

INSTITUTIONAL ADAPTATION OF WATER RESOURCE INFRASTRUCTURES TO CLIMATE CHANGE IN EASTERN ONTARIO

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Abstract. Institutional barriers and bridges to local climate change impacts adaptation affecting small rural municipalities and Conservation Authorities (CAs are watershed agencies) in Eastern Ontario (Canada) are examined, and elements of a community-based adaptation strategy related to water infrastructures are proposed as a case-study in community adaptation to climate change. No general water scarcity is expected for the region even under unusually dry weather scenarios. Localized quantity and quality problems are likely to occur especially in groundwater recharge areas. Some existing institutions can be relied on by municipalities to build an effective adaptation strategy based on a watershed/region perspective, on their credibility, and on their expertise. Windows of opportunity or framing issues are offered at the provincial level, the most relevant one in a federal state, by municipal emergency plan requirements and pending watershed source water protection legislation. Voluntary and soon to be mandated climate change mitigation programs at the federal level are other ones.

“The concept of policy networks (. . .) is based on the observation that policy-making tends to be fragmented into specific *issue areas*, and that most issues are dealt with by a few actors within small groups of participants from governmental and nongovernmental agencies (. . .). It describes the close and consensual nature of policymaking and the often blurred relationship ‘between the governors and the governed’ (. . .) through channels that are often informal and, almost always, extra-constitutional.” (T. O’Riordan et al., 1998)

“ . . .risk perceived is risk acted upon.” (J. Adams, 1995)

1. Introduction

This case-study deals with local institutional¹ adaptation to climate change of water-related infrastructures in the Eastern Ontario region (approximately 5,000 km² in the Great-Lakes Basin, at the confluence of the St. Lawrence and the Ottawa River in the Province of Ontario, Canada and in the vicinity of Ottawa - Gatineau, a metropolitan centre of about one million inhabitants; see Figure 1). Canada is endowed with a federal system of government, in which provinces enjoy a large degree of autonomy for matters of regional relevance. This means that environment is often an area of

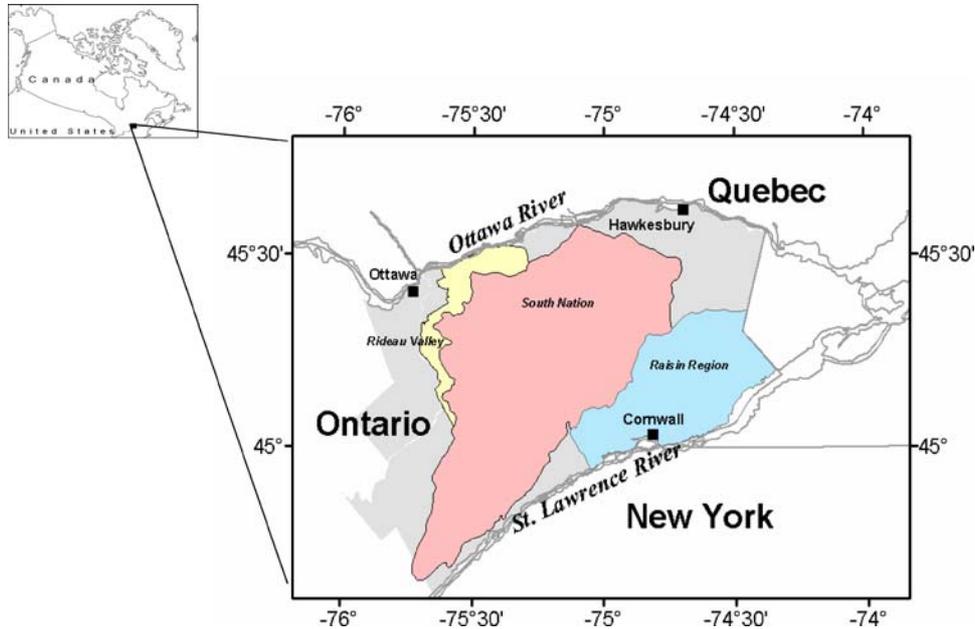


Figure 1. Map of the Region with Watersheds.

shared and, therefore, conflictual jurisdiction. Authority in municipalities (local government) is delegated by the province. This study has several unique features.

First, it is interdisciplinary involving hydro-geologists, environmental engineers, ecologists, eco-toxicologists, geographers, public health professionals, economists, political scientists, and lawyers working on common research and policy questions.

Second the study had partners from the community who assisted in steering the study. These include: the Federation of Canadian Municipalities (FCM), which re-groups most of Canadian municipalities, has been proactive in the area of voluntary climate change mitigation and has agreed to diffuse the results of this case-study; a community-based environmental research and education institute²; and the Eastern Ontario Water Resources Committee (EOWRC), the successor committee responsible to implement the recommendations of the Eastern Ontario Water Resources Management Study (EOWRMS) completed in 2001 (CH2M HILL, 2001). The mission of EOWRMS was to gather information to ensure a safe, cost-effective drinking water supply on a regional scale. EOWRC's members include two Conservation Authorities or watershed agencies (South Nation Conservation (SNC), the Raisin Region Conservation Authority (RRCA)), and two upper-tier municipalities (the United Counties of Prescott and Russell (P&R), the United Counties of Stormont, Dundas and Glengarry (S, D&G)), and the City of Ottawa to the extent of its involvement in the South-Nation watershed.³

Third, the study is focused on institutional barriers and bridges to local adaptation affecting small rural municipalities (a total population of about 140,000 inhabitants)

and Conservation Authorities (CA), i.e. watershed agencies, and proposes elements of a community-based adaptation strategy related to water infrastructures. Water-related infrastructures are broadly defined to include engineering structures, watersheds and pertinent human and social resources such as health, climate- and water-related expertise and institutions. The study developed from EOWRMS (CH2M HILL, 2001), which did not address climate change or institutional change, and from climate change projections for the Great-Lakes Basin over this century identified in publications from the last ten years as well as from original physical climate scenarios based on experienced weather events in Eastern Ontario.

This study utilizes both a top down scenario-based approach and a bottom-up vulnerability approach (Smit, 2003; Adger et al., 1999). It takes the vulnerability approach to the extent that all its physical scenarios are historical analogues and that the study focuses on current adaptation needs and opportunities in a cost-effective perspective. It takes the top down approach to the extent that the stakeholders have not been the driver for this study and that published future scenarios and thus long-term impacts have been taken into consideration as well (Smit, 2003; Adger et al., 1999).

For most people, in their every day life, local government is the most salient political actor. It implements and enforces national and provincial policies through its police force (e.g. vehicle emissions), inspectors, medical officer of health (e.g. beach closure), and supplies essential services such as drinking water, garbage collection, etc. Local government plays a fundamental role in land - use, urban density, etc. Climate change impacts will be felt and differentiated mainly at the local level. If climate change policies are to be effective at the individual and household level, local government will have to play a key role to foster informal networks of expertise and cooperation among local businesses, local schools, colleges, universities, libraries, NGOs, churches, and other social groups, that is policy networks (O' Riordan et al., 1998).

The smallest region relevant to this study, for which impacts have been projected, is the Great-Lakes Basin. Differentiated impacts and vulnerabilities may exist at a much smaller spatial scale than the Basin. As governments closest to the people, municipalities may be the ones to act on adaptation, either because of the subsidiarity principle, which delegates the more local issues to the lower level of government capable of handling them, or because of residual responsibilities (Tindall et al., 2000). Different instruments and uses of those instruments are likely to be appropriate depending upon whether the climate scenarios are in some way locally distinctive rather than uniform across the Province of Ontario. A locally distinctive scenario rather than a widespread one is more likely to place particular demands on local authority.

Invoking the principle of subsidiarity and local public finance principles, all local issues should be steered by municipal governments which are more attuned to local citizens' preferences unless the services they require generate substantial spillovers or demand income redistribution. If municipal adaptation initiatives

generate major spillovers, either positive or negative even on a regional basis, then the Province should intervene possibly to set up some regional governing structure and adopt financing measures to internalize these spillovers or externalities and facilitate regional adaptation. If on the other hand, impacts are expected to be more localized and random in nature, senior governments may be less willing to facilitate preventative and adaptive strategies and more inclined to rely on responsive or emergency measures.⁴

A municipality's ability to develop and implement a comprehensive strategy towards climate change may be called its adaptive capacity or resilience. Municipal adaptive capacity is a function of various factors: the range of available technological options; the available resources and their distribution across the municipal population; the structure of critical institutions and the criteria for decision-making; the human and social infrastructures; the access to risk-spreading mechanisms; the ability of decision-makers to manage credible information and their own credibility; the public's perception of both the source of the impact and its significance to its local manifestations (Yohe et al., 2002). The greater the adaptive capacity, the larger is the set of adaptation options. This is why this study deals with planned anticipatory institutional adaptation that, for short, we call planned adaptation. It does not deal with simply reactive adaptation whose options are much more restricted. The lower the adaptive capacity, the higher is the vulnerability.⁵

The unexpected 1998 Ice Storm which caused about Can \$5 billion damage in Eastern Canada is an extreme event, which, according to the literature on climate change, is expected to become more frequent and more intense in the future (IPCC, 2001). It was vividly experienced in the region. The 2001 and 2002 Eastern Ontario droughts were milder forms of extreme events. The May 2000 Walkerton (Ontario) water quality crisis in which 7 residents of this Ontario village died and 113 others fell seriously ill from *E. coli* contamination had circumstantial ties to climate changes in that contamination occurred after an excessively wet period succeeded a dry one coupled with contaminated run-off from agricultural lands entering the community well (O'Connor, 2002). The July 2004 Peterborough (Ontario) flood is yet another instance of extreme event, though not experienced in Eastern Ontario.

Emergency plans offer the opportunity to take climate change risks into consideration, such as those resulting from extreme events. However, emergency plans do not suffice. Risk assessment/management requires long-term strategies to be included in the planning process of municipalities and risk-reducing measures to be taken in its everyday operations; it goes well beyond the design of purely reactive emergency responses (Bruce et al., 1999).

This climate change adaptation case-study, after looking carefully at water quantity impacts on groundwater resources (the major source of drinking water in the region) under various climate scenarios, concludes that negative impacts are highly localized at least for unusual scenarios of temperature, precipitation

and their combination, whenever historically experienced (see section 3). Moreover, the majority of the recent literature indicates that climate change is rather favorable to North-American agriculture (e.g. Weber et al., 2003 and the literature cited; Reilly et al., 2003; Mendelsohn, 2001). These are no excuse for policy inaction, however.

First of all, these highly localized areas of water quantity vulnerability deserve precautionary measures.

Second, as climate change comes on top of demographic, economic development pressures and environmental degradation, all of which affect both water quantity and quality, it may push water resources to a state which may require more resources for rehabilitation than needed for their protection (Carpenter et al., 1999).⁶ In other words, there may exist currently robust no-regret measures, i.e. measures worth adopting whether or not climate impacts occur, e.g. water use efficiency.

Third, adaptive management to climate change is part and parcel of sustainable management of all natural infrastructures to which many Canadian municipalities subscribe.⁷

Fourth, in the knowledge economy, human infrastructure is the best guarantor against vulnerability; household income and individual health will allow individuals to shield themselves to some extent from climate change impacts.

Fifth, communities can shelter themselves by educating their members, by protecting the most vulnerable, by taking adequate adaptive measures, and by building social resilience, i.e. the ability to cope with generally unanticipated and undesirable events.

Sixth, there is an a priori argument that early planned adaptation, facing a wider choice of feasible options, will be more flexible and cost-effective than late reactive measures.

Seventh, municipalities will be mandated sooner or later by the Federal Government to mitigate against climate change. Actual measures to be adopted may be largely discretionary (Government of Canada, 2002). Mitigation and adaptation are two policy instruments, or rather sets of instruments, which are generally not independent of each other (Kane et al., 2000). "Adaptation is a necessary strategy at all scales to complement climate change mitigation efforts" (IPCC, TAR, WG II, *Summary for Policy Makers*, 2001, section 2.7). In other words, municipalities need to develop a comprehensive strategy towards climate change, for both adaptation and mitigation, taking their particular circumstances into account. This strategy may enable one to identify business opportunities resulting from climate change (such as agriculture for ethanol or bio - diesel, a shift to more valuable cash crops and increased tourism, etc.).

Finally, there is evidence that the institutional set-up is a key factor against vulnerability. Institutions are persistent, sustainable and resilient social arrangements depending on legitimacy, agenda setting, and the environmental risks, which resonate with the institution's agenda, and social capital or infrastructure (see

also O’Riordan et al., 1998 for other features). How do we determine whether an institutional arrangement is appropriate to face exposure to climate change? Appropriateness is determined by whether institutional changes are legitimized within the internal and external constituencies and by the stakeholders of the institution. It is determined as well by whether institutions perceive the risks and whether their interventions are timely and anticipatory. Only real events (another ice storm, another drought or flood, another *E. coli* outburst) can put the institutions to the test (Adger et al., 1999). Appropriateness requires institutional learning in order to shift climate change adaptation from the periphery to the core of people’s concerns, linking climate change adaptation to their everyday concerns in a fashion, which is credible and perceived as valuable by them and their local government representatives. This shift requires shared scientific knowledge (e.g. hazard-mapping), windows of opportunity offered by real events and framing issues (the various ways of conceptualizing an environmental issue in the policy arena), and small incremental but strategic steps (O’Riordan et al., 1998; Young, 2002). Informal local policy networks formed around the issue of climate change adaptation and around existing local institutions, with a limited number of participants with shared values and interacting frequently, are a communication channel capable of changing institutional mindsets progressively and capable of leading to incremental steps. These networks should not be so conspicuous as to provoke negative reactions and opposition (O’Riordan et al., 1998).

A choice of emphasis was needed to make this article reasonably self-contained. It was decided to focus on institutional barriers and bridges to adaptation while keeping reporting of natural science and engineering results to a minimum and eliminating health completely.⁸ This article begins by summarizing the socio-economic and institutional context for the case-study (section 2). Section 3 summarizes the natural science and engineering climate change impacts on water-related infrastructures after reviewing available literature on the Great-Lakes Basin projected climate change impacts and original analogue climate scenarios. The sensitivity of natural infrastructure (groundwater quantity, quality and surface water resources) and of water-related built infrastructures to impacts is considered in the same section. Barriers to institutional adaptation and potential bridges related to social infrastructure are scrutinized and an inventory of innovative water-related institutions is conducted (section 4). The features of a local climate change adaptation strategy are then examined (section 5). Some determinants of Eastern Ontario’s adaptive capacity are reviewed in a concluding section (section 6).

2. Context⁹

The socio-economic context is briefly reviewed in the first two sub-sections and the institutional one is the object of the remaining ones.

2.1. DEMOGRAPHICS

Jointly, Prescott & Russell (P&R) and Stormont, Dundas and Glengarry (S, D&G) encompass 14 rural municipalities. Their population has increased by 1/3 over thirty years (1971–2001) mostly south and east of the City of Ottawa especially in Russell whose population has nearly tripled over the last 30 years under the economic attraction of the City of Ottawa and its urban sprawl. From 1951 to 1996, the rural population has diminished while the urban one has increased in the region due to the decreasing number of farms. As a result of reduction of family size and growing number of single-parent families, the number of households is increasing faster than population growth, increasing the need for dwellings and water consumption.

2.2. LAND-USE AND ECONOMIC ACTIVITY

Approximately 60% of the land area is devoted to agriculture while 1% is urban. Over the past fifty years, the number of farms decreased by over 60% but the percentage of cultivated land has increased. Agricultural land values have increased by over 30% in the last two years. The most valuable crop is corn (about Can \$110 million gross revenue in 2002), followed by soybean (about Can \$45 million), followed by hay (about Can \$3.5 million). Milk production is the least productive activity in terms of gross revenue (about Can \$350,000). Promoters from Quebec, where new large hog farms are forbidden, have been establishing new farms in the region despite the objections of local municipalities, which do not have the necessary environmental tools to protect themselves. An industrial project in the Cornwall area to process approximately 6.6 million bushels of corn per year into 66 million liters of ethanol for use in fuel application has been approved by the municipality. It will have an impact on corn production in the region and on agricultural pollution; corn is a fertilizer – intensive crop leading to high soil erosion¹⁰ and, as ethanol production is also water-intensive, water quantity and quality concerns in the region will increase.

2.3. MUNICIPAL LEGAL FRAMEWORK

2.3.1. The Current Ontario Municipal Framework

In Ontario, the municipal world has been completely transformed since 1995. The number of municipalities has been drastically reduced; their responsibilities have been increased through the downloading of some provincial responsibilities in exchange for the Province assuming the cost of elementary and secondary education. One of the objectives of the ‘Municipal Act 2001’, implemented in 2003, was to improve municipal flexibility and local autonomy so that

municipalities could suitably deal with and react to local economic, environmental and social issues in their communities without having to first find the authority to act in an existing regulation. “It has been impossible to find a solid rationale for the transfer of these new funding responsibilities to the municipal sector. The transfer process appears to have been driven solely by the provincial desire to make its assumption of additional school funding revenue-neutral” (Kitchen, 2003, p. 31). The revenue neutrality of the transferred responsibilities was expected to be shored up by increased cost-effectiveness of municipal services through amalgamation. Note that the province reserves to itself the setting of the standards for the provision of the downloaded services (Kitchen, 2003). Their increasing independence (more responsibilities and fewer provincial transfer payments) drives municipalities to behave more in a business-like fashion, including Public-Private-Partnerships. Despite these functional transformations, Canadian municipal governments are created through provincial statute and may take responsibility for only those areas of activity the province wishes to grant them explicitly.

The region has a two-tier municipal system. Counties or upper tier municipalities (P&R and S, D&G) are endowed with an Upper Tier municipal or County Council, which is composed of the elected Mayors of lower-tier municipalities within county boundaries. Lower-tier municipalities are responsible, through grand-fathering, for most municipal services. When the provincial government downloaded some of its responsibilities on municipalities, such as social housing, workfare (welfare), public health, land ambulances, provincial roads, etc., it transferred corresponding funding responsibilities to counties. Moreover, in order to benefit from economies of scale, some municipal services traditionally provided by lower-tier municipalities were transferred to counties. These include: roads, police, some emergency services, and solid waste management. The split of financial revenue between counties and lower-tier municipalities is roughly even.

Municipal governments are generally responsible for the basic local infrastructure services according to 10 spheres of jurisdiction identified by the Municipal Act. In addition to these ten spheres, specific powers (more restricted than the spheres and more traditionally prescriptive) are granted to municipalities in seven pertinent areas. These powers are restricted because they are considered as overlapping with provincial jurisdiction and, therefore, leading possibly to over-regulation. The allocation of infrastructures to spheres of municipal jurisdiction and powers, relevant for small municipalities, is as follows:

1. For natural infrastructures, the most significant municipal powers are over land-use and zoning regulations, riverbanks, and municipal forests. It is noteworthy that, contrary to the United-States, there has been neither systematic downloading of environmental policy-making responsibilities from the Federal Government to the provinces, nor from the Province of Ontario to municipalities (Abel et al., 2000).

2. For built infrastructures, powers are over municipal roads and bridges, marinas and docks, dams and weirs for flood control, drainage (except storm sewers which are under CAs' jurisdiction), water and wastewater treatment facilities and lagoons, solid wastes, pits and quarries, recreation, GIS, emergency plan infrastructures (e.g. fire stations, ambulances), building code (including dwelling density), and infrastructure standards.
3. For human and social infrastructures, over health and safety (including prevention and early warning systems), essential and emergency services (fire, medical), consumer protection, nuisance (e.g. odor), public education and capacity building.

It should be reemphasized that the Provincial Government may override or limit any of these municipal responsibilities.

Ontario is the first province in Canada to require a yearly report to taxpayers on municipalities' performance in service delivery (Kitchen, 2003).

The fiscal framework within which municipal governments operate is, however, tightly controlled. The authority to spend and to raise revenues derives from provincial legislation and regulation. More and more municipal governments are facing increasing costs and dwindling revenues, triggered by: the offloading of provincial responsibilities, rapid growth, shrinking inter - governmental transfers, regulated caps on tax increases and heightened expectations from their citizens.

2.3.2. The Federal Legal and Financing Framework for Water Infrastructure, Water Quality, and Disaster Relief

Despite the importance of federal government decisions for municipal operations, the federal government rarely interacts directly with municipalities and its involvement is not always welcome. "In almost every case, however, the federal programs were introduced without regard to their impact on the local level. Municipalities had no opportunity for advance consultation and little hope of obtaining adjustments after the fact" (Tindal et al., 2000, p. 227). Federal ventures into water quality, including drinking water, have not proven particularly fruitful either. Municipalities prefer federal financial contributions to legislative intervention. There is a very substantial shortfall between the federal government's current infrastructure funding commitment of Can \$2.65 billion for the 2000–2006 period and an estimated municipal requirement across Canada for some Can \$ 50 billion for water facilities and wastewater treatment over the next decade (FCM, 2001a and 2001b). It is estimated that the Ontario water system infrastructure alone requires an investment of Can \$35 billion over the next 15 years (OMPIR, 2005).

The availability of federal financing is also relevant on the disaster relief side, where costly experience with the Red River flood of 1997 (Can \$815 million) and the Saguenay flood of 1996 (Can \$1.6 billion) stimulated federal interest in measures that could alleviate taxpayer expenditures in the event of future similar catastrophes. Follow-up work released earlier this year by the federal Office of Critical

Infrastructure Protection recommends consideration of several significant options, including, for example, the introduction of user - pay fees for those occupying areas at risk from flooding.

The federal legal context involves one further set of considerations, which may come to influence governmental responses to climate change impacts on water management. New norms or environmental values including bio-diversity, precaution, prevention, sustainability, and ecosystem management have appeared in federal legislation during the past decade or so. The most recent of these is the precautionary principle.

2.3.3. The Provincial Legal Frameworks for Water and Drought Management

The authority of local governments to act in environmental matters was reinforced by the Supreme Court of Canada (*Hudson v. Spraytech, Racal Trucking*) by offering some recognition to the precautionary principle and enhancing the status and autonomy of municipal governments in implementing the mandates conferred upon them under provincial legislation.¹¹

In the past five years, Ontario has experienced more changes to the regulatory framework for water management than at any time since the formative crises of the 1950s. Many of these developments have significant implications for local government thinking about climate change. A number of examples illustrate the surprising dynamism of the Ontario legal environment in its ability to tackle the prospect of water - related challenges associated with climate change:

Ontario has had, for ten years now, an Environmental Bill of Rights which requires provincial government new proposals to be posted for citizens' comments on an Environmental Registry website.¹²

In May 2002, Commissioner O'Connor drew up recommendations to ensure the safety of drinking water across Ontario in Part II of the Report of the Walkerton Inquiry into the *E-coli* deadly outbreak, which affected this Ontario village (O'Connor, 2002). Highlights of that process include nutrient management legislation and legislation enacting new measures to ensure the safety of drinking water systems in the province.

Reports pertaining to proposed legislation on 'Watershed-based Source Protection Planning' have been posted recently by the Government of Ontario on the Environmental Registry for public review and comment and the Provincial Legislature is expected to adopt the legislation in 2006 (Government of Ontario, 2003). It will require a watershed management plan from Conservation Authorities (CA) and will more tightly regulate and charge for Permits-To-Take-Water which are already compulsory for any water withdrawal in excess of 50,000 liters/d. (about 14,000 US gal/d.).

The Ontario Low Water Response plan appeared in 2001 (revised in 2002) as an interdepartmental initiative following a period of lower than average precipitation in 1998 and 1999.¹³ The provincial plan defines physical and socio-economic characteristics of low water conditions. It also conceptualizes three distinct levels of

low water conditions: potential water supply problem (Level I); potentially serious problem (Level II); failure of the water supply system to meet demand resulting in progressively more severe and widespread socio-economic conditions (Level III).

Depending upon the level identified, emergency measures consistent with the *Emergency Management Act* (RSO 1990 c. E.9) are anticipated. These involve initiatives by various provincial ministries, CAs and municipal governments. Most of the relevant initiatives depend upon the classification of water use priorities according to three broad categories: essential, important, and non-essential.

The Ontario Low Water Response plan endeavors to distinguish provincial and municipal responsibilities this way:

The province provides overall direction and coordinates policies, science and information systems and emergency support. At the local jurisdiction, the emphasis is directed to collecting information, interpreting policy, delivering policy programs and responding to emergencies (p. 1).

2.3.4. Municipal Water-related Facilities, Drinking Water, Nutrient Management, Water Source Protection and Emergency Plans

In 1998, Ontario municipalities owned and operated about two-thirds of the water and sewage facilities in the province. About one third was owned by the Ontario Clean Water Agency (OCWA), a provincial crown agency, which is transferring all provincial ownership to municipalities following the introduction of the Water and Sewage Services Improvement Act, 1997.

The Walkerton Inquiry recommendations had a great influence on the creation of the Safe Drinking Water Act, 2002 (SDWA), the Sustainable Water and Sewage Systems Act, 2002 (SWSSA), and the Nutrient Management Act, 2002 (NMA).

The SDWA introduces new instruments to protect drinking water in the province. Two key components are the requirement of a municipal drinking-water license and a standard of care for municipal owners. In order to obtain a license, municipalities will be required to hold a: Permit -To-Take-Water, a Drinking Water Works permit, an Operational Plan approved by the Ministry of Environment (MOE), an Operating Authority accredited by a Ministry-approved Drinking Water Quality Management Standard similar to ISO 14,000, and a Financial Plan (under the SWSSA, 2002). The standards for water testing are high and the owners and operators of municipal drinking water systems must sample and test drinking water in a frequency designed to reflect the size of the population served. Owners and operators must report adverse test results to both the medical officer of health and the Ontario Ministry of Environment (MOE), a requirement introduced after the Walkerton crisis.

SWSSA provides the framework for both water and wastewater infrastructure funding. Under the SWSSA, water suppliers must account and report on the full cost of providing water and wastewater services and they must prepare and carry out plans for recovering the full cost to ensure that suitable financing is available for water and sewer infrastructure over the long term.

The Nutrient Management Act (NMA) implements a regulatory framework for nutrient management and other related farm practices in the province to protect the water and the environment in rural Ontario. New livestock farms, superior to a threshold of nutrients use, and large livestock farms have to develop a Nutrient Management Strategy (NMS) and/or a Nutrient Management Plan (NMP). NMS describes how operators of livestock farm are managing materials.

NMA will assist municipalities in their responsibilities for land use planning and building code approvals. However, there is much controversy about the NMA and its proposed regulations, especially those concerning the hog industry. Large-scale hog farms are a real danger for the quality of drinking water and a threat to the family farm. "Those industries must be dealt with separately; they need to be regulated as what they are – industries, not as what they are not – farms."¹⁴ One failing of the NMA is that the new legislation gives too little responsibilities to the municipalities.

Emergency Plans are a regional responsibility since the Emergency Readiness Act, December 2001. 7 municipalities of S, D&G and 8 in P&R will be integrated into a comprehensive plan at the regional level. Here there is a good opportunity to include climate change related emergencies in the plan. The current regional plans are really frameworks that identify the roles and responsibilities of those involved. The transition period is an opportunity to ensure that emergencies related to climate change are not only built into the plan but also into any accompanying regional information for householders.

2.3.5. Conservation Authorities (CAs)

Conservation Authorities (CAs) are watershed institutions that originated in concerns about 'the combined results of drought and deforestation' and are habilitated to cover all aspects of conservation in the watershed.¹⁵

A major cause for the concern about protection of life and property from damage due to flooding has been and still is, a tendency for municipalities to allow building in scenic waterfront lands as well as less expensive marginal areas prone to flooding. Remedial and protective measures inevitably consisted of both structural (dams, dykes, groins, etc.) and non-structural (forecasting, zoning, planning, etc.) actions at great costs and with little benefit generally (Lawrence et al., 1993; Philippi, 1997; Whipple, 2001). An increasing number of citizens became alarmed as well that local decision makers were only protecting the interests of a few homeowners, but were not protecting public interests in water quality and quantity. All levels of government were forced to take action resulting, in Ontario for example, in responsibility for managing and monitoring various water uses being distributed among a great number of federal, provincial and municipal agencies or departments (Lawrence et al., 1993). Each agency developed its own policies and regulations according to the quality and quantity of water that each water use required. Jurisdictional roles for the management of water-related issues often overlapped. Conflicts inevitably arose (Whipple, 2001). It consequently became increasingly necessary to

create institutional arrangements that would protect the interests of as many water users or stakeholders as possible. It became progressively evident, as well, that the responsible institutional arrangement be as close as possible to the municipalities and to the stakeholders involved for both political and economic reasons.

At the same time, municipalities needed specialized and often outside expertise to resolve water quality and quantity problems that growing demand on already stressed watercourses engenders. For example, municipalities had to deal with the prevention of risk and damage from weather events such as flooding and drought on scales, which they were in no position to handle. Also the scope and complexity of new federal and provincial regulations and standards required a level of expertise that few municipalities could afford.

2.3.6. Legal Framework

The CA is an autonomous, locally-governed organization operating within the legal mandate of the Act which established them in 1947 to provide a venue for inter-municipal and Public Private Partnerships, accountability, experience, and consistency in decision making (CA Act 1990). A distinct CA was thus established for each of the major Ontario watercourses. The Authority is composed of representatives from each watershed municipality. CA funding is provided by the member municipalities through tax levies, by the Province through the Ministry of Natural Resources (MNR), and by the Federal Government through grant programs.

The Conservation Authorities Act was founded on three basic concepts: watershed as a management unit, local initiative, and municipal-provincial partnership

2.3.7. Implementation and Local Examples

Following various kinds of Walkerton-like emergencies, CAs have signed partnership agreements with the Ministry of Environment (MOE) for the installation of monitoring wells equipped with data-loggers. Climate variability since 2000 has reversed priorities from flood control response to drought response in southeastern Ontario. Low Water Response Teams (WRT) were established in CA watersheds by the Ministry of Natural Resources (MNR) under Ontario Low Water Response guidelines. Coordination of these WRT Teams was assigned to the CA's.

South-Nation Conservation (SNC) was selected for a Phosphorus (PO_4) reduction study. This pilot program aims at reducing the principal contributors of eutrophication and hence algal and weed growth in waterways. As part of its mandate to protect wetlands and wildlife habitat, the non-profit organization Ducks Unlimited entered a partnership with SNC to provide grants to farmers who wish to establish buffer strips and plant trees along streams and close to wetlands (SNC, 1997).

Provincial downsizing and restructuring during the mid-1990s removed much of the ongoing financial support to CAs.¹⁶

2.4. MUNICIPAL FINANCIAL FRAMEWORK

Climate Change will impact municipal finances both on the revenue and the expenditure sides. On the revenue side, as land use or agricultural crops may have to be modified due to climate change (e.g. more corn, more soybeans, less hay; see section 3.1 *infra*), property taxes will be affected either positively or negatively according to the revenue stream generated by the new land use; user fees could increase considerably if water consumption were charged at its incremental cost (full-cost pricing). Development charges may also increase if full cost pricing is implemented. Public Private Partnerships and developer financing should also increase for capital projects due to the new defined ‘character’ of municipalities as ‘business’. Debt dependence may worsen if the municipal tax base and/or provincial transfers are not increased. If both the provincial and federal governments implement climate change mitigation, provincial and federal transfers to municipalities will increase.

On the expenditure side, environmental services, both capital and operating expenditures, are expected to increase considerably due to required investment in new or in replacement of built municipal water-related infrastructure. Environmental services also include water supply, wastewater treatment, garbage collection and recycling, storm water system, etc. Well water protection expenditures may have to increase as well. Extreme events will increase expenditures on protection services and insurance. Large-scale service realignment has increased the financial burden of the municipalities many folds. A variety of financial options could be very helpful in redistributing municipal financial priorities: options that could redirect short-term versus long-term funds and spawn partnerships; grants that can impact municipal funding sources and program decisions remain unknown to some municipal administrations. Climate change adaptation should not be seen simply as a new financial burden; rather it should provide another argument for easing municipalities’ access to long term financing.

3. Climate Projections and Scenarios and Natural and Built Infrastructure¹⁷

A quick summary of the natural science and engineering results of this study will now be provided.¹⁸

3.1. CLIMATE PROJECTIONS AND SCENARIOS

In general future climate projections point to a continued increase in average temperature (more in the winter than in the summer, especially for night-time minimum temperatures) which will decrease river water levels, lead to earlier peak flows, and result in longer and more intense heat waves. They indicate a shift to the winter in

the distribution of precipitations, while the latter's average level over a year will not significantly change; this shift will result in more frequent and intense summer droughts, and more frequent and intense precipitation winter events in the form of rain rather than snow.

For the study area, anticipated climate change may result in longer growing seasons and a climate shifting progressively, but not necessarily smoothly, to one more similar to that found in northern Virginia (UCS-ESA, 2003).

This study constructed seven analogue physical climate scenarios which combine normal and unusual, but not extreme ranges of temperature and precipitation, historically experienced in Eastern Ontario. The latter were not intended to cover events with small probability of occurrence; rather they were intended to represent likely scenarios of climatic conditions based on record.¹⁹

3.2. IMPACT OF CLIMATE SCENARIOS ON GROUNDWATER QUANTITY

Groundwater is of utmost importance to the study region as it provides over 60% of the region's drinking water. A Geographical Information System (GIS)-based hydro-geological model was constructed to calculate monthly groundwater budget for the climate-change scenarios, using hydro - geological information from the EOWRMS (CH2M HILL, 2001). The results indicate that on a yearly basis groundwater resources were not very sensitive to the climate change scenarios. Even with a succession of unusually dry years the groundwater systems get recharged during the snow-melt and rainy seasons (in fact, flooding is more the issue during these seasons). On a monthly basis, the picture is very different. The GIS analysis showed that some areas are particularly and consistently vulnerable to droughts during the dry summer months, even during "wet" years, while other regions are vulnerable only during dry years.²⁰ These regions typically correspond to regional aquifer recharge areas (the western and central portions of the study area). Similarly, aquifer vulnerability to contamination was highly seasonal and localized. Aquifer recharge areas were particularly vulnerable during wet periods following dry periods, such as the fall. This suggests that aquifer contamination issues can be mitigated with proper waste management practices and, in particular, by the proper timing of land application of animal waste. This situation is exacerbated in areas where the surface (unconfined) aquifer is the main source of water. Such areas exist particularly in the extensive esker complex in the central and western portion of the study area (these deposits consist of long winding gravel deposits above or under ground). Groundwater supply issues, being seasonal and local, can also be mitigated with proper management and, in particular, with the monitoring and metering of Permits-to-Take-Water holders. An additional measure to be contemplated could be artificial recharge of the groundwater system in supply - vulnerable areas.

3.3. IMPACT OF CLIMATE SCENARIOS ON GROUNDWATER QUALITY

Reduced flow for tributaries of the St. Lawrence and Ottawa Rivers may exacerbate current water quality problems in a predominantly agricultural region, especially in the Raisin and the South Nation watersheds. Currently, the state of these watersheds is perceived as good by municipal and CAs' staff. However, the quality, but not the quantity, of both surface water and groundwater, especially as related to organic waste, is definitely one of the CA staff's major concerns. Staff also cites the lack of pertinent data as another concern. This study has found that groundwater tested positive for bacteria in many areas with counts amplified in areas with intensive agriculture and in areas with dug wells. In any climate scenario, regular testing of water quality should be a priority. In general nitrate was not found in levels exceeding the guideline, although some wells that were dug shallow and located in intensive agricultural areas had high levels of nitrate. The South Nation is one of the most eutrophic rivers in Ontario containing a large amount of nitrates and methyl mercury. An optimization non-point pollution model applied to the South Nation indicates that Best Management Practices, alone or in combination, are unable to improve water quality to the level of national guidelines without reducing the level of agricultural activities. Though climate change may be beneficial for agriculture in the region (especially for corn and soybean; see e.g. Weber et al., 2003 and the literature cited), it will require rural municipalities, within their area of jurisdiction, to become more involved with the diffuse polluting impacts of changing agricultural activity through, for example, reductions in nutrient loading (e.g. with the suggested phosphorus credit system), development of vegetated riparian zones, and wetland protection and creation. Also, increased corn production (e.g. for subsidized ethanol production in the context of climate change mitigation) would further contribute to the deterioration of water quality in the South-Nation watershed.²¹ An ethanol-processing plant is currently being built in Cornwall.

3.4. IMPACT OF CLIMATE PROJECTIONS ON BUILT INFRASTRUCTURE

Since extreme events, especially large and more frequent precipitation events, are concomitant with climate change, water and wastewater treatment plants sizes may have to be adapted to cope with a larger amount of water and larger and longer peak periods, including peaks for water demand during drought periods. Currently only one mechanized wastewater plant and three lagoon plants are at capacity in the region. To address this capacity concern, various measures may be considered including reduced rainwater infiltration into sewers (frequent in the region) and separation of combined sewers (not common in the region). Upstream basin system equalization for mechanized plants may be considered in order to reduce effluent quality deterioration due to storm events. Management of plant turbidity fluctuations (frequently reported in the region, reported as hard to manage, and expected to

be more frequent) and management of distribution systems pressure (to decrease system losses) are required. With lower water levels, lower water intakes may be needed; odor and taste problems resulting mainly from lagoon systems may be more frequent and require treatment dependent on water properties. Pertinent data are insufficient, inconsistently recorded, and not readily available, preventing the identification of treatment efficiency parameters' sensitivity to weather data.

4. Local Institutional Barriers, Bridges and Innovative Water-related Institutions and Adaptive Measures

Climate change²² adaptation is a new issue which enters the municipal world in Canada at a time of turmoil resulting from the reorganization of municipalities, greater demands in terms of accountability, insufficient financial resources for the new assigned tasks, economic globalization (hog farms), urban pressures (expansion of Ottawa), environmental concerns (drinking water, nutrient management, etc.), and greater demands from concerned citizens (see section 2). In comparison, climate change appears distant and cloudy, while climate adaptation is yet a new responsibility for municipalities (Needham, 2003).

4.1. LOCAL INSTITUTIONAL BARRIERS AND BRIDGES

4.1.1. Municipal Institutional Barriers

4.1.1.1. External Barriers. Municipalities encounter a number of institutional barriers to climate change adaptation of water-related infrastructures, which are either internal or external. External barriers result from the status of Canadian municipalities as creatures of provincial governments. Municipalities enjoy very little autonomy in terms of financial resources and in terms of water resources and agricultural management despite of their linkages. As mentioned in section 2.3.3, the Ontario Low Water Response plan assigns negligible managerial responsibilities to municipalities except for emergency responses.

Moreover, municipalities inherited a legacy of aging manufactured infrastructures whose location often conflicts with current development pressures and of past but currently inadequate planning decisions. The legal framework for municipal capital financing is inadequate especially in limiting access to long-term borrowing.

Municipalities lack information about the impact of climate change on infrastructure design and performance, despite their acknowledged financial vulnerability to climate events. They are overly dependent for information on engineering consultants who tend to ignore the social context of municipal decisions. Perhaps the main barrier to long term municipal investment in infrastructure projects is the fact that municipal councils are elected for three years only, though functioning in election mode for the last 9 months of their term of office; this is a disincentive for articulating a long-term planning vision (Needham, 2002).

4.1.1.2. Internal Barriers. Internal barriers pertain to management culture and conflicts, to the absence of lifecycle planning for manufactured infrastructure, to inadequate management of water resources within the area of municipal competence, to lack of enforcement of by-laws and other regulations, and to lack of databases about regional manufactured infrastructures including abandoned ones, such as old landfill sites and water wells. Small municipalities suffer from insufficient expertise at all levels, which increases their dependency on outside consultants. This leads the municipalities to rely overly on technological fixes rather than on management solutions. Conflicts occur among municipal, political and administrative priorities and between levels of local government (between lower tier and upper tier municipalities). Municipal culture is characterized by management-by-crisis, which leads municipalities to rely excessively on emergency measures, on inertia, and on oral communication with key personnel.²³ Municipalities neglect to take appropriate measures within the ambit of their authority to insure that regional supply and demand for water match in quantity and quality and to anticipate the impacts of climate change on the current mismatch (e.g. lower water intakes due to expected lowered water level, account for larger rain water events in infrastructure design). Municipalities mistrust the information they obtain about climate change (Needham, 2002).

4.1.2. Municipal Institutional Bridges and Municipal Learning

4.1.2.1. Climate Information. In order to attract the attention of small rural municipalities to climate change adaptation one has to make the climate change information consistent, credible, downscaled at the local level, pertinent to specific municipal infrastructures, their operations, and to their managers. This is why it is important to streamline the climate change information pertinent to politicians, administrative officers, planners, economic development managers, public works, road, waterworks, and drainage superintendents, and their professional organizations. The benefits of early adaptation measures vs. reactive ones have to be identified. This requires identification of bridges, which may help overcome the institutional barriers identified at the beginning of this section.

4.1.2.2. Bridges for External Barriers. The bridges related to external barriers are, first, jurisdictional; other bridges are: 1) federal intervention in municipal infrastructure financing; 2) financial (potential new sources of municipal revenue); 3) planning (needed revisions to provincial legislation related to municipal planning under climate change); 4) administrative (facilitate access to provincial funding sources, and pay attention to requests from various provincial professional associations); 5) informational (need to separate the more speculative climate change information from the more certain; identify the local impacts of a hazard within a finite time period; select appropriate means of communication).

4.1.2.3. Bridges for Internal Barriers. Bridges pertaining to internal barriers are: 1) administrative (acquisition by municipalities of Permits -To-Take-Water to be

allocated among local users, enhance municipal enforcement functions); 2) informational (use of windows of opportunity to release credible information about climate change; develop GIS-based manufactured infrastructure inventory); 3) management (emergency preparedness plans, regional procurement system for equipment needed for infrastructure servicing, public consultation on infrastructure design and location, water metering); 4) planning (risk management, watershed, well-head and landfill protection); 5) liability (infrastructure service standards, due diligence at the infrastructure design stage); 6) adequate combination of policy tools (including the ones required for mitigation; need to address motives behind behavior); 7) health (develop stronger relations with medical officer of health, who should provide health-related climate change messages for politicians, staff and constituents); and 8) education (which changes values but not behavior) (Needham, 2002; Dietz et al., 2002).

4.1.2.4. Information and Citizens' Participation as Bridges. Adaptation evolves through two main mechanisms, which affect individuals and institutions respectively, namely social learning and policy learning. "Social learning can be thought as a composite of individual adaptation, such that adaptation comes about through activities which depend on the participation of group members in discourse, imitation or shared collective and individual actions" (Adger et al., 1999, p. 257). Institutions constrain or facilitate social learning. Policy learning refers to the adaptation to external change by organizations, which attempt to retain and strengthen their own objectives and their domination over existing socio-economic structures. Policy learning can be done through the formation of new coalitions of advisors and technical knowledge (Adger et al., 1999).

Citizens' advisory groups are potentially the most direct mechanism for citizens' involvement at the local level (Abel, 2000). Local residents increasingly perceive themselves as 'stakeholders' in the municipal debate about what is socially desirable and acceptable for their communities; they find that governments, the definitive stakeholders which score high on legitimacy and power, are clearly not doing an effective management job by scoring low on the urgency of an issue (Eythórson, 2003; McDuff, 2001). Numerous studies have confirmed the longing by individuals and groups to have both a voice in, and a closer scrutiny of municipal decision-making, especially the environmental policy process (Benest, 1998; Frewer, 1999; Margerum, 1999; Smith, 1998; Abel et al., 2000; Sweeney, 2001). Case studies, where participatory approaches have been applied successfully, are also numerous (Byron et al., 2002; de Loe et al., 2002). Benest (1998) feels citizen involvement should be enlisted to advantage in financial decision-making (Beierle et al., 2001; O'Neill et al., 2000; O'Neill, 2001).

The very concept of stakeholder is poorly defined. It is often restricted to organized interest groups. Citizens are latent stakeholders (Eythórson, 2003). Contrary to the definitive stakeholders, they score low on legitimacy and power but do better on pushing forward the urgency of an issue (Mikalsen et al., 2001; Mitchell, 1997).

However, Abel et al. (2000) have shown that, for the US, greater opportunities for participation at the local level do not translate necessarily in greater participation of those who did not participate in the past. In any event, in post-Walkerton Ontario public scrutiny and questioning of local and provincial decision-making have increased manifold (O'Connor, 2002).

For rural municipal governments, demands for greater participation present considerable challenge. The scope of these demands has broadened to encompass not only public resources such as infrastructure, health and schools, fish and wildlife habitat, groundwater, wetlands and hazardous areas, but also private resources such as croplands, livestock and woodlots.

A few municipalities and two CAs (South Nation and Rideau Valley) have established Communications Committees and all but one Eastern Ontario municipality now have developed and maintain an active website. P&R has received federal grants from Industry Canada for the development of an important GIS database, which has the potential of increasing municipal capacity to improve land-use decision-making county-wide. Since land-use patterns impact on water resources, a GIS database also has benefits for improved water management. This type of community - based initiative is presently being undertaken with considerable success in a number of places (Kellog, 1999). The Upper Tier project, called *Prescott and Russell à la carte*, has necessitated the hiring of specialized staff but has also expanded the scope for educational and community-involvement by making use of high-school student volunteer talents and by initiating projects with a number of benefits: 1) that students gain insight into the relationship between land-use, planning and resource protection, and 2) that staff gathers and provides the data, but does not have to do the time-consuming task of data entry; and 3) that keeps people informed on issues that impact on the environment and quality of life at a regional scale.

4.2. INNOVATIVE WATER-RELATED INSTITUTIONS AND ADAPTATION MEASURES: COUNTY/MUNICIPALITY COUNCIL COMMITTEES

Municipalities rely on higher levels of government in the public sector for material and knowledge support (county, province, federal government). This support may come at a cost in terms of loss of autonomy and indifference to local circumstances. Therefore, municipalities rely on the private sector as well, especially consultants and business, for advice and special services. However, the latter are for profit and may substitute their interest to the one of the citizenry. There is a third sector of society, which is not-for-profit and often made up of volunteers able to assist elected councils with professional expertise. Social learning occurs not only through becoming a latent stakeholder but also by evolving into an expectant stakeholder who stands somewhat in between definitive stakeholders, i.e. those with sectoral responsibility: municipal staff, provincial civil servants, insurance companies who can be expected to take a jurisdictional or legal responsibility in climate change

adaptation, and the citizenry, i.e. the latent stakeholders (Eythórson, 2003; Mikalsen et al., 2001).

The establishment of municipal committees, commissions, boards and advisory committees is one of the means whereby these three sectors (public, private and civil society) can and do come together and provide input to the municipal decision-making process, which is subject to two important constraints. One is the requirement to provide services deemed essential. Therefore, a majority of municipalities have Public Works, Roads or Transportation Committees, Protection to People, Property and Emergency Measures Committees that include fire, police, lighting and signage and the drafting of emergency plans and, of course, Community Economic Development. The second is the need to provide communication and collaboration among various jurisdictional levels. For example, both larger and smaller municipalities can experience specific problems such as low-income housing requirements, brownfield areas for development, or lagoons at capacity (preventing further development) that require collaboration among and commitment by various jurisdictional levels (municipal, county, province) and community at large.

Another type of committee is less driven by the essential services constraint than by the desire of the municipality to develop or protect those aspects or characteristics that residents feel important within their particular cultural or physical setting (e.g., environment). This latter type allows the municipal administration much more flexibility in drafting the objectives and composition of the committee. These committee initiatives are ideal venues for the introduction of steps towards the development of climate change impacts and adaptation county/municipal strategies.

5. A Municipal Adaptation Strategy for Climate Change in Eastern Ontario

5.1 A CLIMATE CHANGE STRATEGY²⁴

Climate change adaptation needs to be a new municipal concern motivated by cost-effectiveness. Planned adaptation is likely to be less expensive than reactive adaptation to climate events similar to the 1998 ice storm, the 2001 and 2002 droughts, and possibly the Walkerton crisis, which are expected to become more frequent and more intense. Early adoption of cost-effective measures – a measure is a combination of a policy and an action (e.g. volumetric water pricing and water meter installation) – regional cooperation, cooperation with the Province, with municipal organizations and the insurance industry should be encouraged.

Small Eastern Ontario rural municipalities and CAs need to progressively develop an integrated strategy for adaptation to climate change. This strategy should be integrated with both their planning and operations. It should be elaborated, preferably, at the regional/watershed level and in collaboration with municipal

organizations such as the Federation of Canadian Municipalities (FCM), the Association of Municipalities of Ontario (AMO), other professional organizations and the provincial government. EOWRC, CAs, Municipal Committees, and the Health Unit should all be given leading roles in formulating the Strategy. Existing venues for regional cooperation, such as EOWRC, should be supported and reinforced. The Eastern Ontario Health Unit (EOHU) needs to take a leading role in epidemiological surveillance and monitoring, communication strategies for the public and, in cooperation with municipalities in emergency plans. The Province needs to reform long-term financing of water-related infrastructure. It needs to maintain a precautionary approach to the granting and renewal of Permits-To-Take-Water, define infrastructure standards possibly in collaboration with the Federal Government and FCM, and declare climate change a 'provincial interest', paving the way for provincial climate change - related conditional grants to municipalities.

To be able to develop an adaptation strategy, municipalities and CAs should ensure that they have access to credible climate change expertise that universities and higher levels of government can provide. The possession of information is central to power and planning and thus to local government. On the basis of this expertise, municipal and CAs' senior staff should conduct, in collaboration with NGOs, the insurance industry, and the public, an environmental and financial vulnerability assessment of their water-related infrastructure; staff should identify vulnerability alleviation measures and business opportunities (e.g. in agriculture) as well. Co-operation between the insurance industry and municipalities is needed to assess risk-reducing adaptive measures taken by municipalities. A socio-economic climate change scenario analysis is also needed to assess the potential burden of financial risk to municipalities.

GIS-based hazard - mapping for all infrastructures, including water-related ones, is likely to be an indispensable tool for this vulnerability identification and alleviation exercise. The strategy should include best practice mechanisms, including for monitoring and evaluation whereby adaptation progress can be assessed and cost-saving adaptation measures, promptly implemented; formal levels of accountability, a regional governance structure, and emergency response plans need also to be developed. The strategy should be feasible, transparent, supported by the community and championed.

Because insurance companies have incurred huge losses from weather-related events in the last decade, it may be extremely difficult for municipalities to become insured commercially against climate-related risks, other than residual risks (which, being surprise events, should be covered by federal or provincial disaster funds in any case). Direct access to reciprocal insurance (e.g. OMEX) related to climate events across the country and emergency lines of credit may be substitutes to private sector insurance.

To develop their own adaptive measures municipalities need to have plenty of valuable information at their disposal and to diffuse this information. If the benefits or advantages of a local institution's adaptive actions are perceived to be

minute or inconsequential by its members and the public, the local institution will not undertake costly action. This is why stakeholders' participation in developing adaptive measures is so important.

Stakeholders should be involved in each component of a climate change adaptive policy for three primary reasons. First, they may possess valuable information, which will assist in refining the design and implementation of adaptation measures. Second, such involvement will enhance the prospects for consensus and consent thereby promoting compliance. And, third, ongoing participation is desirable in order to increase understanding of the significance of Climate Change. Therefore, people's participation in local government is essential to allow them to adapt their own living environment to change (Pelling, 1998). General benefits of stakeholders' participation are: decreased likelihood of litigation, overall planning time, unforeseen costs, and better acceptance of distributional issues if the process is perceived as fair (Abel, 2000).

It was found out in this study that municipalities tend to rely on the Province for information while CAs tend to rely more on local knowledge networks. Newspapers are a significant source of information. Clearly, university expertise is underutilized. An innovative partnership between university experts and local newspapers could contribute to the dissemination of relevant and valuable information to the community. A partnership among universities with CAs and with municipalities through their municipal committees may affect water policy.

The best way to diffuse this information internally within local government is to demonstrate for each professional group (councillors, planners, treasurers, engineers, etc.) how climate change vulnerability affects day-to-day municipal operations and how the implementation of concrete responses might alleviate adverse or uncertain consequences. This could also be done through low risk demonstration projects.

Access to information and expertise by constituents shapes people's relationships with hazardous environments. Vulnerable people or communities face events beyond their control and sometimes, beyond their comprehension (Adger et al., 2000, p.165). Therefore, information regarding the spatio - temporal scale of the hazard is required to assess the magnitude of vulnerability. Information, even if it is accurate, will not be used unless it is available to relevant constituencies, is found to be valuable from their own perspective, and applicable in practical ways.

The diffusion of valuable information still requires looking for windows of opportunity or framing issues (e.g. Emergency Preparedness) to ensure its availability. Framing issues are not entirely determined by the objective characteristics of the relevant environmental problem. Framing issues are supplied by organizational mandates, the interests of key actors, and by policy initiatives which have a high chance to get stakeholders' support and to which climate change issues may be tied in a synergistic fashion (Young, 2002). They also serve as conduits for perceptions of vulnerability.

On the other hand, current measures for adapting to uncertain long-term impacts are of a precautionary nature and should be robust, i.e. provide benefits no matter which climate scenario materializes (Adger et al., 1999).

The best combination of measures is as good as the policy capacity of the local institution whether municipality or CA. The latter can benefit from the dissemination of information by professional organizations or senior governments about the initiatives and behavior of other local institutions (peer pressure); this disseminated information may then become a standard.

Since mitigation and adaptation cannot generally be dissociated, lessons learned from community mitigation initiatives are relevant for community adaptation. Key lessons from the implementation of FCM voluntary mitigation programs, which allow municipalities to become aware of and to reduce their Greenhouse Gas emissions, are adaptable to municipalities' efforts towards climate change adaptation (FCM, 2002). Mitigation measures will soon be required from municipalities by the Federal Government. Though discretionary, these measures are likely to affect energy efficiency (buildings) and solid waste management (methane emissions). Similarly, climate change adaptation experience by private firms is adaptable to municipalities (CERES 2002, 2003).

5.2. ADAPTIVE MEASURES FOR INFRASTRUCTURES

5.2.1. *Infrastructure Design*

The National Guide to Sustainable Municipal Infrastructure is designed to help municipalities to better manage infrastructure. It is the product of a joined collaboration among Infrastructure Canada (IC), the National Research Council (NRC), and the Federation of Canadian Municipalities (FCM).²⁵ The guide gathers the best and most sustainable practices for the planning, design and delivering of drinking water, sewer and stormwater systems, roads and transit. However, it does not address climate change concerns! Municipalities can also find out about management best practices at the Ontario Centre for Municipal Best Practices (OCMBP).²⁶ The Centre was founded in 2002 by the Association of Municipalities of Ontario (AMO), other municipal associations, and the Ontario Ministry of Municipal Affairs (OMMA). OCMBP identifies municipalities' best practices but does not reward them.

5.2.2. *Water Infrastructure Design and Related Measures*

EOWRC and CAs should take the lead in stormwater management, groundwater protection, monitoring for both quantity and quality at locations of high groundwater sensitivity and surface water – groundwater interactions, in relevant data gathering, and in supply-demand projections based on best practices. The level of public education and of well and septic system inspections need to be increased.

Service standards and due diligence for water-related infrastructure under climate change need to be determined in cooperation with the Province. Attention

should be devoted to the appropriate mix of measures, including best practices, water efficiency measures such as metering, Permits-To-Take-Water and volumetric tariffs

The EOWRMS report (CH2M HILL, 2001) indicated that much of the water and wastewater built infrastructure in the region requires upgrading and is in need of capacity increase to face demographic pressures especially in the North - West part of the region. Therefore, it is essential that climate change be taken into consideration in the renewal and expansion of these infrastructures, including the reduction (up to 15%) of water losses in the distribution system. The need for infrastructure expansion (up to 40%) and the required funding can be significantly dampened through volumetric (or full-cost) demand management. Water consuming efficient devices, such as low-flow home devices, may reduce water demand as well (up to an additional 10%). Wastewater recycling is another conservation measure for agricultural land and golf courses. Permits-to-Take Water, new applicants as well as nearly expired ones, require especial attention; they should be considered revenue generating and managed on a precautionary basis. In time of water scarcity, water - rationing measures, imposed or advocated by the municipality or CAs, may be required and have been used in the area. Major water users, such as golf courses, may benefit from some voluntary water conservation certification programs.

6. Conclusion: Adaptive Capacity of Eastern Ontario Small Rural Municipalities and Conservation Authorities

Factors (identified by Yohe et al., 2002) affecting the adaptive capacity of a local community were listed in the Introduction of the paper. Except for financial barriers, a municipality in Canada has access to all available technological options for climate change adaptation. However, it may not know which technology is most appropriate for relevant climate infrastructure impacts and there is little available expertise on these issues. Municipalities in Ontario, as they are elsewhere in Canada, are cash-strapped because of the mismatch between their responsibilities and their revenues. Income and, generally, resources distribution inequalities within the population, a determinant of vulnerability, is not a municipal responsibility but rather a provincial one. Some critical institutions for adaptation to climate change are underfunded and under-utilized. This is the case for CAs. There seems to be a strong community spirit in Eastern Ontario, especially in the environmental area. Municipalities have access to reciprocal insurance, which, given the size and differentiated ecosystems of the province, are able to redistribute the climate risks. The ability of decision-makers to manage credible information in the area of climate change is unknown, except for the Eastern Ontario Health Unit (EOHU) which is likely to rank high on this score, and the decision-makers' own credibility is unknown as well. The public's perception of the source of the impacts of climate change and

the significance of exposure to their local manifestations is likely to be poor; this seems to be confirmed by a recently conducted survey in Canada (Greenway, 2005, p. A10).²⁷

While there are no generalized water quantity problems expected for our area of study, there are definitely localized problems and water quality ones which result mainly from agricultural activities over which municipalities and EOHU have almost no jurisdiction. The projected installation of two hog farms and of an ethanol production plant in the area may have significant impacts on groundwater quality (see section 2.2 *supra*). The human infrastructure offers vulnerabilities in terms of age-structure of the population and income in some areas. Lack of expertise as related to climate change and its impact on built infrastructure is also significant. No persistent drought is expected; agricultural productivity may actually increase for cash crops (corn, soybeans; see section 3). There is no reason to believe that local adaptive capacity to climate change would be lacking in Eastern Ontario. What is required now is to spread climate change awareness to the public at large and to translate this awareness into a climate adaptation strategy at the municipal and regional level. EOWRMS has provided recommendations with respect to some water infrastructures independently from climate change. Many of these recommendations go a long way towards adaptation to climate change. Therefore, our adaptation strategy aims at synergy with EOWRMS' recommendations and their implementation through EOWRC. The Province is offering a potential framing issue with Watershed Source Water Protection (Government of Ontario, 2003).

Under adaptation of water resources infrastructures, all those who directly benefit from adaptation should pay for the adaptation service according to the benefits-received model of public finance. For some other adaptation benefits such as emergency services, it will sometimes be difficult to identify who benefits from the service; therefore, the service should be funded under municipal general revenue. Inter - municipal agreements are difficult to administer especially for public goods and lead to discontent when they are not limited to upper-tier municipalities (Kitchen, 2003).

Climate adaptation is likely to generate regional spillovers in terms of water quantity and quality management, which may not extend to the Province of Ontario as a whole, but may extend to portions of the Great -Lakes Basin, Eastern Ontario for example. Adaptation is more of the nature of a local public good than of a common property resource. Therefore, an institution like EOWRC, as a policy network on water-related infrastructure issues, should extend its scope to the whole Eastern Ontario region. Cooperation among local municipalities and CAs on a reciprocity basis is of the essence (Keohane et al., 1995). This is what the Ontario 'Municipal Act 2001' is supposed to encourage (see sub-section 2.3.1). However, unlike in international regimes, the Province remains a hierarchical authority, which may block or facilitate the process.

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Notes

¹We adopt here Young's distinction between institution, as 'rules in use' and organization, as a material entity (e.g. Young, 2002, p. 4–5).

²The St. Lawrence River Institute of Environmental Science (SLRIES)

³The other EOWRMS partners were the federal Agriculture and Agri-Food Canada department (provider of the Geographic Information System data), the Ontario Ministry of the Environment (MOE; the major funder of the study), and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)(CH2M HILL, 2001, p. 1–1).

⁴In local public finance this is called the "disentanglement" problem, i.e. determining the functions of each level of government (Kitchen, 2002).

⁵Vulnerability means to be prone to or susceptible to damage or injury (Blaikie et al., 1994, p.9; see also Kaspersen et al., 2001) but is not a natural state; it is a social construct (Adger et al., 1999; 2000; 2001).

⁶This is called hysteresis.

⁷<http://kn.fcm.ca>.

⁸Detailed natural science and engineering results may be found in Crabbé et al., *Final Report*, 2004.

⁹This section is also based on work by M. Ait-Ouyahia, R. Alam, I. Aurelson, J. Benidickson, D. Burhoe, D. Lagarec, and M. Woodrow.

¹⁰The high erosion impact of corn and soybean was pointed out to us by a reviewer.

¹¹The question was whether municipalities have the right to issue by-laws banishing the use of pesticides.

¹²http://www.ene.gov.on.ca/envision/env_11_reg/ebr/english/

¹³http://www.mnr.gov.on.ca/mnr/water/publications/OLWR_11_2002.pdf

¹⁴<http://www.creekwebsite.org/NewsItems/year2003/news03035.htm>

¹⁵<http://www.conservation-ontario.on.ca>

¹⁶Community Stewardship Councils, created by MNR may fulfill functions similar to CAs but at the landscape level. However, they operate on private lands without legislative authority but rather through shared interest, partnership and teamwork and must respect the decision-making rights of landowners.

¹⁷This section is also based on work done by D. Carberry, B. Daneshfar, R. Droste, K. Gajewski, D. Lean, N. Lemay, R. Narbaitz, G. Parker, V. Paris, and F. Pick.

¹⁸Details can be found in its Final Report (Crabbé et al., 2004).

¹⁹A reviewer has pointed out to us an unpublished article by K. Adamowski et al., which documents this point for Ontario and for the St. Lawrence region. Our scenarios focused on unusual but not extreme scenarios while Adamowski et al. focus on extreme scenarios. Only one recording station on which precipitation data were collected is relevant for our area and, actually, located at its extreme west (Kingston). For duration of precipitations, the trend in Kingston is one of the lowest in Ontario. This seems to agree with the absence of trend found by Zhang et al. (2001) for the fraction of annual precipitation falling in the largest 10 th percentile of daily events (except for Spring) in Eastern Canada. In a published paper (2003), Adamowski et al. found significantly negative regional trends and large ones for the St Lawrence region. The St Lawrence region contained the following stations: Ottawa Airport, Ottawa CDA, Kemptville, Picton, Kingston, and Trenton. The region was homogeneous (based on L-moments) and all stations had generally a negative trend (for most of the storm durations). This seems to indicate that the record for Eastern Ontario heavy precipitation events is far from conclusive. An Environment Canada (Ontario Region) representative was contacted as well and confirmed that regional precipitation trends are very difficult to obtain as local climatic factors affecting individual stations are very significant.

²⁰See maps in section 4.1 of the *Final Report* (Crabbé et al., 2004)

²¹A reviewer has pointed out to us that increases in annual extreme precipitation events, discussed in footnote 19, already have an impact on erosion rates and transport of nutrients and toxic contaminants of waterways and, moreover, that corn and soybeans are crops which normally lead to high erosion rates.

²²This section is also based on the work of I. Aurelson, D. Burhoe and R. Needham.

²³It is interesting to note that similar internal barriers occur within Norwegian municipalities (L.O. Naess et al., 2003).

²⁴This section summarizes thirty-six recommendations which were made by this study to various governance bodies. detailed recommendations are available in the *Final Report* (Crabbé et al., 2004)

²⁵<http://www.infraguide.ca>

²⁶<http://municipalbestpractices.ca/home.asp>

²⁷The survey was taken across the country during a summer heat wave both in 2001 and 2005 asking whether the heat was part of a trend towards increased global warming. A slight majority of respondents replied affirmatively in both years with significant regional and gender differences in 2005 over 60% of British-Columbia and Québec residents and women answered affirmatively while residents of Prairie provinces were barely affirmative.

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