e.g. combined sewage overflow) • Wastewater treatment and control of excess natural waste water • Basement flooding • Water quality • Building infrastructure • Communications (e.g. IT, cell, phone) • Building codes and standards • Emergency preparedness and planning	• Longer summer and shoulder tourism season • Heat-related illnesses (respiratory and cardiovascular disorders) • Increased exposure to vector borne diseases (West Nile, Lyme) • Increased exposure to UV radiation • Fluctuating lake levels • Increase in water demand • Increased opportunities for outdoor recreation • Decline in aquatic habitat and wetlands • Distribution of fish species (cold to cool, cool to warm) • Decreased winter tourist season • Reduction in snowmobile season • Downhill skiing, cross-country skiing, snowshoeing, ice-fishing and ice-climbing may be negatively impacted

Questions for Discussion

1. Climate and weather data from the **Sioux Lookout** area show an **increase** in annual average temperature in the range of **1.2^{0}C** (Figure 2, page 11) over the 69 years of record, with a similar increase in minimum (night time) and larger increase in winter season temperatures (Figures 6 – 8, pages 13 and 14). The increase in annual average air temperature for **Canada is 1.3^{0}C** while the increase in **global** annual average air temperature is **0.6^{0}C**. **Ontario's** average annual temperature has increased by **0 to 1.4^{0}C** over the same time period. Projections indicate larger increases into the future (Table 1, page 18).

   Precipitation (as rain) shows an **increase of 100 mm** over the 69 years of record (Figure 5, page 12). Although not clearly captured in this data, climate variability and extremes have also occurred in the past, i.e. heavy rainfall, early spring warm periods, winter rain, extended heat periods. Projections show average annual increases into the future (Table 2, page 19).

   Are you surprised? Do these statements agree with your impression of the changing weather and climate? Do you have any comments around how the weather has changed on your area?

2. Current operational challenges in light of weather and climate – weather and climate affect many aspects of natural and human systems. Municipal infrastructure, including transportation components (rail, road, air strips, ports), energy transmission lines, bridges and buildings is highly vulnerable to extreme weather and climate change. Tourism, while heavily dependent on natural resources and the biophysical systems, is also impacted by extreme events, climate variability and warming. **In what areas of your work are you sensitive to extreme weather including droughts, heavy rainfall, rapid snow melt, extended heat periods, significant evaporation, etc.? How have these sensitivities changed over the years? Has your sector or business adjusted operations to account for extreme weather, i.e. shifted event timing,**

3. Based on these existing sensitivities or vulnerabilities to **current weather extremes**, AND given that the data that suggests the conditions will continue to change in northern Ontario; **will you become more vulnerable to extreme weather and climate variability? In what areas?**

4. The ability to cope with the increased frequency and magnitude of climate variability/change defines adaptive capacity. Metrics such as human resources, financial means, technology, access to data and information, political support, and regulatory framework, etc., all constitute adaptive capacity**. Is your sector/business/municipality deficient in terms of adaptive capacity? If yes, explain.**

5. Efforts to reduce greenhouse gas emissions appear to be more tangible and quantifiable. Measures to increase energy efficiency, reducing energy consumption, green energy (wind, solar, biomass, etc) and various methods of sequestering carbon all lead to reduced GHG's in the atmosphere and constitute the mitigation response to climate change. **Has your company/sector/municipality**

implemented such strategies or do you intend to develop energy plans? Have these plans been driven by cost savings or environmental concern?

The purpose of this exercise is to understand the current and future challenges imposed by climate variability and change into the future on municipal infrastructure and the tourism sector in northern Ontario. Upon its release, the Northern Ontario Growth Strategy will identify opportunities for economic prosperity in a variety of sectors, including tourism. Funds have already been identified to support provincial infrastructural renewal or upgrading. Considering the projected changes for climate in Northern Ontario, building economic foundations for enhanced growth in Northern Ontario without considering climate change may have adverse impacts. At the same time, Northern Ontario is poised to benefit from the efforts required to combat climate change. Opportunities in the area of renewable energy development and distribution, carbon capture and storage and carbon credit trading can transform an economy and stimulate growth and development in Northern Ontario. Projections of future climate also indicate that in order to have a solid, functioning economy, sectors must be aware of the current and future changes and prepare for more extreme weather.

Should future economic development planning in Northern Ontario consider climate variability and change? Will the combination of climate change and increased economic development present challenges or opportunities for your sector/municipality?

Additional questions for thought

- Are you aware of the sensitivities or critical threshold values of your infrastructure and how often you exceed those critical thresholds?
- If your community were to participate in a more thorough vulnerability assessment, what information would you like to have? Who would you invite?
- Are there specific areas that you deem more vulnerable to climate change? Which ones?
- Would tools for adaptation planning help? Would training and knowledge extensions help develop a climate change plan?
- Is the private sector considering the potential impacts of climate change on their operations?
- What role does the provincial government play in supporting climate change adaptation plan development and enactment?
- Are there no regrets options available to begin to reduce the vulnerability of your community to climate change?

Works Cited

Chiotti, Q., & Lavender, B. (2008). Ontario. In F. J. D.S. Lemmen (Ed.), *From Impacts to Adaptation: Canada in a Changing Climate 2007* (pp. 227-274). Ottawa: Government of Canada.

Environment Canada. (2007). *Bioclimate*. Retrieved 2009, from Canadian Climate Change Scenarios Network: http://www.cccsn.ca//Scenarios/BioclimateTool/Bioclimate-e.phtml

Environment Canada. (2005, 05 13). *Canada's Wind Chill Index*. Retrieved March 2009, from The Green Lane: http://www.pnr-rpn.ec.gc.ca/air/wintersevere/windchill.en.html

Environment Canada. (2009). *Canadian Climate Normals or Averages (1971 - 2000)*. Retrieved February 17, 2009, from National Climate Data and Information Archive: http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

Environment Canada. (2008). *Climate Data Online*. Retrieved February 2009, 19, from National Climate Data and Information Archive: http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

Environment Canada. (2008, 11 01). *Glossary*. Retrieved March 2009, from National Climate and Data Information Archive: http://climate.weatheroffice.ec.gc.ca/prods_servs/glossary_e.html

Environment Canada. (2005, 09 28). *Models: Third Generation Coupled Global Climate Model (CGCM3)*. Retrieved March 2009, from Canadian Centre for Climate Modelling and Analysis: http://www.cccma.ec.gc.ca/models/cgcm3.shtml

Environment Canada. (2007, 01 26). *Scenarios: Introduction*. Retrieved March 2009, from Canadian Climate Change Scenarios Network: http://www.cccsn.ca/Scenarios/Scenarios_Introduction-e.html

Environment Canada. (2004). *The Humidex*. Retrieved March 2009, from Meterological Service of Canada: http://www.qc.ec.gc.ca/meteo/Documentation/Humidex_e.html

Environment Canada. (2008). *WMO Standards for "CLIMATE NORMALS"*. Retrieved March 2009, from National Climate Data and Information Archive: http://www.climate.weatheroffice.ec.gc.ca/climate_normals/climate_info_e.html#1

IPCC. (2007). Summary for Policymakers. In O. C. M.L. Parry (Ed.), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (p. 16). Cambridge, UK: Cambrige University Press.

Lemmen, D., Warren, F., & Lacroix, J. (2008). Synthesis. In D. Lemmen, F. Warren, J. Lacroix, & E. Bush (Eds.). Ottawa, ON: Government of Canada.

Smit, B., Burton, I., Klein, R., & Street, R. (1999). The Science of Adaptation: A Framework for Assessment. *Mitigation and Adaptation Strategies for Global Change , 4*, 199-213.

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Hug, S., Klein, R., et al. (2001). Adaptation to climate change on the context of sustainable development and equity. In O. McCarthy, N. Leary, D. Dokken, & S. White (Eds.), *Climate Change 2002: Impacts and Adaptation, and Vulnerability (Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change)* (pp. 877-912). Cambridge, United Kingdon and New York, New York: Cambridge University Press.