



Integration of Climate Change Impacts and Adaptation into Municipal Policy and Programs: A Focus on Water Management

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1. Introduction

There is strong scientific consensus that climate change, the greatest environment challenge of the 21st century, is happening now and that we need to develop adaptation strategies to deal with its impacts. Global trends are becoming apparent, but the exact impacts of climate change at the regional and local levels are not well understood. It is widely accepted that even after introducing significant measures to reduce greenhouse gas emissions, (for example, meeting the reduction targets in the Kyoto Accord) additional global warming is inevitable. This will have a significant economic, social and environmental impact on Canada and Canadians.

Climate change may manifest itself as a shift in mean conditions (such as average precipitation rates) or as changes in the intensity and frequency of extreme events (such as flooding and drought). There is a growing recognition that planning for changes in the intensity and frequency of extreme events may pose the most challenging problems for natural resource managers (IPCC 2001b). While uncertainties remain and must be acknowledged, there is growing 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 activities across a range of space and time scales.

Globally, there are two broad policy responses to address climate change. The first is mitigation, which is aimed at slowing down climate change by moderating greenhouse gas emissions. 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 focus of this workshop is on the latter approach.

2. Purpose of the Workshop

The purpose of this workshop is to:

- share information on climate change as it relates to water management;
- develop a better understanding of municipal needs and gaps related to climate change adaptation and risk management;
- to familiarize participants with a vulnerability assessment approach to understanding and managing climate related risks from a municipal perspective; and
- identify key areas of further research to inform strategies and tools for climate change adaptation.

The presentations will address: the science of climate change; regional risks and water management vulnerabilities including source protection, infrastructure management and financial implications; and new tools and applications, including risk management approaches.

The final session in the workshop will be an interactive Facilitated Group Exercise, which is designed to familiarize participants with a vulnerability assessment approach to understanding and managing climate change-related risks from a municipal perspective. The session draws upon recent research that advocates the use of risk analysis and structured decision-making methods (UKCIP 2003, Turner *et al.* 2003) within a generic, flexible planning framework. Our focus will be on the planning and decision-making steps, recognizing that effective implementation and monitoring using an adaptive management cycle is also an integral part of a broad risk-based approach to climate change adaptation.

A key deliverable from this workshop will be the identification of key areas of further research which, in turn, will inform policies and programs at all levels of government.

Over the course of the workshop we will explore the following questions:

- What is climate change and what are we adapting to?
- What climate-related concerns arise in the context of municipal planning and management for water management?
- What research data and tools are currently available and what are its implications in the area of adaptation to climate change?
- How has climate change already affected and how will it continue to affect our communities' water resources, water infrastructure and economies? And how municipalities are dealing with risk issues in their emergency planning and decision making processes?
- What will be the consequences if we do not act?
- What do municipalities need (e.g., training, tools, partnerships etc.) to address climate related challenges more effectively?

Participants at the workshop will:

- Learn from experts about community-level impacts from a changing Ontario climate focusing on water resources, water infrastructure, source protection and the role of the insurance industry;
- Draw from the experiences and insights of researchers and practitioners from Ontario to identify current feasible approaches to climate risk management including how to integrate climate change into existing processes;
- Highlight the issues and challenges involved and explore the interconnectedness and complexity of climate risk management and adaptive responses;
- Identify gaps and barriers in addressing climate related risks;
- Learn how to reap future economic, social and environmental rewards by planning now for the inevitable impacts of a changing climate.

3. Climate Change in Ontario

Canada is already experiencing the effects of a changing climate. So far the impacts have been felt most acutely in the Arctic. However, there is scientific consensus that **major changes** will be felt in **Ontario** within the lifetime of our children:

- **Higher temperatures** - The average annual air temperature in northwest Ontario has increased by 1.6 degrees C since 1948; in the east of the Province the increase has been a little less than 1 degree (Environment Canada). The Canadian Climate Model projects temperatures increasing by up to 5 degrees by 2050. This is faster than the increase at the end of the last glaciation.
- **Less snow, more winter rain and increased summer evaporation** - There is less confidence about future precipitation levels. Modeling suggests that average annual precipitation for Ontario will be close to current amounts. However, there will also be changes in the seasonal pattern. Models show average winters will likely be wetter (with more rain and less snow) and summers drier. Higher summer temperatures mean substantially greater evaporation, lowering lake levels and soil moisture despite possible increases in rainfall.
- **Lower levels in the Great Lakes and lower mean annual flows for other waterways** - The combination of warmer weather and greater evaporation will reduce river and stream flows and may result in degraded lake, river and stream water quality – widely used for drinking in the north. The Canadian model projects an average drop of 0.3m for Lake Superior and 1m for Lake Huron by 2050.

- **More frequent Extreme Events** – The insurance industry has already documented more frequent extreme events in Canada such as floods, droughts, wind and ice storms. Trends show once in 100 year events becoming once in 50 years or less. Models show that variability and unpredictability will also increase.

4. Vulnerability of Ontario to Climate Change

The most significant **economic, social and environmental consequences** of climate change in Ontario are likely to be:

- **Forestry - Disruption of the Boreal Forest** - In the short term, increasing atmospheric CO₂ may spur plant growth, but forests are already being disturbed by more frequent and intense forest fires fuelled by dead wood from more extensive insect infestations and drier forest litter. More important are the impending changes to the forest ecosystem as invading species from the south replace species no longer well adapted to changing seasonal temperatures, snow cover, soil moisture and overall growing conditions. Recent research shows the potential for the boreal softwood forest in mid-northern Ontario being replaced by hardwoods and grasslands within the lifetime of the next tree rotation. The location and nature of the forest industry will change as existing mills are compelled to relocate because of regional timber shortages. One projection suggests that the bulk of Canada's forest will be subjected to new ecological rules within one rotation based on a yearly rate of disturbance of only 1-2%. What does this mean?
- **Mining** - There will be impacts on all stages of the mining cycle from exploration to mining, smelting and mine site remediation. Increased evaporation will lower water cover on submerged tailings as well as reducing the volume of receiving waters available for waste water disposal and the availability of process water. Heat and drought stress can lead to loss of vegetative covers and increased wind erosion from desiccated exposed tailings. Extreme rainfall events will increase peak loads on dams and flows in water diversion and retention structures. More frequent violent storms could increase the vulnerability of power transmission structures.
- **Hydro power generation** - Declining, less predictable and seasonally different river flows and lake levels will lead to difficulties in hydropower production.
- **Shipping/Transportation/Pipelines** – The Great Lakes shipping season could be extended by reduced ice, but lower lake levels may reduce shipping capacity. A one metre drop in water levels at the Sault would result in an approximate 17% decrease in the carrying capacity of a typical lake vessel, causing a 20% increase in transportation costs. Less snow could mean lower road maintenance costs. However, in the Hudson Bay Lowlands, melting permafrost and peatland could degrade winter roads and lead to instability of buildings and pipelines.
- **Maladapted Infrastructure** - Storm drainage, water supply and treatment systems, culverts, snow load capacity, power transmission towers and many other components of community infrastructure have all been designed based on past climate. As weather extremes change, the criteria used for the design and engineering of buildings and infrastructure will also need to change. Furthermore, premature deterioration of infrastructure may be caused by climate factors like freeze-thaw cycles, ground frost penetration, wind and water actions, ultraviolet radiation and pollution. One of the great and expensive issues of the future will be on how to retrofit substandard buildings and other structures to the latest building code and standards requirements reflecting the changed climate. Another concern is the increase in insurance claims from extreme event disasters.

- **Tourism/Ecotourism** - A shorter snow and ice-on season puts the skiing and snowmobiling industries in jeopardy. Warmer summer temperatures have already affected cold water sport fishing. Lowered lake and river levels together with ecosystem shifts that lead to changes in the distribution of fish, animals, birds and vegetation will affect recreational, adventure and ecotourists, including visitors to Parks.
- **Human Health** – Urban smog, degraded water quality, insect and vector borne diseases, as well as economic hardships that may lead to social problems will exacerbate the stress of an already over-burdened health care system.
- **Agriculture** – A longer growing season will increase opportunities for some crops, providing that soil type and soil moisture are suitable. However, with the loss of soil moisture due to evaporation and accompanying drought, the potential for new, invasive insect pests, and the impact of more frequent extreme weather events may counterbalance those opportunities.
- **Shift/Disappearance of traditional hunting, trapping and food resources** – Many of the remote First Nation communities of the most northern part of the province are especially vulnerable to climate change. Hunting and trapping depend on the availability of habitat, predictable migration patterns, transportation along rivers, sea ice and other environmental factors related to climate. The very way of life in these communities may disappear with threats from permafrost and peatland melting, and ecosystem changes.

5. Climate Change Impacts and Adaptation

There is a strong consensus in the international scientific community that climate change is occurring and that the impacts are already being felt in some regions. Research summarized in the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report indicates that global average surface temperatures are increasing, and that snow cover and ice extent are decreasing in the higher latitudes of the Northern Hemisphere (IPCC 2001a). While the absolute magnitude of predicted changes such as these is uncertain, there is a high degree of confidence in the direction of changes, and in the recognition that climate change effects will persist for many centuries.

It is possible to reduce our vulnerability to climate change. An effective response involves both the reduction of greenhouse gas emissions as well as adaptation to the impacts resulting from a changing climate. Reducing greenhouse gas emissions will decrease both the amount of climate change, as well as the rate of change, so that effective adaptation can occur. Adaptation refers to activities that minimize the negative impacts of climate change, and position us to take advantage of new opportunities that may be presented.

Adaptation to climate is not new. Human societies have successfully adapted to their climate for thousands of years. Highway snow removal, management of water levels along the Great Lakes – St. Lawrence Seaway, and the constructions of floodways, breakwaters, and irrigation systems are all examples of modern adaptations to Canada's naturally variable climate.

Adaptive measures range from actions by individuals or companies, to policies related to planning and infrastructure development. They may be implemented on a local, national, or global scale, and may involve technological, institutional, or behavioral changes.

There are five basic categories of adaptation measures that can be employed in response to an identified risk:

- Prevent the loss- Adopt measures to reduce vulnerability to climate change.
- Tolerate the loss – Do nothing to reduce vulnerability and absorb losses.
- Spread or share the loss – Do not reduce vulnerability, but rather spread the burden of losses across different systems or populations.
- Change the activity – Stop activities that are not sustainable under the changed climate, and substitute with other activities.
- Change the location – Move the activity or system.

As the costs of adaptation may, in some cases, be quite high identifying the risks and early planning involving both communities and industry will be essential for designing effective strategies, and reducing long-term costs associated with their development. Maximizing participants will help build support for the development of adaptive options that will minimize economic, social and environmental costs.

6. Municipal Risk Management Issues Resulting From a Changing Climate¹

6.1 Introduction

The potential impacts of a changing climate are closely related to the safety and protection of people, the protection of property, and the environment, public health and safety of municipalities. Therefore, adaptation to climate change is in the interest of municipal governments. Currently, there is a need to better educate the public and municipal officials about the climate change issue, and its potential impacts upon our municipalities.

In spite of mitigation measures to reduce greenhouse gas emissions, climate changes will continue to occur. A doubling of atmospheric carbon dioxide concentrations is expected to occur even if the provisions of the Kyoto Protocol are fully met by all participating countries. As we head toward a doubled atmospheric CO₂ concentration, municipalities can expect that increasing impacts of climate change will create both positive and negative results for communities, at home and around the world. The estimated overall climate change effects (and impacts) could include:

- An increase in the frequency and severity of extreme weather events (violent winter storms, short disturbances/high-intensity rainfalls, extended heat waves and accompanying smog conditions, wildfires and forest disturbances, severe thundersstorms are tornadoes).
- A change in precipitation, distribution, amounts (lack or abundance of precipitation creating drought or flood conditions, respectively), and types (e.g. – freezing rain and hail damage).
- Overall temperature increases would vary regionally across Canada. Projected increases are estimated for most populous communities in Canada as great as 5°C to 8°C (increased cooling demand, increased heat-related illnesses, northward movement of natural ecosystems, and changes to agricultural crops and forests).
- Polar ice and permafrost melt in northern Canada (landslides and sinking of terrain, ice-free waterways).
- Seal level rise (threatening sensitive coastal areas, e.g. – Atlantic Canada, Fraser Delta, and southern Vancouver Island).

Also, certain changes in our climate may have multiple national, regional and municipal impacts. For example, an increase in the frequency and duration of drought conditions in the Great Lakes-St. Lawrence system would lead to

¹ Bruce et al. 2000, Executive Summary, Background paper prepared for the National Secretariat on Climate Change Municipalities Tables. Complete report available at www.nccp.ca

lowered water levels, which will adversely affect many activities such as shipping, hydropower production, and municipal water supply and quality.

A more complete list of potential climate change impacts, and possible adaptation measures, is presented in Table 1.

6.2 Municipal Adaptation Measures

Canadian experience indicates that adaptive measures and policies that are sensibly and consistently applied over the long-term allow us to persevere under such difficulties on national, regional and municipal scales. For example, water use restriction, efficiency measures, and conservation programs must be adopted to ensure that municipalities have adequate reserves during periods of water shortages. Since it is anticipated that these shortage periods will only increase in severity and duration in the future due to climate change in most regions, municipalities must be prepared for this impact.

Municipalities that increase their adaptive capacity decrease their vulnerability to climate change. Success will depend upon their ability to meet the various adaptations of objectives required as we experience increases in the frequency and intensity of Canadian weather phenomena. Although the climate is changing at an unprecedented rate, sufficient time is available for steady, affordable progress to be made, provided that recognition is given now to the need for adaptation to begin immediately and be allowed to proceed at a reasonable pace. The costs associated with successful adaptation can be high, and can only be very roughly estimated at the present time. However, the costs associated with weather variability and extreme events (e.g. forest fires, droughts, and storms), and other events will remain significant and are likely to increase over present levels as recent trends already indicate.

It is also important for Canadian communities to adapt and take advantage of benefits that may be presented with a changing climate. Winter temperatures may be less severe in much of Canada, thereby extending the shipping season and the growing season in and along the St. Lawrence Seaway, for example. It will require effort, initiative and investment by municipalities to determine and exploit the opportunities that may arise and limit the adverse affects that may occur, as a result of a changing climate in Canada.

Finally, it is important to note that many adaptation measures, especially those which should be taken for extreme weather-related events have merits quite apart from those related to climate change. Also, on a human scale, even considering the replacements schedule for some infrastructure items, climate change will occur relatively slowly. The case for avoiding denial, deferral and delay and initiating timely, appropriate and carefully considered actions is very strong.

Table 1: Summary of Critical Impacts for Communities ²

Ecosystem Health

- Threats from: Extreme weather events, ice changes, lower lake levels, loss of wetlands, cumulative impacts.
 - Threats to: Biodiversity, land resources, management ability, water quality and quantity, air quality.
-

Human Health

- Vector borne and waterborne diseases.
 - Extreme weather - extreme heat and cold.
 - Deteriorating air quality.
 - Deteriorating water quality.
 - Secondary impacts, e.g. indoor mold, weather related transportation.
-

Infrastructure

- Runoff, landslide and flooding impacts.
 - Water intake/control infrastructure (water quality).
 - Deterioration of infrastructure (buildings, roads, transmission towers, etc).
 - Reduced security of energy supply.
 - Implications for design specifications/margin of safety in building codes.
-

Water Resources

- Increased capacity demands on sewage/water control infrastructure.
 - Pressure on source water resources.
 - Change in pattern of supply (municipal management implications).
 - Social and economic impacts (e.g. tourism, recreation).
 - Degraded water supply.
-

² From Climate Change impacts and Adaptation Priority Research Areas for Ontario, 2003

7. Vulnerability and Risk Management

7.1 What is a Vulnerability Assessment and Risk Management as it relates to Climate Change?³

The extent to which ecosystems or socio-economic systems are vulnerable depends on both exposure to climate change (or other) effects and on the adaptive capacity of the system. In order to conduct a vulnerability assessment, the first task is to trace the exposure pathways that lead from climate to our previously stated management objectives. Climate change precludes the impacts which link to the socioeconomic and biophysical objectives of management. The stresses can then be used to identify important exposure pathways, communicate system vulnerabilities and target information collection efforts.

Vulnerability assessments strive to consider both climatic and non-climatic stressors and address not only the hazard but also the system to which the hazard impacts upon and its ability to cope. Vulnerability assessments also engage stakeholders at the onset of the process and focus on the risk to the community as opposed to an impact-focused approach.

Risk management is the process of measuring, or assessing risk and then developing strategies to manage the risk. In ideal risk management, a prioritization process is followed whereby the risks with the greatest loss and the greatest probability of occurring are handled first, and risks with lower probability of occurrence and lower loss are handled later.

In practice the process can be very difficult, and balancing between risks with a high probability of occurrence but lower loss vs. a risk with high loss but lower probability of occurrence can often be mishandled.

Risk management also faces a difficulty in allocating resources properly. This is the idea of opportunity cost. Resources spent on risk management could be instead spent on more profitable activities. Again, ideal risk management spends the least amount of resources in the process while reducing the effects of risks as much as possible.

Risk assessment is measuring two quantities of the risk, the **magnitude of the potential loss**, and the **probability that the loss will occur**. The purpose of risk assessment, in the context of climate change, is to identify risks and hazards that may be induced or exacerbated by climate change and to evaluate the magnitude of their impacts and the probability that they will occur. It can be a useful tool in adapting to the negative aspects of climate change since it can be used to address a range of climate-related impacts with both a high or low probability of occurrence. Risk assessment may be the most important step in the risk management process, and may also be the most difficult and prone to error. Once risks have been identified and assessed, the steps to properly deal with them are much more programmatical.

Part of the difficulty of risk management is that measurement of both of the quantities in which risk assessment is concerned (magnitude of problem and probability of occurrence) can be very difficult itself. Uncertainty in the measurement is often large in both cases. Also, risk management would be simpler if a single metric could embody all of the information in the measurement. However, since two quantities are being measured, this is not possible. A risk with a large potential loss and a low probability of occurring must be treated differently than one with a low potential loss but a high likelihood of occurring. In theory both are of nearly equal priority in dealing with first, but in practice it can be very difficult to manage when faced with the scarcity of resources, especially time, in which to conduct the risk management process.

³ From a C-ClARN Risk Management Workshop Framework. Taylor, 2005.

7.2 Why should a Vulnerability Assessment and Risk Management be used in adapting to climate change?

To begin with a few principles must be assumed.

- o Climate variability, including climate extremes or combinations of several climate extremes and other factors, currently can damage communities. Therefore, even without climate change, communities are at some risk from this current climate variability.
- o Climate change may exacerbate these vulnerabilities/ risks, though it is uncertain how the probability or severity of these vulnerabilities/ risks will change. But, ameliorating the risks associated with current climate variability and extremes will also help in reducing the effects of future variability and extremes.

The vulnerability assessment and subsequent risk management is a process that can help identify current risks caused by climate-induced hazards and impacts and reduce these risks. If these risks will continue in the future, possibly resulting in a greater magnitude of loss or a higher probability of loss, then risk management can also be used in adapting to climate change. Estimates can be made on how the magnitude of the impacts could change, and how the probability of their future occurrence may change. However, these are difficult quantities to predict and climate change models cannot provide much guidance.

The following presents a simplified methodology using a vulnerability assessment and risk management approach to adaptation to climate variability and change.

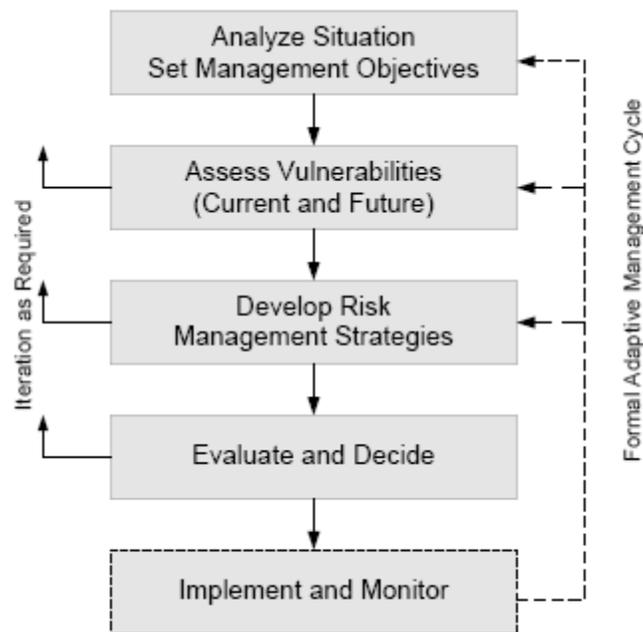


Figure 1: Risk-Based Approach to Climate Change Adaptation ⁴

⁴ From McKinnon, G., and S. Kaczanowski. 2003. Climate Change and Forests: Making Adaptation a Reality. A Report on the Workshop. Winnipeg, MB.

The Community of Wetbury

Demographics, Economy and Governance

Wetbury is a large urban community with 1,180,000 residents living in two distinct sections of its total area. A river system that intersects the town separates the east from the west. The eastern section is the older part of the town, with the majority of its physical infrastructure constructed prior to the 1970's while development in the western part of the city has accelerated over the past 10-15 years. The southwestern section is also home to current residential and commercial expansions as the town predicts the population will exceed 1.3 million over the next five to seven years. The economy of Wetbury is mixed with sectoral representation in the area of health services, business/finance, tourism, education and a strong manufacturing component.

Water management in the community is overseen by a group encompassing three separate functions: **Wastewater Management, Source Water Protection and Sustainable Water Use**. The groups work independently most of the time but coordinate on issues where there is overlap or where action on the part of one group impacts another. The municipal council is equally represented in terms of population distribution and the water management groups reports directly to committees of council.

The average age of council exceeds 60 including the mayor who has been in office for 9 years. Their tendencies are conservative.

Landscape and Topography

The landscape in Wetbury is similar to other major urban cities in Ontario highlighted by golf courses, parks, a central riverfront promenade and an international airport. A major river system flows from north to south through the city which feeds into a small lake near the downtown core. The town's drinking water is supplied by the lake which is situated centrally. The town also has a large industrial park located within the city limits to the east which has been under scrutiny as of late by town people complaining of contamination stemming from the industrial park and the railway. Much of the raw materials for manufacturing arrive by rail in the eastern industrial park. The metropolitan area is expanding at such a rate that it is enveloping once smaller, outlying communities to the west and south. Agricultural land dominates the landscape to the west and south of the city.

The topography of the land reveals an overall, moderate slope from north to south, similar to the flow of water in the Flood River, with the terrain slightly sloping from west to east. Potential flood zones have been mitigated in the southern section of town as a result of new drainage design systems including street-flow systems and larger, more strategically placed catch basin areas. Although flooding is rare in the south, two large storm events have recently caused a number of flooded basements.

Water Supply

With the exception of the southwest portion of the city, the water supply for the community comes from lake <<>> which is both river-fed and groundwater fed. Recharge calculations from early 2001 show a 0.1% recharge rate per

annum based on average inflow and outflow. The surrounding watershed has been characterized in all areas but due to increased development to the south, these assessments are in need of revision. Well fields currently servicing the southwest have historically shown stable aquifer conditions. Future demands on this aquifer due to increased development in this area may reflect non-sustainability. Increased consumption from lake waters is also risky with notable drops in lake level, increased lake water temperature and upstream alterations to the river system.

Existing Infrastructure and Planning

The older infrastructure in East Wetbury, combined with physical and locational factors make it very susceptible to flood events. The downtown core has the benefit of being located centrally with many commercial and retail groups in operation. Due to recent flooding from the nearby river system, insurance rates have gone up and vacancy rates are increasing. Current tenants are finding the rental/lease spaces in West and South Wetbury to be more cost effective.

Recent planning initiatives to minimize sprawl will place greater dependence on aquifers to the southwest. This will also have an impact on smaller communities further south who also depend on this aquifer as a headwater feeder system. Well head protection studies have identified conflicting land use patterns which also impact on development to the southwest. The city planners have also considered brownfield redevelopment in the central parts of the city or retrofitting the older buildings in the east of the city in an attempt to mitigate against flooding. Each option poses its own benefits and risks.

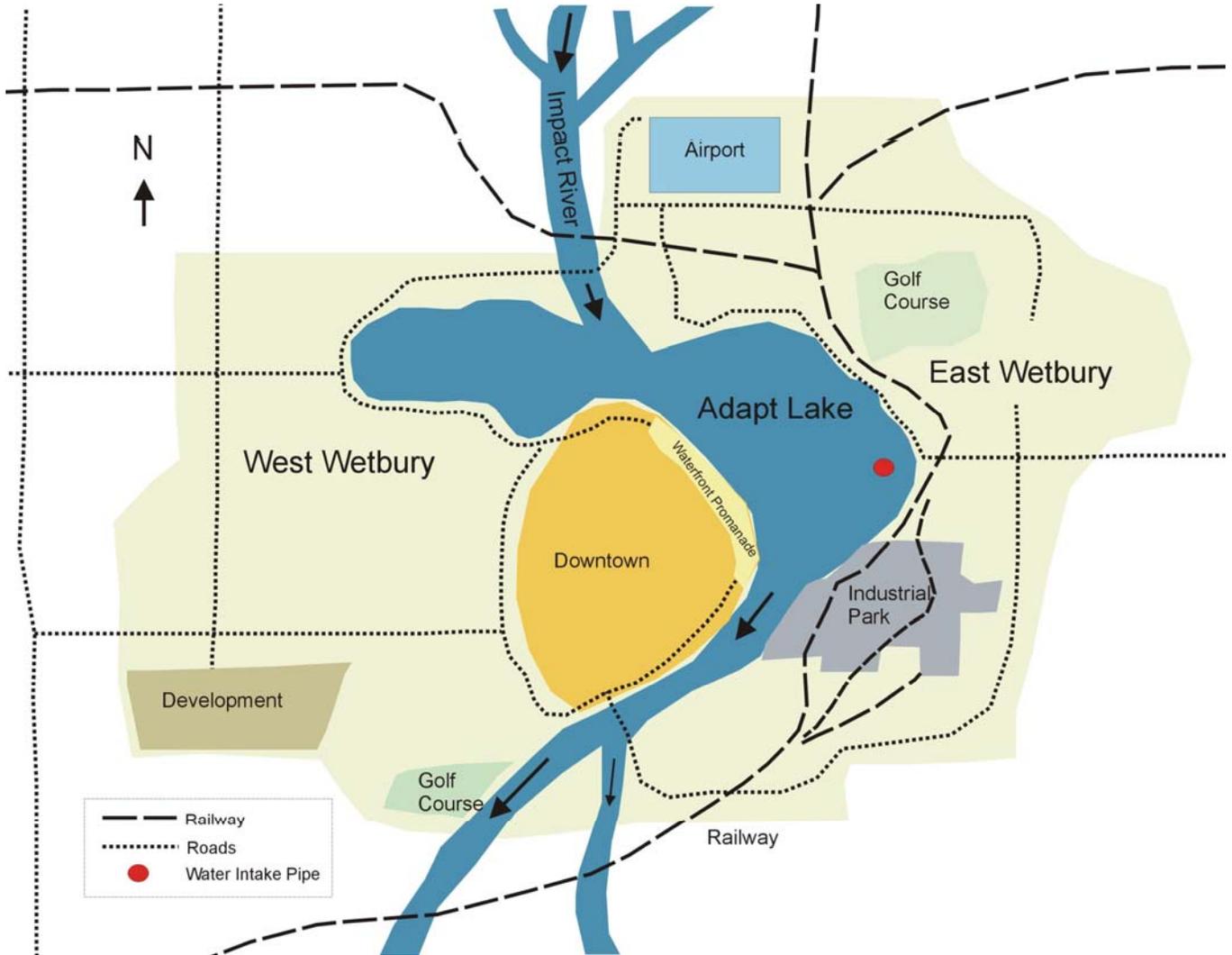
Current and Future Climate Conditions

Many people within the community and local government officials have noticed an increase in the number of extreme weather events including precipitation in the form of rain. Severe rain storms over the past 18 months have set new records for 1 hour and 24 hour precipitation totals. Flooding caused by these heavy precipitation events has battered infrastructure, triggered massive insurance claims and induced contaminated drinking water supplies. Extended periods of draught also plague the community during the spring to fall months and have induced watering restrictions and water conservation efforts.

These climate driven factors along with sustainable planning issues are propelling development to the outskirts in Wetbury. Although climate models show no increase in average annual precipitation, projections warn of increased frequency and intensity of these precipitation events including winter rain and snow.

The community of Wetbury has called a meeting of council to deal specifically with these apparent climate driven events in an attempt to plan adaptive strategies. You are one of those participants.

The Town of Wetbury



Vulnerability Assessment/Risk Management Worksheet

				IMPACTS						
SEVERITY OF IMPACT	Economic Impact \$									
	Environmental Impact (L, M or H)									
	Social impact, including number of people affected (L, M or H)									
PROBABILITY OF OCCURRENCE (L, M or H)										
PRIORITIZED VULNERABILITIES/ RISK (subjective assessment)										
L = low										
M = moderate										
H = high										

APPENDIX B: Vulnerability Assessment /Risk Management as it Relates to Adaptation to Climate Change

Facilitators Guide

This begins the process for facilitators in working through risk assessment of climate driven extremes and hazards for a community. Decisions based on the outcomes of this exercise are ones that the delegate group will be responsible to make if this process is utilized in their own community. The tasks stated below, and the example they follow, allow the facilitator to proceed through the risk/vulnerability process using information provided in a community case. The level of detail within the case allows delegates to picture a community and how it is being affected by climate change. Apparent lack of detail is intentional as certain assumptions must be made in light of time restrictions. They are noted:

- Climate change is real and *is* driving the extreme events laid out by the case. Refuting the concept of climate change indicates that there is no need for this exercise;
- A degree of scientific uncertainty exists within the global climate models and perhaps at predicted changes at the regional level but this is *not* the topic of discussion;
- Sufficient resources (money, people, desire, need) exist within the community to deal with the problems witnessed;
- Although not part of the process, the challenges of *how* to accomplish the proposed risk controls are not the main focus of this exercise.

The first task is to have delegates re-read the case. The case outlines a city that has many features common to other cities within Ontario. Delegates should note the relevant details and should contemplate how their role in real life would be involved as this process unfolds and how they would work towards making these decisions.

To keep the process moving forward, be aware of the time and try to keep attendees on track. If the group thinks there is insufficient detail within the case to make a decision, make an assumption and keep going.

At each stage of the process, keep in mind:

- The makeup of a team required to complete that task;
- Communication – if details need to be communicated to other groups, identify who they are and what their role is;
- The process involves iterations. As new data comes in, changes in risk controls may occur. Feedback and group participation is essential.

It is natural for each person in the group to come to the table with their own baggage i.e. they're own questions, concerns and comments of how climate change is affecting their community. The exercise is meant to be geared towards the given case and the conversation should not stray to discussion of specific community hazards.

It is important to note that this process involves continuous communication and feedback into the system. As information changes or new information arrives, each step can be revisited.

Task 1 Identifying Extremes and Hazards

Identify current climate extremes that could produce negative impacts; and that will likely not diminish with climate change and may increase in magnitude or frequency. *e.g. heavy summer precipitation, rapid spring melt of snow, extreme and extended drought, etc.*

Task 2 Identify the Impacts and Hazards from one or more of these extremes

For each one of these extremes (in practice it may only be feasible to choose one extreme, such as “heavy summer precipitation”), identify the impacts and hazards that current climate (and therefore future climate) extremes could cause through a “vulnerabilities/ risk scenario”. This scenario would include first and higher order impacts.

Figure 1 shows such a scenario produced for a case study involving a small rural southern Ontario community at the C-CIARN Ontario workshop held in March 2004. Only a selected set of important impacts can be placed on the page, and in this particular vulnerabilities/ risk scenario the degradation of water quality was chosen as an important impact. This led to a set of fourth order set of impacts (contamination of groundwater, ecosystem disruption, tourism and recreation disrupted and human health problems) that were assessed for their vulnerabilities/ risk.

The details of this vulnerabilities/ risk scenario are not as important as an understanding of the process that people go through to develop the scenario. It is this process that decision-makers could make use of in adapting to climate change in their own community or sector.

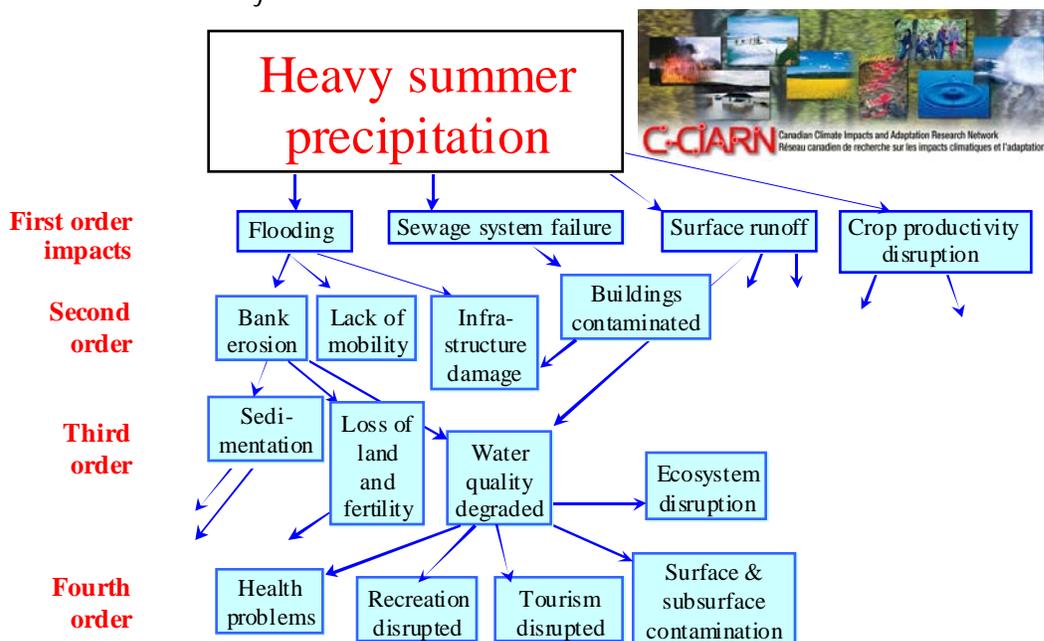


Figure 1: Example of a vulnerabilities/ risk scenario of first and higher order impacts and hazards resulting from a climate extreme, in this case short-term (24 hour) heavy summer precipitation.

Task 3 Estimating vulnerabilities/ risk of each of the final set of important impacts or hazards

Each of the chosen set of impacts or hazards is then put through a vulnerabilities/ risk assessment to identify both the *relative* severity of the impact and the *relative* probability that it could occur in a certain time period (e.g. a decade). The stakeholders in the group are critical to the success of this process. The small group should create a methodology for estimating the severity of the impact and the probability of occurrence, which could be in the near or long term. Using this information, the overall vulnerabilities/ risk (a function of the severity of the impact, the probability of occurrence, and local knowledge) of each impact is assessed and all of these vulnerabilities/ risks are then prioritized. This vulnerabilities/ risk assessment is difficult and is a subjective judgement.

IMPACTS

Table 1 Vulnerabilities/ risk Assessment of important impacts from Figure 1 from the C-CIARN Ontario workshop in Guelph, March 2004.		Groundwater	Ecosystem disruption	Tourism and Recreation	Direct human health	Mobility restriction	Agriculture disruption	Infrastructure damage	Other
SEVERITY OF IMPACT	Economic Impact (\$)	\$\$\$	\$	\$	\$	\$\$\$	\$\$	\$	\$
	Environmental Impact (L, M or H)								
	Social impact, including number of people affected (L, M or H)	H	L	M	VL	M	L	H	M
PROBABILITY OF OCCURRENCE (LOW, MODERATE, HIGH)		M	M	M	L	L	L	L	M
PRIORITIZED VULNERABILITIES/ RISK (SUBJECTIVE ASSESSMENT)		1	4	4	5	2	3	4	4

Table 1 summarizes the conclusions of the small group discussion on assessing the vulnerabilities/ risk of different impacts on a small rural agricultural community in southern Ontario. The methodology chosen for the severity of the impact in this case was the relative economic and social impacts on the community. The social impact included the relative number of people affected. Since this is a subjective process, and there were time constraints, another group of people could have assessed risk differently.

Task 4 Vulnerabilities/Risk Management as Adaptation

This almost-final task is to recommend strategies that would result in all vulnerabilities/ risks being either reduced, or accepted without any further controls. A first step is identifying non-climatic activities or sources that contribute to the vulnerability of the system and then improving ways, or implementing new actions, to reduce their contribution. Due to time constraints, only the highest risks can be addressed in this way a workshop environment, but all risks can be dealt within a community, sector or private industry.

The small group focussing on the rural Ontario community at the C-CIARN Ontario workshop arrived at a number of control (adaptation) measures that could reduce the risk of groundwater contamination by short-term heavy precipitation in summer. The sources of rural contamination in this area were first identified as manure, fertilizer, pesticides, herbicides, municipal sewage and septic fields.

The following risk controls for groundwater contaminations were identified:

a) Manure management

- i. Reduce manure production in the area
- ii. Correct manure storage problems
- iii. Dispose of manure so as to reduce contamination risk through:
 - Field and garden composting
 - Correct timing and rate of application on fields
 - Reduce the amount of manure on fields
 - Use as a biofuel to generate energy

b) Management of fertilizers, pesticides and herbicides:

- i. Reduce use of chemicals on farms
- ii. Encourage production and consumption of organic agricultural products through economic incentives, advertising and government subsidies to organic farmers.
- iii. Correct the timing and application of chemicals on farms

c) Septic field management:

- i. Strengthen and rigorously enforce standards for septic fields.
- ii. Encourage conversion to municipal sewage system through government incentives.

d) Manage raw sewage in river (from a municipality upstream of this community disposes of raw sewage into the local river.)

- i. Negotiate with upstream community to treat its sewage
- ii. Use legal or political means to force the upstream community to comply with this request.

Training and education – the need to raise the awareness of the public and industry of the potential of groundwater contamination and that contaminants need to be better controlled.

At this point, delegates are invited back into the central room to convey their findings to the rest of the group. At this workshop, each group will present their tree diagram of first, second, third order impacts and then the quantification and prioritization of the risks. They will also summarize their risk control measures.

Conclusion

It is interesting to note that “climate change” was not mentioned when identifying risk controls, or adaptation, above. Yet farmers and others are grappling with all of these “adaptations” in some way already in rural communities in southern Ontario. Implementing any of these options would likely involve more of a reinforcement of current efforts by noting that adaptation to climate change is another reason to act.

This framework for a risk management workshop shows an example from a rural community, so it may need to be modified for large sectoral work or large regions. But the key points from this approach are that decision-makers and other stakeholders have the opportunity to:

- Appreciate that adaptation to climate variability and change is not a curious scientific concept but a tangible approach that practitioners and decision-makers can comprehend and undertake, if they so desire.
- Realize that adaptation to climate variability and change is almost always addressing issues and problems that are influenced by climate now. Climate is not the primary driver in most cases, and identifying and reducing the contribution to the problem from the other drivers that are involved is the key to reducing risk.
- Be engaged in identifying adaptation options that are feasible.

Understand that climate-related risks are part of a comprehensive risk management strategy and will be considered alongside multiple stressors, not independently

APPENDIX C: Climate Risk Management Terminology

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptation benefits: the damages avoided or benefits accrued from the adoption and implementation of adaptation measures.

Adaptation costs: costs of planning, preparing for, facilitating, and implementing adaptation measures, including transaction costs.

Adaptive capacity: the ability of a system to adjust to climate variability and change to moderate potential damages, to take advantage of opportunities, or cope with the consequences.

Climate scenario: projection of future climatic conditions.

Climate variability (CV): climate variability refers to fluctuations in climate over a short term

Hazard: a source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value

Hazard identification: the process of recognizing that a hazard exists and defining its characteristics.

Residual risk: the risk remaining after all risk control strategies have been applied.

Risk: the chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value.

Risk communication: any two-way communication between stakeholders about the existence, nature, form, severity, or acceptability of risks.

Risk control option: an action intended to reduce the frequency and/or severity of injury or loss, including a decision not to pursue the activity.

Risk information library: a collection of all information developed through the risk management process. This includes information on the risks, decisions, stakeholder views, meetings and other information that may be of value.

Risk perception: the significance assigned to risks by stakeholders. This perception is derived from the stakeholder's needs, issues, and concerns.

Risk scenario: a defined sequence of events with an associated frequency and consequences.

Vulnerability: the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is the function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

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