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Local Government Responses to Climate Change:
Canadian Jurisdictions Outside of BC

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EXECUTIVE SUMMARY

Although the realities of climate change are now widely accepted and its major impacts have been projected, Canadian local governments have been slow in strategizing their adaptation to these impacts. The majority of resources devoted to climate change planning have been used to develop and implement mitigation strategies, and adaptation has been at the margins of actions at all three levels of government. Each region of Canada has specific impacts pertaining to them, and each region needs to plan and implement its own targeted adaptation strategies, yet most regions are still in the beginning stages of assessing their risks and vulnerabilities to projected impacts. In addition, some regions are putting resources into upgrading and increasing their monitoring systems of current impacts caused by climate change.

Some notable local governments that have been proactive in starting the process of adaptation management have been Halifax, Yellowknife, and Toronto. The Halifax Regional Municipality, in partnership with a group of environmental consultancy companies has developed climate change public education tools, assessed the region's vulnerabilities and adaptation options, and developed adaptation recommendations. The City of Yellowknife is undertaking a comprehensive risk assessment and adaptation planning process.

Toronto has developed and implemented a heat-health alert system to adapt to projected increasing heat waves of greater intensity. Another strategy that Toronto is planning to widely implement in order to adapt to heat waves, as well as more intense storm events, is the use of rooftop gardens. Studies that have tested this method have shown that if implemented city-wide, it is effective in reducing the heat island effect and reduce storm water flow.

As well, for some impacts, regional bodies have been most active, and perhaps most effective, in planning adaptation strategies. One notable example is the Grand River Conservation Authority in southwestern Ontario which has been developing strategies to adapt to projected future impacts of changing precipitation levels. Their strategies have been aimed both at possible droughts and floods through the integration of climate change adaptation planning into watershed management, contingency plans for future droughts, and demand management.

Since local governments are heavily supported by provincial bodies, there is a place for provincial governments in supporting, promoting, and requiring local governments to plan for the impacts of climate change. Some notable provincial governments who have been proactive in supporting their local governments in this process have been Quebec, Ontario and many of the east coast provinces. Ontario and Quebec have put in place regulations that will require local governments to establish comprehensive emergency management strategies. Quebec also plans to invest in consolidating and modernizing their climatology and hydrometric networks to allow for better capacity to quantify, evaluate, and respond to climate change impacts.

Provinces in the east coast are very concerned about the projected impacts of sea level rise, and are supporting local communities in undertaking risk and vulnerability assessments in regards to this impact. Sea level rise could bring secondary impacts such as coastal flooding, storm surges, and coastline erosion. Some of the assessments and studies being undertaken include digital flood-risk and ecosystem maps of sections of the coastline, raising dykes, and analyses of the status of shoreline erosion in certain sections. Provincial governments are providing support for these assessments and the development of strategies through various methods. For example, Newfoundland plans to establish an interdependent committee to develop a provincial land use policy, and New Brunswick is developing a policy tool that will help minimize impacts to municipalities in coastal areas.

Though most local governments are still assessing their vulnerabilities to climate change and the development and implementation of adaptation strategies is not well established, the trend seems to show that “no-regrets” strategies are most promising. These strategies are ones that will provide benefits to communities whether projected climatic changes occur or not. For example, community water conservation initiatives will benefit communities regardless of the intensity of future impacts, and compared to the alternative policies to adapt to fluctuating water supply, they are less environmentally, economically, and socially costly.

Other important factors in ensuring the development and implementation of promising climate change strategies and management is the establishment of institutional mechanisms, staff, and adequate resources that are dedicated specifically to adaptation measures. Institutional mechanisms are also important in providing guidelines to integrate climate change considerations and adaptation into general local government decision-making. Finally, local governments should implement monitoring and evaluation programs of strategies in order to determine their effectiveness, efficiency, and adequacy.

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INTRODUCTION

Adaptation strategies for climate change in Canada are still in their infancy, and most efforts in developing these strategies are still mainly in the early stages of determining region and sector-specific vulnerabilities to projected impacts. Some work has been done on developing adaptation options and responses to impacts, but relatively little has been done in implementing these options.

This paper will serve as a scan of climate change adaptation activities taking place in local governments across Canada, outside of British Columbia. It will firstly look at some of the impacts that have been projected, and their possible effects on local government core businesses. It will then scan some of the policy alternatives that are being developed and implemented to address various impacts of specific projected climatic changes. Thirdly, it will look at how some local government policy tools are being used to address climate change impacts. Finally, it will look at the local government policy development process and how it is being used to address climate change.

In carrying out this research, the following sources were reviewed: 1) provincial climate change action plans, 2) projects funded by Natural Resources Canada and its Climate Change Impacts and Adaptation Program, 3) Canadian Climate Change Impacts and Adaptation Research Network archives and conference proceedings, and 4) local government websites, reports, and other documents

The paper is based on specific examples of strategies being undertaken by Canadian local governments in order to illustrate the various policy options. The paper will attempt to assess which set of possible actions would give the greatest return on investment for local governments. It will also attempt to determine which actions have already been most effective or are most promising, regardless of their efficiency. These two last points will be difficult to determine confidently as there is still very little research on the effectiveness and efficiency of adaptation policy options.

BACKGROUND

With the increasing concern about immanent global climate change, governments have begun putting more resources into studying the possible impacts of climate change to different sectors in society, regional vulnerabilities to these impacts, and possible adaptation strategies to lessen the negative consequences of forecasted impacts. Canada is no exception, with all three levels of government taking effort to develop and implement possible climate change adaptation strategies. Although to date considerably more resources have been allotted into climate change mitigation strategies, adaptation strategies are just as important as Canada is situated in the mid- to upper-latitudes and is therefore projected to experience more warming and climatic changes than most territories around the globe (Government of Quebec, 2006).

Climate change is projected to have a variety of effects on Canadian communities, depending on the region, such as warmer summers and winters, more frequent and severe storms, droughts, water level rise in the oceans, water level decline in the Great Lakes, and more frequent freeze-thaw events. The Intergovernmental Panel on Climate Change (IPCC) has indicated that governments need to take action in both climate change mitigation and adaptation initiatives. Based on this recommendation, local, regional, and provincial governments are allocating more resources into studying the possible impacts that their region may experience and their region's vulnerabilities to these impacts.

It is also becoming more apparent that local governments will be carrying most of the burden and paying for the negative consequences of climate change impacts as they are responsible for safeguarding and managing the region's infrastructure and assets, economy and growth, and public health, amongst other things. Urban areas will likely experience the greatest impacts from climate change due to the high concentrations of people, wealth, infrastructure, and communications (Wittrock, 2007). Some impacts may be costly, disruptive, and dangerous, therefore local governments would benefit from identifying and implementing adaptation strategies.

FINDINGS

Section One: Climate Change Impacts

This section serves to give an overview of the projected impacts of climate change to important local government sectors and responsibilities, and the subsequent implications for local governments. These are comprised of: 1) asset management, 2) economical and growth management, 3) environmental and public health management, 4) disaster management, and 5) cultural and recreational activities.

Asset Management

Infrastructure and assets in urban areas are projected to increasingly be forced to withstand more frequent and extreme weather events such as storms that are increasing in intensity and frequency and changes in water levels. These changes will impact infrastructure in various ways depending on the region. The impacts will have consequences for roads, bridges, communications structures, water and wastewater infrastructure, energy transmission networks, and buildings (Infrastructure Canada, 2006).

An example of infrastructure and assets that can be impacted significantly by climatic changes is urban drainage systems. Engineers are still designing most urban drainage systems using historical climate records. For example, if precipitation patterns change so that more extreme storm events become more frequent, urban drainage systems could fail and cause sewer back-ups and basement flooding, and cause subsequent loss of assets (Infrastructure Canada, 2006).

This risk has already materialized in some areas. Intense rainfalls in 2001 and 2002 in Stratford, Ontario caused sewer systems to fail and basement flooding, with a resulting \$250 million class action lawsuit from local residents against the municipality. The municipality is now spending \$70 million to retrofit its stormwater management infrastructure with a 250-year storm design. Similarly, an extreme thunderstorm in 2005 in Toronto resulted in a failure of a culvert under a major street, causing the entire roadbed to wash downstream and resulting in about \$500 million in insured losses. These examples illustrate that failure of water infrastructure due to an inadequate threshold to withstand intense weather events can cause multiple infrastructure losses (Infrastructure Canada, 2006).

Economical and Growth Management

The economies of many Canadian regions, even urbanized regions, rely on the natural resource sectors such as forestry and fishery. As the abundance and quality of natural resources depends on the climate, these regions are particularly vulnerable to the impacts of climate change. For example, the forest industry is highly susceptible to insect epidemics, forest fires, disease, and damage from extreme climatic events. Climate change is projected to increase the frequency and intensity of some of these problems, and could therefore affect the characteristic and yield of the forest industry (Government of Quebec, 2006).

Also, in the face of potential increases in extreme climatic events, local governments will have to assess population growth and development and climate changes' effects on people and their property. City development plans, zoning by-laws, development regulations, and building by-laws may need to be reviewed, and may have to be adapted to changing conditions.

Environmental and Public Health Management

Health related vulnerabilities related to climate change will be different and specific in each region, therefore assessments need to be undertaken to determine how climate variability will affect the health of sub-populations (Government of Newfoundland, 2005). The identified public health concerns in Canada resulting from the impacts of climate change include heat stress from extreme temperatures, air pollution and related diseases in urban areas, waterborne diseases, food-borne diseases, vector and rodent-borne diseases, allergens, ultraviolet radiation, food spoilage, water contamination and shortages, and air quality issues from forest fire smoke (C-CIARN Ontario, 2004 and Warren, 2004).

The public health issues that policy-makers are addressing with the most urgency are ones related to more frequent and severe heat waves, specifically in urban centres. Climate change is also expected to bring about prolonged and intense heat waves. This will exacerbate the urban heat island effect that is caused by replacing vegetated surfaces

with asphalt and concrete and by waste heat emissions. Extreme heat poses a serious risk to public health, particularly to vulnerable individuals (Ligeti et al, 2007b).

An identified systematic concern in Canada is that preventative health, with public health being part of it, receives much less resources than healthcare. Canada has a basic public health system, which is adequate for managing challenges typical to industrialized countries, such as anti-smoking, STDs, and teenage pregnancy; but an outbreak of a major infectious disease such as SARS can push the system to its limits. It is predicted that if Canada experiences a major heat wave, such as the one experienced in France in 2003, the public health system would be completely overwhelmed (C-CIARN Ontario, 2004).

Disaster Management

Extreme weather events such as tornados, which offer a very short timeframe to issue warnings, will require emergency response strategies. Local governments can be held liable in negligence in the case of inadequate preparedness to prevent an emergency or mitigate its impacts, or inadequate preparedness in responding to an emergency. An increase in the frequency of extreme events makes the importance of robust emergency responses even more important. Local governments will also have to ensure that their budgets are planned in a manner that allows sufficient flexibility to deal with such extreme weather events (Wittrock, 2007).

Culture and Recreational Activities

In many Canadian regions, the quality and quantity of winter tourism and recreation are strongly influenced by the climate and weather. The weather affects the physical resources that are the foundations of many recreational activities. For example, in Southern Ontario, record warm winters in 1997/98 and 2001/02 resulted in a reduced ski season of about 25% because of limited natural snowfall and warm temperatures that made snowmaking inefficient. The warm temperatures also shortened the ice fishing seasons due to dangerous ice conditions. Yet there have been very few assessments of the vulnerability of individual recreational sectors and tourism regions to climate change (Scott et al., 2005).

Section Two: Adaptation Strategies Directed at Specific Impacts

This section is an overview of some of the measures that local governments are developing and implementing to adapt to specific projected climatic changes and their subsequent impacts. These include: 1) changes in precipitation levels leading to floods and droughts, 2) increasing temperatures leading to an increase in frequency and intensity of heat waves, 3) sea level rise leading to coastal erosion, storm surges, and floods, and 4) increasing temperatures in the north leading to permafrost degradation.

Floods and Droughts

Changes in historic precipitation levels, and the subsequent impacts these variations will have on water supply and wastewater have received a considerable amount of attention. The management of water supply and wastewater management are recognized as two of the highest priority issues in Canada as they are highly vulnerable to the impacts of climate change, critical to human health, the economy, and the environment, and have a potential for the greatest damages and losses (Warren, 2004).

In many regions, dryer summers and decreasing water supply levels are projected. Climate change studies indicate an increase in rainfall intensities that could result in adverse effects on existing urban drainage systems, which might result in more frequent drainage system failures and increases in flood damages and health problems (Kije Sipi Ltd, 2001). The need to adapt to a changing water supply and the need to manage changing storm water levels have motivated local governments to take new initiatives in water management.

A communities' capacity to deal with climate change impacts can be increased by practicing good water management through efficient water use and water conservation programs, appropriate development, focusing on watersheds, developing water budgets, and allocating water resources based on a good understanding of water supplies and demands. Taking a watershed-based planning approach to water protection can be more effective in implementing these aspects than local governments in each watershed working in isolation (C-CIARN Ontario, 2004).

For example, with the guidance and direction of the Grand River Conservation Authority, municipalities in the Grand River basin in southwestern Ontario have begun to develop and implement programs to make water use, storage, and distribution more efficient (Warren, 2004). The Authority is taking steps to integrate climate change adaptation planning into watershed management. Eighty percent of the population living in the watershed depends on groundwater. In 2000, they implemented a voice alert system that gives them 5 hours of lead time to allow them to manage an imminent flood. They also work with the municipalities in the watershed to develop long-range, integrated water management plans and to adapt and improve low water response plans (C-CIARN Ontario, 2004, p.21).

The Authority has also begun to develop contingency plans for future droughts, and has held a series of workshops to evaluate decision analysis methods for dealing with changing water levels in Lake Erie. It is projected that through better planning and management and modifications of existing operating procedures and increases in reservoir capacity, rather than the introduction of new structures, the Grand River basin will be able to adapt to all but the most severe climate change scenarios (Warren, 2004).

Another strategy being used by both individual local governments and conservation authorities is demand management. This management strategy is considered an effective, as well as an environmentally and economically sustainable, adaptation option to address

water supply impacts. Demand management involves reducing water demands through water conservation initiatives and improved water use efficiency. These strategies can be very successful in reducing water demands and minimizing the impacts of climate change on regional water supplies. One study found that 63 out of 65 municipalities that were studied have already implemented water conservation initiatives (Warren, 2004).

Increasing Temperatures

Increasing temperatures and more frequent and extreme heat waves are a public health concern, especially in urban centres. For example, Toronto's temperature is estimated to rise between 2 and 5 degrees Celsius in the next 100 years. In response, some local governments, such as Toronto and Montreal, have developed and implemented policy options to adapt to increasing temperatures.

In June 2001, Toronto developed and implemented the Heat-Health Alert System. This measure aims to help protect vulnerable population groups, such as seniors and homeless people. The measure includes extensive collaboration between many different governmental and non-governmental organizations. Some organizations involved are emergency services, housing services, libraries, pharmacies, and seniors' networks (Warren, 2004). Using meteorological and mortality data, a model was developed that predicts when the probability of excess mortality due to certain meteorological conditions rises above expected thresholds. The system is able to predict a heat alert up to 48 hours prior to the event (Mehdi et al, 2006).

Some of the adaptation strategies implemented include extreme heat announcements via news media, active intervention by public health and volunteer agencies such as street patrols to locate and care for homeless people, an increase in the availability and accessibility of air-conditioned public buildings and shelters, and new guidelines for managing long-term care facilities (Warren, 2004). The City also issues information about hot weather risks and vulnerable populations to its partners and the media. In effect, the measure ensures that when there's a Heat Alert, there is a city-wide response (Mehdi et al, 2006). Montreal has implemented a similar program.

Sea Level Rise

Around 7 million Canadians live in coastal areas, and coastal infrastructure is essential for trade, transportation, and tourism, and is the livelihood of many coastal municipalities (Warren, 2004). Climate change is anticipated to cause coastal communities to experience a rise in sea level and an increase in the frequency and intensity of storm surges and coastal erosion. As such, local governments situated along high risk coastal areas have been the most proactive in taking measures to evaluate and implement their adaptation needs and options. Some local governments, situated in recognized high risk areas provide good examples of measures being taken to assess and develop policy options to address vulnerabilities and impacts to coastal communities. Four such

communities are communities on the southeastern New Brunswick coast; Charlottetown, Prince Edward Island; Annapolis Royal, Nova Scotia; and Sept-Îles, Quebec.

Southeastern New Brunswick coastal communities are experiencing a severe threat to their coastline due to coastal flooding and erosion during wind storms. Rising sea-levels in the winter may cause the ice cover to be pushed inland, impacting infrastructure. A multi-partner study is aiming to quantify the impacts of climate change and sea-level rise on coastal erosion, flooding, and ice hazard, as well as develop sustainable adaptation strategies. The study will undertake to create digital flood-risk and ecosystem maps for this section of the coastline. An impact assessment is being conducted in order to better understand the vulnerabilities. The public is being involved in order to understand the potential impacts of the community's lifestyles. The involvement of the community and stakeholders is considered crucial, as their support must be garnered before scientific studies of the hazards can be undertaken. Risk management techniques are being used to assess the cost and benefit of various short, medium, and long-term adaptation options, and will be tested in pilot areas to assess their viability (Environment Canada, 2005 and C-CIARN Atlantic Region, 2003).

In Charlottetown, Prince Edward Island, many commercial and residential properties are located in flood vulnerable zones caused by storm surges and rising sea levels. A major project was implemented to examine the impacts of sea level rise and storm surges and identify vulnerable areas (*C-CIARN Atlantic Region, 2003*). Property maps were used to estimate the value of properties threatened in the downtown area by storm-surge flooding, consistent with sea level projections for the next 100 years. The property damage was assessed at values ranging from \$172 to 202 million (Warren, 2004). The assessment revealed that, as there are 30 to 49 heritage properties in the threatened areas, tourism could also be impacted. City infrastructure, such as roads, water pipes, and sewers, could also be impacted (Warren, 2004). The assessment was beneficial in helping city officials understand the magnitude of the threat posed and start planning accordingly (*C-CIARN Atlantic Region, 2003*).

Annapolis Royal, Nova Scotia is a small coastal community which is experiencing coastal erosion and flooding due to sea level rises. A climate change vulnerability assessment led to the adoption of adaptation strategies that will provide benefits regardless of climate change impacts. These strategies included raising the dykes, relocating emergency equipment, and improving and practicing emergency response plans (Mehdi et al, 2006). An example of a specific measure that came about due to the assessment was the fire department acquiring a boat to transport personnel and equipment during an emergency, since in case of extreme flooding the fire department could be isolated from the rest of town (*C-CIARN Atlantic Region, 2003*).

Another coastal community, Sept-Îles, Quebec, is experiencing 8 metres of land loss per year, and climate change is altering the historical erosion rates due to sea level rise, the reduction of sea-ice cover, a shorter sea-ice period, and increases in storms. Similar communities along the Gulf of St. Lawrence are faced with the constant threat of storm, and previously installed protective structures, such as rock protection, have exacerbated erosion rates in adjacent sectors. From 2000 to 2004, the provincial government

undertook an analysis of the status of the shoreline erosion. Based on the findings, the city of Sept-Îles undertook several initiatives to adapt to the increased erosion rates. It communicated the findings with the community, limited development and prohibited all new construction in the erosion-affected areas, and is working to establish a master plan for coastline intervention (Mehdi et al, 2006).

Permafrost Degradation

In northern regions, the average surface and ground temperatures have increased and will likely continue to increase. This has led to an increase in the depth of the permafrost active layer. This has already affected transportation infrastructure such as roads and railroad lines, as well as other infrastructure such as buried water and sewer lines.

Considering the limited resources that northern communities have to work with, they are taking various approaches to dealing with this impact. For example, municipal planners in Iqaluit, Nunavut are working with developers in considering climate change impacts in the design and building of subdivisions. These considerations include the potential future impacts of climate change on terrain stability and the consequences of placing sewer and water lines above or below ground (Mehdi et al, 2006).

The province of Quebec is monitoring the condition of permafrost and the consequences of thawing in its northern regions. It has installed automated systems for measuring the permafrost thermal regime at different depths under transportation infrastructures. Also, in seven northern airports which are deemed at risk to accelerated permafrost thawing, conditions are being tracked (Government of Quebec, 2006).

Section Three: Local Government Policy Toolbox

There are four main policy tools that local governments can use in order to address climate change impacts and adaptation needs. These are regulation, investment, information, and incentives. In this section, there will be an overview of the use of these four tools by Canadian municipalities in addressing various impacts. One example, which is particularly useful, is Toronto's Green Roof Strategy as it uses all four tools. The Strategy encompasses four main categories in encouraging green roofs, each one using one of the four tools. The Strategy's use of each tool will be given in more detail in each section below.

There is also a fifth method that warrants considering, though it is not a tool per se. This is the use of appropriate institutional arrangement and partnerships, which are key factors in implementing adaptations strategies.

Regulation

Local governments can use their regulatory power to influence climate change impacts to be considered and adaptation strategies to be implemented in urban projects and activities. For example, Toronto's Green Roof Strategy will encourage green roofs in building construction and on-going maintenance through its inclusion in zoning by-law amendment approvals and site plan control applications (City of Toronto, 2005). The strategy is also being integrated into the City's Green Development Standard which promotes green building techniques in the construction and renovation of City-owned buildings and private development (City of Toronto, 2007).

Another example is local governments using their regulatory power to influence engineering requirements for new infrastructure. Some of the impacts from recent failures in storm water management infrastructure have led to some lessons learned that municipalities may be able to influence. Impacts point to a need for new infrastructure to be designed in a manner that can resist climate change impacts through the use of vulnerability and risk assessments instead of the use of historical climate data. Design codes and standards also need to be updated based on the latest changes in regional climate and precipitation variables (Infrastructure Canada, 2006).

In Canada, provincial governments play a significant role in creating guidance and influencing local governments to take action, including climate change adaptation action. Also, since provincial governments are a key source of funding for many municipal projects and activities, they can require the inclusion of climate change considerations into municipal projects and decision-making. The following are some examples of how provincial government policies and regulations are enabling and encouraging local government to implement adaptation strategies.

Provincial governments are using policies and regulations to guide local governments in climate change adaptation and consideration in regards to development and infrastructure. For example, the government of Newfoundland plans to establish an interdependent committee to develop a provincial land use policy. Also, the province will require that infrastructure projects that receive public funding meet a standard set of criteria addressing climate change impacts (Government of Newfoundland, 2005). Similarly, the government of New Brunswick is developing a policy tool that will help minimize impacts to municipalities in coastal areas. The policy, called the Coastal Areas Protection Policy, outlines an integrated approach to land use. This includes the maintenance of beaches and dunes to reduce flooding and damage to infrastructure, and not allowing the development of multi-family, commercial, or industrial development in areas at high risk of flooding (C-CIARN Atlantic Region, 2003).

The Ontario government is attempting to "mainstream" climate change adaptation into local government planning processes through the new Clean Water Act, which would require municipalities and conservation authorities to develop source protection plans at the watershed scale. This would involve developing a water budget to consider how

much water is available within the watershed and how much is being used (Infrastructure Canada, 2006).

As well, provinces can create an opportunity for local governments to incorporate climate change considerations into their disaster management plans. For example, in 2003, the government of Ontario passed the Emergency Management and Civil Protection Act which requires all municipalities to establish, by 2007, comprehensive, risk-based emergency management programs. These programs are to include a prevention/mitigation strategy and plan for identified high risks, publication of a recovery plan for these risks, a response strategy for identified hazards, implementation of guidelines for risk-based land use planning, and implementation of a detailed risk-based public education program. The Meteorological Services of Canada has developed the Atmospheric Hazards in Ontario website to help communities identify and assess the atmospheric hazards that pose a risk and develop emergency management programs in response, as required by the Act (C-CIARN Ontario, 2004 and Infrastructure Canada, 2006).

Since 1998, the government of Quebec also started requiring that its municipalities develop emergency response plans in response to climate-related risks. Regional authorities help ensure that communities are prepared, and there is cooperation amongst municipalities (C-CIARN Ontario, 2004). By 2007, several regions are required to implement an emergency preparedness strategy to deal specifically with heat waves, including planned actions in providing assistance to individuals at risk, designating cool-off areas, water distribution to the homeless, and protection for patients in hospitals or at home (Government of Quebec, 2006).

Investment

Local governments can address climate change impacts and implement adaptation strategies through investing in adaptation activities and technologies. For example, Toronto's Green Roof Strategy calls for the investment in green roof installation on all new City-owned buildings and when roofs need to be replaced in existing City buildings where feasible and practical. This can be considered an investment since the cost of installing a green roof is greater than a conventional roof, but the City has recognized adequate benefits in green roofs that they consider the up-front costs to be worthwhile.

Investments can also take many other forms, such as investment in vulnerability assessment studies, investment in developing emergency preparedness plans, or investment in developing comprehensive adaptation plans. Therefore, most of the strategies outlined in this paper can be linked to some form of investment.

Information

Local governments can also use information, education, and outreach to help increase local knowledge about climate change impacts, and build support for adaptation strategies. For example, the education and awareness portion of Toronto's Green Roof Strategy will be aimed at building owners' and developers' awareness through a technical booklet on green roof construction and maintenance and technical workshop. Also city staff will be trained and there will be a green roof resource person in all appropriate City divisions. The general public will be targeted through brochures, posters, and a website (City of Toronto, 2005).

According to a study by the Upper Credit River watershed, some important factors in determining a community's capacity to adapt to climate change impacts include stakeholders' perceptions and awareness of the issues involved, the level and quality of communication and coordination between stakeholders and local government managers, and the level of public involvement in management decision-making and adaptation implementation. These factors could be enhanced through public communication mechanisms, such as information sessions and increased networking (Warren, 2004).

Halifax is considered a public awareness leader and has implemented strong awareness and outreach tools in their adaptation strategy. For example, the municipality's Environmental Management Services department has included articles on climate change impacts and adaptation strategies in almost every issue of their quarterly newsletter, *Naturally Green*, distributed to all households. It also developed a climate change adaptation website, with maps and video animations, to provide background information for policy-makers and the public. The program's website, ClimateSMART, included a primer on climate change, fact sheets on impacts, and a guide to preparing for weather emergencies.

On the other hand, the government of Newfoundland does not consider public education about specific adaptation measures to be a priority, as current adaptation measures involve long-term planning at the level of systems or communities rather than households. Instead, they plan to direct adaptation education at key decision-makers in various levels of government and professional bodies involved in planning. For example, the province's Department of Environment and Conservation was involved in holding a workshop on regional impacts and adaptation (Government of Newfoundland, 2005).

Incentives

Incentives are the fourth tool that local governments can use in order to encourage adaptation strategies to be undertaken in an urban area. Once again, Toronto's Green Roof Strategy is an example of the use of this tool. Through the Green Roof Incentive Pilot Program, which in 2007 was renewed for a second year, the City offers a flat rate per square meter towards the installation of a green roof for private building retrofits

(City of Toronto, 2005). This pilot program was awarded the Federation of Canadian Municipalities' Sustainable Community Award (City of Toronto, 2007).

Institutional Arrangements and Partnerships

The institutional arrangements in a community or system, and the resulting capacities of these arrangements, are important factors in implementing effective adaptation. Appropriate institutional arrangements are a key factor against a community's vulnerability. The following are examples of three institutional arrangements that are intended to more appropriately address the impacts of climate change, namely: 1) local government partnerships with other local governments, 2) local government partnerships with non-government organizations, and 3) local government partnerships with the private sector.

As mentioned above in regards to water supply and storm water management, demand management policy options are considered an effective, as well as environmentally and economically sustainable, adaptation option to address water supply impacts. But many municipalities are unable to adopt demand management due to insufficient legal or institutional provisions (Warren, 2004).

Watershed-based management is a way of local governments to work in conjunction with other local governments in the same watershed. This type of institutional arrangement, headed by a watershed authority, is recognized and being used as a more appropriate arrangement when dealing with water sources and supply. Watershed authorities have the potential to facilitate effective water management due to a stronger water allocation system. Ontario has committed to watershed-based source water protection planning which is intended to provide an opportunity to link water management and land use planning more closely. If this arrangement produces better water management, then it will increase the local governments' capacity to adapt to climate change impacts and variability (C-CIARN Ontario, 2004).

The Clean Air Partnership (CAP) is an example of a partnership between several local and other levels of governments and a non-governmental organization in the Greater Toronto Area (GTA) whose work includes developing and implementing adaptation initiatives. The partnership works with the GTA Clean Air Council (CAC), a network of governmental organizations that are committed to collaborating to improve air quality in the GTA. The Clean Air Partnership convenes meetings, and manages research, policy analysis, program development, social marketing, and communications work for the GTA Clean Air Council.

Members of the Council include the federal departments of Environment, Health, Natural Resources, and Transport, the provincial ministries of Environment and Transportation, the regional governments of Durham, Halton, Peel, and York, and the municipalities in the GTA. There are also associate members, including surrounding municipalities and

the Toronto and Region Conservation Authority. CAP is strongly supported by these governmental members.

CAP and CAC are working on developing and implementing climate change adaptation strategies. One strategy is the Urban Heat Island Mitigation program, in which CAP will use maps and data to quantify the magnitude of the urban heat island in the GTA. They will also identify the location of the hottest and coolest places, lowest urban forest cover, and lowest percentage of impermeable surface, as well as identifying types of surfaces that retain the most heat and assist municipal decision makers in choosing the best urban heat island reduction strategies. CAP has also recently completed a four-phase research project to assess the potential impacts of climate change in Toronto and how adaptation strategies could be developed to reduce these impacts (Clean Air Partnership, 2007).

The institutional arrangement working on adaptation in Halifax is a good example of a local government partnership with the private sector, both for its achievement and its short-comings. ClimAdapt is a group of environmental consulting companies with interest and experience in working on climate change issues. In 2003, ClimAdapt, Halifax Regional Municipality (HRM), and the Nova Scotia Department of Energy formed ClimateSMART to work on both mitigation and adaptation strategies.

The intention was to develop a climate action toolkit including a climate change risk management plan and adaptation strategies for affected sectors. In regards to adaptation, the collaboration has produced the ClimateSMART website which contains information for Halifax residents on climate related issues, an issues paper reviewing the region's vulnerabilities and adaptation options and workshops with HRM staff on climate change impacts and adaptation, a submission to the Regional Plan with recommendations to incorporate climate change concerns throughout the plan, and a community action guide to climate change and emergency preparedness.

There are some observed short-comings of this kind of institutional arrangement to consider. ClimateSMART is not fully embedded institutionally at HRM, especially in regards to adaptation. HRM has not yet publicly released the adaptation issues paper, which was completed in July 2005, nor commented on it, even though it has released the ClimateSMART mitigation action plan. One-time grants were used to complete the impact studies and an initial assessment of adaptation options. These resources were found to be inadequate, and once the initial grants were depleted, it became difficult to continue the process. The ClimAdapt network seems to have diminished as an organization.

These short-comings may indicate that enterprising private-sector consultants and researchers can achieve some good steps, but cannot drive a comprehensive adaptation agenda for a local government. Ultimately, for systematic action to take place, local governments need to establish an ongoing mechanism for integrating adaptation (Ligeti et al., 2007a).

Section Four: Evaluating Policy Options

Risk Assessment and Planning

In developing climate change adaptation policies, the first step is to evaluate the risks that are posed to a specific region by potential and projected impacts. This evaluation can take many forms. Most regions are undertaking assessments to determine the risks that future impacts, which may be caused by climate change, can pose. Other regions are focusing more on monitoring the current impacts that are being caused by climate change. Both of these processes are important in determining the highest priority impacts and planning future adaptation strategies to address them.

Risk and Vulnerability Assessments

Most local governments in Canada are still in the assessment stage towards their adaptation planning for climate change impacts. Risk and vulnerability assessments are being undertaken by different levels of government in different regions. For example, the Halifax Regional Municipality undertook a vulnerability assessment specific to the municipality, whereas Alberta is undertaking a province-wide vulnerability assessment which includes urban systems and communities, as well as tourism, transportation, and health in addition to other sectors. Some regions are undertaking comprehensive assessments whereas others are assessing the risks posed to specific sectors. For example, the City of Yellowknife is undertaking a comprehensive risk assessment and adaptation planning process. On the other hand, the National Capital Commission has commissioned a climate change risk assessment and adaptation study focused on its tourism and recreation sector.

The risk assessment undertaken by ClimAdapt for the Halifax Regional Municipality took a classic risk assessment approach to evaluating climate impacts, based on existing research and information. The report reviewed current conditions and stressors for urban systems with their related impacts, historical and current climatic trends in the region, climate change scenarios for the future, and key expected impacts of climate change on different sectors in the city. The sectors considered are comprised of water resources, energy demands and supply, transport, ecosystems, coastal impacts and flooding, public health, social impacts and vulnerable groups, fisheries, and forests (Ligeti et al., 2007a).

The report also estimated the probability of the occurrence and severity of each impact on socio-economic and environmental systems by applying a risk assessment matrix to identify impacts that are of greatest concern. Impacts with a high level of severity and medium or high level of probability, or with a medium level of severity and a high level of probability were assessed as high-risk. These high-risk impacts were prioritized for further investigation and more detailed risk evaluation. This analysis allowed for the identification of 18 high-risk areas of impact (Ligeti et al., 2007a).

Alberta's vulnerability assessment is examining the region's biophysical, social, and economic vulnerabilities. It is an in-depth assessment, involving numerous ministries that will be looking at all sectors of the economy from a short- to long-term perspective (Government of Alberta, date unknown). The tasks that will be undertaken in the assessment include climate scenario modeling, biophysical scenario development, economic, social, and environmental scenario development, strategic scenario planning analysis, and vulnerability estimation (Government of Alberta, 2006).

The process will engage stakeholders in order to fully explore the vulnerabilities of each sector and to provide a forum for information exchange and education. The assessment is aimed at identifying the highest priorities for medium and long-term research within and across sectors. The results of the assessment are hoped to guide the integration of climate change impacts and adaptation issues into the province's risk management frameworks for sustainable development (Government of Alberta, 2006).

Newfoundland and Labrador is another example of a provincial government undertaking a risk assessment, but Newfoundland is concentrating on selected communities' along the coast. These communities' risks from flood events are being investigated and quantified. The data that will be compiled from this research is expected to be valuable for local land-use and emergency preparedness planning. By providing local decision-makers with information needed in planning for potential impacts and changes, the provincial government's research can aid community-based climate change planning processes (Government of Newfoundland, 2005).

The City of Yellowknife, Northwest Territories, has also recognized the benefits of undertaking a pro-active and comprehensive climate change risk assessment and development of an adaptation plan. By doing so, the City plans to minimize unanticipated remediation costs of future impacts, to better understand its risks, and to develop the capacity within the organization to ensure due diligence in managing public assets. Also, by being proactive, the adaptation planning process can be integrated into the City's ongoing capital infrastructure planning process (Pembina Institute, 2007).

The assessment and planning process encompasses several stages. In assessing the risks, existing community planning documents will be reviewed, current responses to climate change impacts will be examined, potential risks to the preferred community future plan will be reviewed, climate change scenarios for the region will be presented, and the scope of possible impacts from these scenarios will be examined. In developing the adaptation plan, improvements to decision-making processes will be determined to ensure that they are made effectively and efficiently and consistent with the community's long-term vision. As well, the engagement and support of the municipality's elected officials, key administrative staff, and external stakeholders will be ensured. Changes needed to be made to decision-making processes will also be recommended (Pembina Institute, 2007).

An example of a sector-specific risk assessment and planning process is provided by the National Capital Commission, which is responsible for many lands and activities in the National Capital Region. It commissioned a study to assess how climate change will

influence the seasonality of major winter and warm-season recreation and tourism in the region, and what the implications are of climate change on major tourism event planning and programming (Scott et al., 2005).

Monitoring

The development of effective and efficient adaptation strategies requires access to reliable climatological data, interpretation data, and indicators adapted to climate change. No other region has demonstrated their dedication to monitoring climate change related data and the impacts of climate change more than Quebec. The province is currently undertaking or planning to undertake monitoring of a wide variety of sectors and indicators. The majority of the province's adaptation strategies are currently focused on monitoring and improving monitoring systems.

Quebec plans to invest in consolidating and modernizing their climatology and hydrometric networks, particularly in the northern region of the province. Consolidation and adaptation of environmental monitoring networks will allow for a more effective and efficient capacity to quantify climate change trends, evaluate their impacts, and develop appropriate adaptation actions. Quebec intends to invest in the needed capacity for analyzing, interpreting, and distributing climatological data, including interpretation tools and adapted indicators (Government of Quebec, 2006).

Monitoring actions are planned in many other sectors as well. As part of their climate change action plan, the government of Quebec is investing in setting up a short- and long-term epidemiological monitoring system for physical and psychosocial health problems related to extreme climate events. They will also improve the region's disease monitoring systems to allow for quick detection of pathogens and diseases whose development may be accelerated by climate change. Quebec is also currently reviewing the province's air quality monitoring network to better monitor the presence of atmospheric pollutants. The province is also monitoring coastal erosion and the effectiveness of protection barriers (Government of Quebec, 2006).

Generate policy alternatives and select preferred options

Once vulnerabilities and risks have been assessed, local governments can start generating policy options to adapt to projected impacts. Most Canadian local governments are still in the beginning stages of developing policy options and assessing their effectiveness and efficiency. Since it will take some time in order to determine the effectiveness and efficiency of adaptation options, many local governments are planning to or are currently implementing "no-regrets" options, which will benefit communities regardless of the materialization of climate change impacts.

Although the Halifax report does not develop a comprehensive adaptation plan, it recommends an initial set of responses based on the resulting 18 high-risk areas of

impact. As a precursor for implementing adaptation action, it recommends better monitoring and research of the most vulnerable areas to gain a better understanding of them, and to evaluate adaptation options in addressing them. In order to do this, it recommends high resolution topographical mapping to better identify areas at risk of flooding. As a more reactive adaptation option, the report recommends the relocation of vulnerable transportation infrastructure. Also, it recommends education about vector-borne diseases to counteract outbreaks and increased incidence associated with warmer winter temperatures, in an attempt to reduce harm. The report also identified agencies that would logically have responsibility and authority for implementing these responses (Ligeti et al., 2007a).

“No-Regrets” Strategies

At this point, the implementation of “no-regrets” strategies is important and most promising, as some communities will most likely not have the capacity to implement adaptation strategies based on comprehensive assessments for at least another 15 to 20 years (Wittrock, 2007). These strategies provide benefits to communities whether projected climatic changes occur or not (Infrastructure Canada, 2006). It is therefore easier for communities to buy-in to these strategies and dedicate resources and lifestyle changes in order to implement them.

Green roofs are a good example of a no-regrets measure. Green roofs offer many benefits to a community, regardless of future climate change impacts. For example, widespread greening of Toronto’s roofs would offer benefits that can contribute to adapting to climate change impacts, such as increasing heat waves and intense rainstorm events. It is estimated to result in a reduction in storm water flow of 12 million m³ per year and reduce local ambient temperature from 0.5 to 2 degrees Celsius.

In addition to these benefits, green roofs offer benefits that are worthwhile regardless of climate change impacts. It is estimated to result in infrastructure savings worth \$79 million, erosion control measures savings worth \$25 million, pollution control avoidance worth \$13 million, and 3 additional “beach open” days per year worth \$700,000, citywide savings from reduced energy for cooling of \$21 million, equivalent to 4.15 kWh/m² per year, and avoid energy costs due to reduced demand at peak times of \$80 million (City of Toronto, 2007). Another study based in Ottawa, Ontario on green roofs found similar benefits (Natural Resources Canada, 2006). Also, green roofs create more scenic views and recreational areas, opportunities for local food production, and habitat for birds and invertebrates, and last up to twice as long as regular roofs (City of Toronto, 2007). The overall benefits are considerable enough that even though further research is required to determine whether the private and social benefits of green roofs exceed their costs (Banting et al., 2005), the City of Toronto has decided to proactively adopt a green roof strategy.

Another example of a no-regrets type of strategy are community water conservation initiatives, or demand management, which were discussed in more detail in a previous

section. These strategies are most promising in adapting to climate change impacts to water supply since they are beneficial to communities regardless of the intensity of future impacts. They are also relatively efficient in comparison to the environmental, economic, and social costs associated with most alternative policies to deal with fluctuating water supply, such as building new water infrastructure.

Implement and evaluate climate change policies

Following the selection of a climate change adaptation option, its implementation may take many steps. There needs to be support for the option at many levels, including policy and administration. This is illustrated by the implementation of the Toronto Green Roof Strategy.

At the policy level, Toronto had considered green roofs as an effective and promising policy option for some years as reflected in the recommendations of the City's Environmental Plan and in the policies of the Official Plan. Implementing the Green Roof Strategy was a 10 month process with a number of steps. In 2004, a study was commissioned to estimate the potential benefits of widespread implementation of green roofs throughout the city. Next, a set of consultation workshops were held with green roof stakeholders in order to receive input on the proposed strategy. Then the City prepared a discussion paper which proposed options for encouraging green roof implementation, based on the study results, the policies of international green roof municipal leaders, and the stakeholder workshop. The paper was presented to the public and to Toronto's Roundtable on the Environment, after which City Council approved the resulting strategy. The strategy is being implemented through various methods, as described in previous sections of this report (City of Toronto, 2007).

A crucial step for implementing and evaluating adaptation strategies is the establishment of institutional mechanisms for ensuring that the process is taken forward. In conjunction with this is a need to have staff that are dedicated specifically to adaptation measures, adequate funds for research and analysis, and workshops and other activities. This can help in ensuring that there is an ongoing process to bring stakeholders in the local government and related organizations together to assess the latest information on climate impacts and adaptation options and strategies. Institutional mechanisms are also important in providing guidelines to integrate climate change considerations and adaptation into general local government decision-making (Ligeti et al., 2007a).

Local governments should implement monitoring and evaluation programs as an on-going activity, alongside other adaptation strategies. Continuous evaluation of implemented adaptation strategies is important to determining their effectiveness and efficiency, and to determine whether additional measures need to be implemented (Wittrock, 2007).

CONCLUSION

The scan provided in this report of climate change adaptation activities taking place in local governments across Canada has revealed some important lessons that can be used by local governments in British Columbia, as well as by the provincial government of British Columbia. As being done in many provinces in Canada, the provincial governments can play a strong part in influencing, encouraging, and helping local governments in working towards developing and implementing adaptation strategies.

There are some lessons that are general to current adaptation planning, whether it is at the local or provincial level. As being done in many jurisdictions across Canada, the first step towards adaptation planning is conducting risk or vulnerability assessments, with the involvement of stakeholders and the community. This ensures that the highest priority risks are planned for first and foremost, and that public resources are used most appropriately. Secondly, whenever possible and appropriate, the implementation of “no-regrets” adaptation strategies should be prioritized as they will benefit the community regardless of the future outcomes of climate change. Thirdly, efforts should be made to establish adequate and appropriate institutional arrangements to ensure that adaptation planning can be continuous and adequately supported.

There are some lessons that can be applied more specifically to local governments. To build stronger and more resilient community adaptation plans, local governments can work together in partnerships with other sectors and other governments in the same or different levels. Secondly, in developing adaptation strategies, local governments can and should make use of various policy tools available to them, namely the implementation of regulations and incentives, the use of information, and investment in various adaptation methods, technologies, and programs. Thirdly, an important part of adaptation planning is the monitoring of the current impacts of climate change as well as the monitoring of implemented strategies to detect their effectiveness and efficiency.

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