



C-CIARN Quebec

State-of-Play Report

2006-2007



C-CIARN Quebec – State-of-Play Report

*The Status of Climate Change Impacts and Adaptation
from the Perspective of C-CIARN – Quebec*

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Preface

In the last year of C-CIARN's mandate (July 2006-June 2007), each C-CIARN office was asked to write a report summarizing their perspectives on the state of climate change impacts and adaptation within their region or sector.

The resulting State-of-Play reports identify, from the point-of-view of C-CIARN, the key climate change impacts, as well as the key stakeholders and adaptation decision-makers (including how these stakeholders/decision-makers were most successfully engaged) of each representative region and sector of Canada. The reports also include a description of the important research questions which, from the perspective of C-CIARN, need to be answered, as well as the steps that need to be taken to both increase the level of engagement on the issue and to facilitate the decision-making that is needed to reduce vulnerability, across Canada, to the impacts of climate change.

It is anticipated that the State-of-Play reports will serve as a valuable point of reference for climate change impacts and adaptation initiatives carried out across Canada, post-C-CIARN.

1. Introduction

The mandate of C-CIARN is to promote and facilitate the development of new climate change knowledge by bringing together researchers, users and decision-makers from industry, governments and NGOs to address the issue of climate change impacts and adaptation.

By joining Ouranos in 2001, C-CIARN Québec has been able to promote communications and ensure effective networking. Numerous brainstorming sessions have been held to bring users and decision-makers together around a specific climate change impact and adaptation issue in Quebec. We have participated in most conferences/congresses of interest in our region, presenting scientific, technical and, occasionally, non-technical information. Various media interviews have also provided opportunities for information dissemination and outreach on various topical issues. A web site was developed and is receiving growing traffic, and a newsletter is sent out to the more than 1,000 contacts that have been added to our distribution list over more than a year. Regular scientific workshops are also held.

It is also important to underscore the ability of Ouranos to initiate numerous projects and collaborations with users/technicians, decision-makers and politicians. Today, Ouranos plays a lead role in the development of knowledge promoting the implementation of climate change adaptation strategies.

In concrete terms, our activities have enabled us to more effectively structure and organize research and development activities that address the priority needs of a wide range of users, to introduce the concept of adaptation, and to engage in outreach activities to disseminate information and uncertainties regarding climate change impacts.

It is important to point out that Ouranos shares the objectives of C-CIARN outlined above, and that, given its financial, human and logistical resources, capacity and credibility, it is in a position to address the issue in a particularly effective and integrated manner. Although this report is focused primarily on C-CIARN Québec, it is difficult to truly separate C-CIARN from Ouranos, in the sense that the two are complementary. Ouranos is responsible for drafting the Quebec chapter of the national climate change impacts and adaptation assessment, which will be released in 2007. This report will be revised on the basis of that assessment.

2. Key Climate Change Impacts in Quebec

The province of Quebec lies between latitudes 45° and 62° north (roughly 2,000 km) and longitudes 57° and 79° west (roughly 1,500 km), for a total area of 1,700,000 km². Given its large size, the impacts of climate change will affect the various regions of the province differently. Quebec has been affected by a number of climate change impacts. The purpose of the following paragraphs is to describe a number of the impacts being felt in Quebec, namely the melting of the permafrost in the Quebec Arctic, the hydrology of the major hydroelectric reservoirs, coastal erosion in maritime zones, infrastructure problems in cities (urban drainage, critical infrastructure) and health. Of course, other impacts are also being felt in Quebec, but those described below may be considered representative of the current situation. While the impacts in several areas, such as forestry, ecosystems and agriculture, are less well documented, that is not to say that they do not exist—on the contrary. Details in this regard will be available in the Quebec chapter of the national assessment.

Quebec Arctic and permafrost melting



In the 20th century, the climate warmed more quickly in the Quebec Arctic than in the rest of the province. Starting in 1992, temperatures increased very quickly in Nunavik. In Kuujuaq, for example, the mean annual temperature has increased from around -7°C in the early 1990s to about -4°C since 2002. In Salluit, temperatures rose from about -9°C in 1990 to -5.7°C in 2005. (Bégin, 2006). It is inevitable that heat transfer in the soil resulting from climate warming will cause partial or total melting of the permafrost (depending on the actual extent of warming) in Nunavik in the 21st century (Lawrence and Slater, 2005). Today, the Inuit are reporting significant changes and even experienced hunters admit they are having difficulty anticipating weather conditions and the state of snow or the ocean during their hunting trips on snowmobile or in canoe.

A number of major weather events have occurred in recent years, such as the major avalanche in Kangiqsuaq in 1999, which killed nine and injured 25 (Emergency Preparedness Canada, 2006). In Tasiujaq (Ungava Bay), permafrost melting resulted in the settling of a building and the deformation of the local airport runway (Allard et al., 2003). Such events not only cause high levels of insecurity among a community that is largely dependent on air transportation for food supplies and medical evacuations to large hospitals, but they also pose a threat to human lives.

Critical infrastructure

In terms of impacts, the level of risk varies considerably from one community to another, depending on its geomorphology and climate. To date, the planning of urban

growth has taken the nature of the terrain in each community into account. Moreover, most major buildings, such as schools and hospitals, and most houses are built on pilings or trestles that allow air to circulate under them, thereby maintaining the soil at temperatures approaching those of the air (Fortier and Allard, 2003). Some major infrastructure, such as airports and roads, has had to be partially or completely built on sensitive land. In areas where the soil is comprised of unconsolidated, ice-containing deposits, permafrost melting has caused soil settlement and deformation that could damage existing infrastructure. This is true of the integrity and security of airport runways, which are a source of concern for the Quebec Department of Transportation, which is responsible for the management of airports and access roads of 13 of the 14 villages. Permafrost melting in several areas under these structures has already caused settling, cracks and other signs of deterioration on several airport runways and roads between the villages. To date, regular maintenance has been sufficient to ensure their safety, but the frequency of repairs and associated costs are increasing. Runway monitoring systems (thermal profile, settling and climatic conditions) have been put in place and studies are under way to monitor the problem (Beaulac and Doré, 2005).

Local transportation and access to resources

The two main modes of transportation used by the hunters and gatherers of Nunavik are boats in summer and snowmobiles in winter. Travel and access to resources play a critical role in ensuring continuous food supplies and maintaining

social cohesion, which are essential to the survival of a culture recently threatened by an increasingly sedentary lifestyle (Lafortune and Furgal, 2005). Climate warming over the last 15 years has been so rapid that the traditional Inuit knowledge is sometimes less reliable for anticipating weather events, such as storms and ice conditions. Many accidents are reported, sometimes involving very experienced individuals.

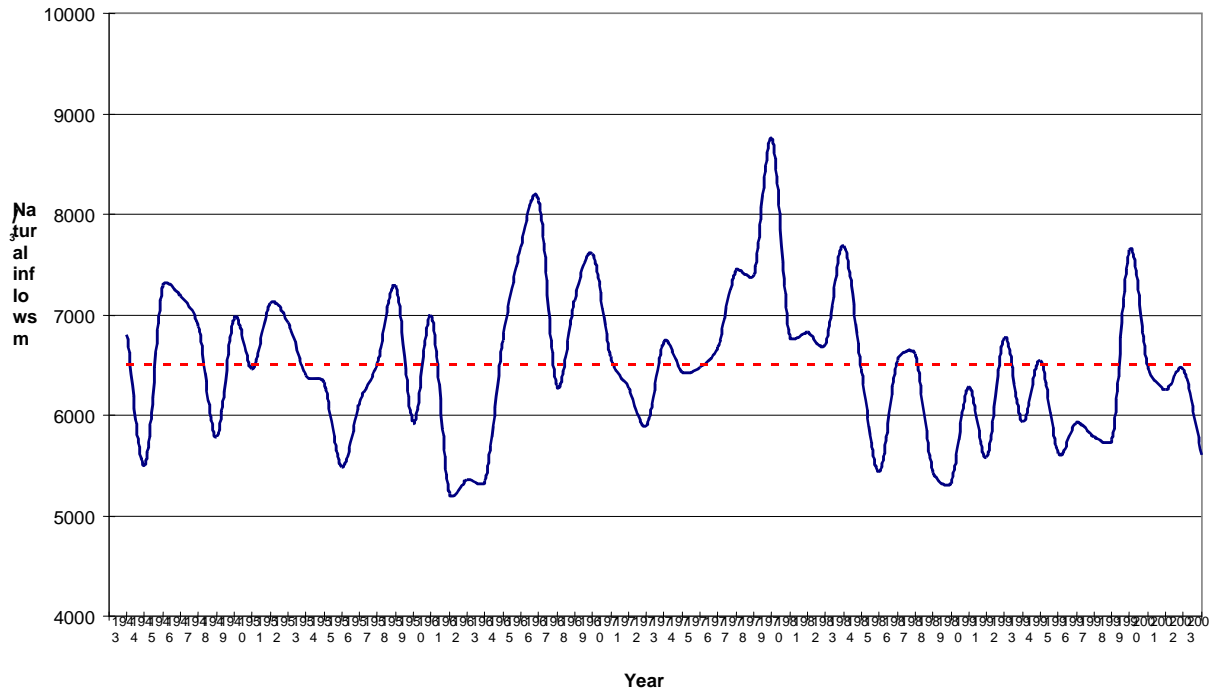
Permafrost melting, a direct impact of climate warming, gives rise to many problems that the Government of Quebec has had to manage and will continue to have to manage in the near future. Although the population totals only a few thousand, the underlying political, economic and cultural implications are considerable and cannot be ignored.

Hydrology of major hydroelectric watersheds of Quebec

In Quebec, hydroelectric power plants generate close to 94% of all electricity produced in the province (MRNF, 2006). In northern Quebec (including Churchill Falls), 95% of the installed capacity is derived from storage power plants (power stations with reservoir), whereas in southern Quebec, 95% of the installed capacity is based on run-of-river power plants. Changes in the hydrological regime depend on both changes in the precipitation regime and variations in the thermal regime.

The time series of natural inflows north of the 49th parallel is characterized by very significant interannual variability and a period of relative deficit since 1985, as seen in the figure below.

Natural inflows to hydroelectric plants north of the 49th parallel



This relative deficit of inflows over the last 20 years, if it continues, raises concerns for the future. It is important to have an understanding of the issue before the impact of future climate projections can be considered with credibility.

The analysis of the outputs of a number of general circulation climate models suggests warmer temperatures and higher precipitation for Northern Quebec. The main impact of a rise in temperatures will be a decrease in solid precipitation and snow cover and an increase in the rate of evapotranspiration during the open-water period. In Northern Quebec, the increase in atmospheric water losses should be offset by a significant increase in precipitation. Despite the higher temperatures, however, the hydrological balance would be such that inflows into the reservoirs of Northern Quebec would increase. Of course, this prediction must be treated with caution given that it is derived from a climate model, the uncertainty of which has yet to be determined.

Maritime region: coastal erosion

The maritime region of Quebec includes the entire St. Lawrence estuary downstream from Quebec City and part of the Gulf of St. Lawrence, including the North Shore, Lower St. Lawrence, Gaspé Peninsula, Magdalen Islands and Anticosti Island regions. Approximately one-third of its population lives within 500 m of the banks of the St. Lawrence River. A large part of the infrastructure is affected by the climatic and hydrodynamic processes governing shoreline dynamics. Most of the coastal villages were built on the poorly

consolidated friable deposits along the shore. The value of the built heritage threatened by erosion over a 30-year horizon is estimated at approximately \$1 billion.

Coastal areas are generally highly vulnerable to climate change and the shores of the Gulf of St. Lawrence are no exception. One of the main causes of vulnerability is the rise in sea levels, which leads to increased erosion, higher risk of flooding and saline intrusion into the water table. These factors pose a threat to communities near the high water line (IPCC, 2001; Neumann, 2000; Zhang et al., 2004). Several other climate factors can affect erosion in the Gulf of St. Lawrence, including the decline in the period of freeze-up and ice cover (Bernatchez and Leblanc, 2000), the increase in cyclone activity (Forbes et al., 2004) and the increase in the frequency of freeze-thaw cycles. Ice can contribute to reducing shoreline erosion by mitigating wave action and forming a protective layer that stabilizes beaches and banks. Preliminary results of wave modelling using a coupled ocean-atmosphere climate model at the regional scale (Saucier et al., 2006) suggest a 50% reduction in sea ice by about 2050 and its virtual disappearance by the end of the 21st century. Beaches would therefore be exposed to both winter and fall storms. The data gathered by the expert committee on North Shore erosion (Dubois et al. 2006) show that erosion rates have increased significantly over the last 10 years, during which time ice cover in the Gulf, particularly on the North Shore, was well below average.



Problematic erosion areas on the North Shore and estuary of the Gulf of St. Lawrence

Evaluation of the vulnerability of coastal communities and infrastructure (roads, wharves, existing shoreline protection, etc.).

Although coastal erosion is a natural process that has always occurred in the maritime region of Quebec, the vulnerability of coastal communities has increased in recent decades. Climate change clearly plays a role; a number of the factors responsible for the increased vulnerability of communities are anthropogenic. For instance, since 1970, there has been a growing trend to build along river banks in response to the increased interest in coastal areas due to the growth of tourism and the availability of shoreline protection methods. However, the shoreline protection technologies used—primarily linear riprap protection and vertical walls (concrete, steel sheet pile, stone and timber cribs)—have not aged well and are causing significant residual environmental impacts. One of the most serious impacts is sand deficits in protected areas. Bank erosion accounts for a large proportion of the sand supply and is the main source of sand replacement on beaches and shores. On the North Shore, close to 40% of the active banks have been protected from erosion (Morneau, 2004) by riprap installed at the base of the bank. The cumulative impact of the riprap protection is a 50% reduction in the sand supply from

bank erosion, resulting in beach slumping and increased erosion of unprotected banks.

With respect to coastal areas in the Gulf of St. Lawrence, climate change has important economic, social and environmental implications for the communities of the maritime region and significantly increases their vulnerability. There are several reasons for this. First, these communities are already socio-economically vulnerable, as shown by demographic, employment, economic growth and other indicators. In addition, coastal communities are already seriously affected by coastal erosion; the issue of erosion is an ongoing topic of discussion and debate in the local broadcast, print and electronic media. Damage to coastal infrastructure caused by erosion and the associated costs and losses have increased rapidly in recent years and it is predicted that these costs will continue to increase quickly if nothing is done to correct the situation.

Urban environment: drainage infrastructure

Climate change could result in an increased frequency of extreme precipitation events. Where stormwater management is lacking, this could cause sewer back-ups, flooding and overflows. Existing infrastructure was sized on the basis of historical data

available at the time of its construction and is not necessarily capable of accommodating a significant increase in heavy rainfall. The design criteria are based on a level of risk considered economically and socially acceptable. In the event of an increase in the frequency of extreme precipitation, as suggested by climate change scenarios, there is reason to believe that the risk of flooding and sewer

In the summer of 2005, the City of Montreal was hit by a number of extreme precipitation events, causing several networks to overflow. On June 14, 2005, 40 mm of rain fell on Montreal in just two hours, resulting in the accumulation of close to 2 m of water in the L'Acadie Circle underpass.

Following the heavy rains, the City received 714 claims from residents and insurance companies. Three weeks later, on July 5, further flooding occurred and an additional 5,000 claims were received by the City's claims office (*Le Devoir*, August 15, 2005). Although the floods cannot be directly linked to climate change, they clearly illustrate the potential impacts of changes in precipitation.

Climate change and health: impacts of heat waves and the urban heat island effect

Higher temperatures, an increasing daily humidex in Montreal and Quebec City over the last 40 years, and more frequent and more intense heat waves pose significant health risks. In addition to these climate phenomena, there is the impact of the urban heat island effect (UHIE), which is caused by asphalt and other surface materials that

back-ups will increase and possibly reach an unacceptable level for existing facilities. In such a scenario, the risk of significant damage and the costs associated with such events will increase to a level beyond what had originally been predicted (or assumed) and will lead to a situation where the level of network service would be below what had been initially planned (Mailhot, 2003).



absorb heat and increase the surrounding air temperature by 0.5 to 5.6°C in urban centres (Oke, 1982).

Heat can cause a range of ailments, from severe weakness to impaired consciousness, heat syncope and heat stroke, which can be fatal (Besancenot, 2004). Heat can also aggravate chronic diseases, such as diabetes, respiratory failure and renal failure. Sunlight is also known to contribute to the formation of ground-level ozone in urban areas, which is harmful to human health.

Communities in southern Quebec are more vulnerable to the increased frequency of extreme heat stress events in their region, whereas communities in northern Quebec suffer more from the increased temperatures, since they are not acclimatized to them (Health Canada, 2004a). A number of scientific studies (DSP

de Montréal, 2004; Commission de la santé et de la sécurité du travail, 2004) have found that some people have increased vulnerability due to environmental (e.g., housing, work, access to cool premises) or personal (e.g., disease, handicaps, age) factors.

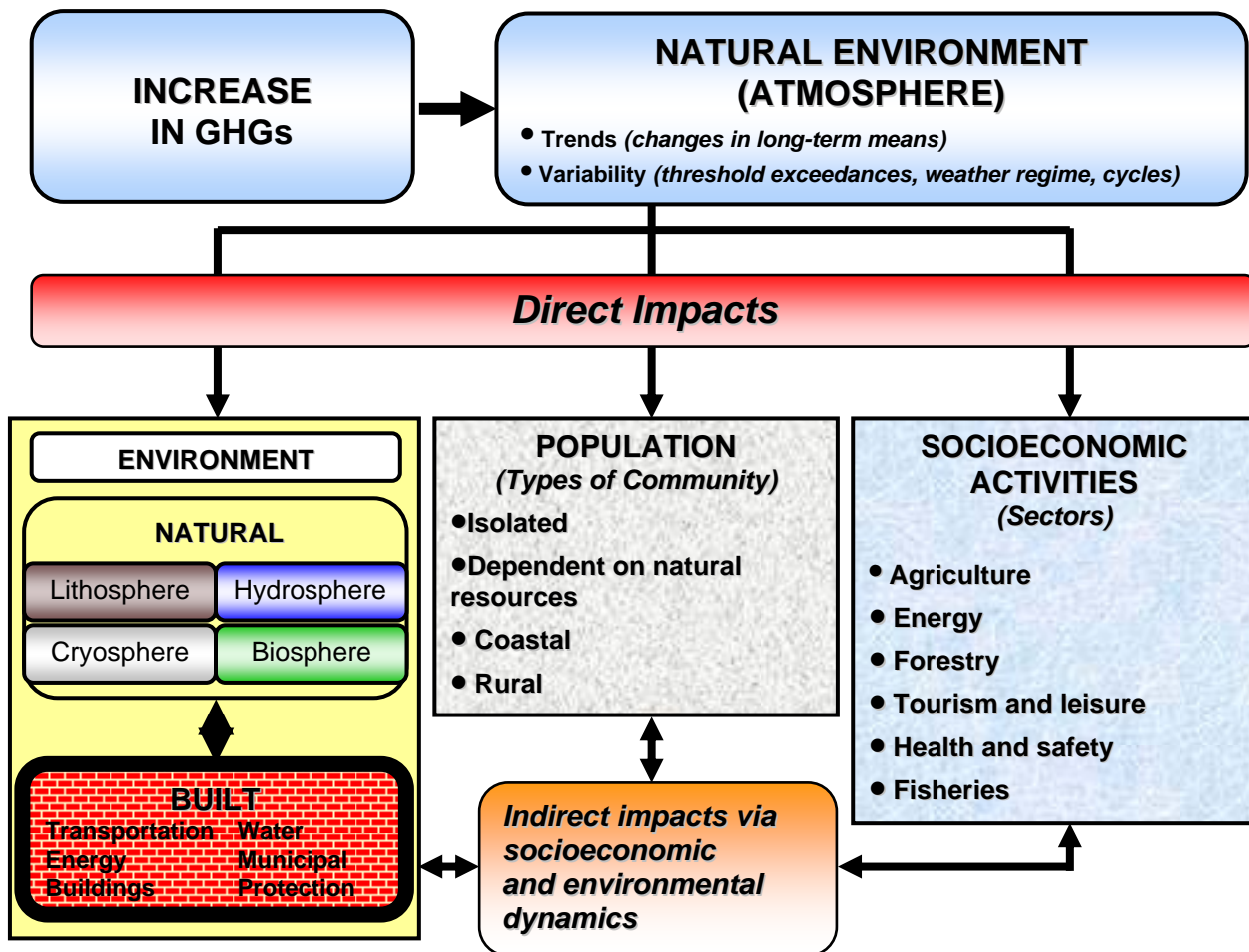
Health effects of air pollution

WHO recently suggested that global climate change could contribute to a warmer, wetter climate, leading to higher air concentrations of certain pollens and, as a result, to an increase in allergic disorders, such as allergic rhinitis and asthma (McMichael et al., 2003). Allergic rhinitis is a serious public health problem in industrialized countries. It adversely impacts the quality of life of affected populations, resulting in absenteeism and loss of productivity. The costs associated with medical consultations, hospitalization and medication are also very high (Garneau et al., 2005). For the Quebec City and Montreal regions, between 1994 and 2002, a link has been established between increased pollen concentrations and increased frequency of medical consultations for rhinitis. Allergic rhinitis due to pollen, to other allergens or to unspecified causes is the fifth most common (9.4%) health problem reported by the public (ISQ, 2000). The rate seems to have increased by 6% since 1987 (Garneau et al., 2005), but several external factors may also have contributed to the increase.

3. Key Stakeholders

It is important to distinguish between stakeholders responsible for the various policies that guide the decisions of others,

and those responsible for specific decisions (sector experts, such as engineers, agricultural producers, dam managers, etc.)



Direct and indirect impacts of climate, climate variability and climate extremes on three areas, i.e., the environment (natural or built), the population and socioeconomic activities, illustrating the significant sphere of influence of climate change impacts.

The following are the key stakeholders for the climate change impacts and adaptation in Quebec:

The various levels of government, since they make the rules and govern society; the following provincial departments can be mentioned for their role and influence on the environment, populations or socioeconomic activities:

- Sustainable Development, Environment and Parks (MDDEP);
- Public Security (MSP);
- Health and Social Services (MSSS);
- Natural Resources and Wildlife (MRNF);
- Municipal Affairs and the regions (MAMR);
- Transportation (MTQ);
- Agriculture, Fisheries and Food (MAPAQ);
- Economic Development, Innovation and Exports (MDEIE)
- Industry: hydro, forestry, pulp and paper, water, etc.
- Municipalities (City of Montreal, etc.) and regional authority (e.g., Kativik)
- Associations: Ordre des ingénieurs du Québec, Ordre des agronomes, etc.
- Communities and individuals (in that they are the ones who create the environment and society).

The influence of stakeholders depends essentially on their nature and role. For example, the public does not influence decisions in the same way as government does. It is difficult to give a specific answer to this question because every case is different.

As mentioned in the introduction, C-CIARN Québec and Ouranos are complementary. The key stakeholders generally have very good relations with Ouranos/C-CIARN Québec. The provincial departments cited above are members of Ouranos, as are Hydro-Québec and Environment Canada. Several other industries, municipalities and communities have been invited to and have participated in brainstorming sessions or small group meetings. Most have at least heard of Ouranos.

However, the number of stakeholders yet to be reached is still very high and their requests for information are increasingly demanding. In short, interest and needs are growing exponentially.

4. Strategies for Stakeholder Engagement

In our experience over the last five years, the most effective strategy for securing stakeholder engagement is to hold brainstorming sessions bringing together experts or persons involved around a given issue (permafrost melting, drinking water supply, human health, etc.) for a day. The individuals invited to the sessions must represent the sectors involved.

For example, it is important to have a balance of university researchers, departments, NGOs, etc. The sessions generally begin with one or two presentations on the issue, followed by discussions. They are often organized on the basis of the request for proposal schedules of funding bodies (Climate Change Action Fund (CCAF), Natural Science and Engineering Research Council (NSERC), Fonds québécois de la recherche sur la nature et les technologies, etc). The objective of each meeting is to lay the groundwork for a project, funded in part by CCAF (or other body) and in part by the other players around the table. These meetings often serve to facilitate linkages between researchers and/or organizations and there is no doubt that they have generated stakeholder interest and involvement.

Similarly, many of the presentations given by various organizations or at colloquia/conferences have also contributed to strengthening stakeholder involvement, through effective information dissemination efforts.

However, in our view, major conferences devoted to climate change tend to bring together the same people and are not conducive to a two-way dialogue.

In fact, the strategy is to reach stakeholders according to their preferences (flexibility). The best approach is therefore a combination of methods:

- One-on-one meetings
- Meetings in small groups
- Brainstorming sessions
- Breakfast/lunch/dinner conferences, annual congress
- Congress

Depending on the objective, the stakeholders involved are sometimes only users, sometimes users and researchers.

The meetings generating ideas and discussions must lead to concrete, feasible initiatives. New funding opportunities for projects relating to climate change impacts and adaptation would go a long way towards strengthening or at least maintaining stakeholder engagement. As mentioned above, in most cases, meetings between stakeholders were prompted by requests for proposals.

5. Engaged Stakeholders

The Government of Quebec has definitely taken a major step forward in terms of its involvement in climate change impacts and adaptation, as demonstrated by its involvement in the Ouranos Consortium. No fewer than eight provincial departments are directly involved in the consortium: Public Security; Sustainable Development,

Environment and Parks; Natural Resources and Wildlife; Municipal Affairs and Regions; Transportation; Agriculture, Fisheries and Food; Economic Development, Innovation and Exports; and Health and Social Services. Their involvement consists not only of financial support, but also of direct support via the contribution of employees.

In addition to the Quebec government's involvement in various projects of the Ouranos Consortium, its level of engagement in adaptation is reflected in its 2006-2012 Action Plan entitled Quebec and Climate Change: A Challenge for the Future (http://www.mddep.gouv.qc.ca/changement/plan_action/index.htm). Four of the report's 40 pages are devoted to adaptation. This is real progress, given that the 2000-2002 plan devoted only one short paragraph to the issue (<http://www.mrnfp.gouv.qc.ca/publications/climatiques/climat.pdf>). These measures are accompanied by appropriate funding that clearly reflects the government's commitment to action (announcement of \$1 million for adaptation measures related to forestry).

At a more operational level, the Quebec Department of Transportation (MTQ) recently issued two directives recommending an increase in flows for watersheds of 25 km² and less in the design of culverts:

For now, it appears that more frequent, short, heavy showers will be inevitable, whereas the phenomenon affecting the path of the storms is only speculation. Therefore, we recommend that flows be temporarily calculated in the conventional manner, and that flows for watersheds of

25 km² and less be assigned a weighting factor of 10% (factor of 1.1) to take account of climate changes.

Although precise figures are not yet available, this directive clearly shows the level of MTQ engagement and interest in the issue of climate change impacts. A number of MTQ representatives have attended many of the presentations and meetings at Ouranos or C-CIARN in recent years, which likely explains their level of awareness.

Although the stakeholders have different reasons for becoming aware of and engaged in the issue, it seems apparent that when a group begins to feel the impacts or become aware of the risks, their involvement comes about naturally.

For example, in addition to the influence of the Ouranos Consortium, following the heat wave in Europe in the summer of 2003 and its human impacts (over 14,000 deaths in France), the Department of Health and Social Services became fully aware of the potential risks of a similar heat wave in Quebec. After this extreme event occurred, the MSSS became a full member of Ouranos, and has developed a number of projects to assess its vulnerability and to find effective adaptation strategies.

Similarly, the City of Montreal took the opportunity of the 11th Conference of the Parties in November 2005 to become involved in the issue of climate change impacts and adaptation. A number of meetings were held at the offices of Ouranos, and relevant alliances were created (more specifically with the authorities responsible for the project on

urban drainage, already under way). A project under the direction of the City of Montreal is now being drafted and should be launched in the coming weeks.

5.1 Outstanding needs of engaged stakeholders

There are still a number of impediments to decision making related to climate change impacts. First, although there has always been a need for outreach and communication among key stakeholders, the individuals and organizations involved are in many cases looking for concrete, technical assistance, such as recommendations on adaptation scenarios connected to their reality. These impediments could also be minimized through better documentation of the certainties and uncertainties (climate scenarios, “no-regrets” adaptation measures) or through the development of tools to facilitate operationalization.

6. Unengaged stakeholders

A more systematic assessment/documentation of the relevance of the issue of climate change is needed to compel, or at least facilitate, engagement by interested stakeholders and decision making. In Quebec, although there is increased awareness of this issue among the various players, the ingredients for engaging stakeholders are as follows:

- Climate extremes generating the development of strategies/responses (short, medium and long term). For example, the two extreme weather events that occurred in Quebec in 1996

and 1998—the ice storm and Saguenay flooding—were major factors in the creation of the Ouranos Consortium. Similarly, the heat wave in Europe in the summer of 2003 caused many countries to take action. Quebec was no exception, with MSSS becoming an official member of Ouranos the following year;

- Realize that longer-term climate fluctuations are also important (St. Lawrence, reservoirs, erosion);
- Political will to take action and the emergence of some degree of leadership to address responsibilities;
- Scientific development (in Quebec and elsewhere) confirming the concerns.

In conclusion, stakeholders want to be approached by credible, concrete and well-connected organizations that have a genuine capacity to help them.

7. Unanswered Research Questions

There are many research questions that remain unanswered, particularly with respect to:

1. Cumulative, integrated and non-linear impacts (combination of stress factors and accumulation of effects over time);
2. Applicability and effective implementation of adaptation solutions;

3. Extent of future changes and introduction of uncertainty; and
4. How to perform good cost-benefit analyses.

It is also important to mention that a growing number of researchers are asking the following question: What is the risk of a potentially abrupt, highly non-linear climate change (e.g., thermohaline circulation, sudden climate changes)?

There will always be a need for outreach and communications in that some people are still skeptical about climate change. This can be largely explained by the fact that these individuals are not aware of the research on climate change but tend to change their minds quickly once they have access to the information. This no doubt accounts for the recent shift in the perception of climate change around the world.

8. Advancing the Impacts and Adaptation Issue

From the perspective of C-CIARN Quebec, other than more funding, the factors standing in the way of progress on the climate change impacts and adaptation issue in Canada are:

- the lack of clarity of federal government statements, policies and actions;
- the lack of means for all other players (financial, technical capabilities, expertise); and
- the impact of the media in conveying information to the public, e.g., tendency to present “both sides of the coin” with respect an issue when there is broad scientific consensus supporting one of the two sides. Similarly, the tendency to use a specific, spectacular event when talking about climate change, which inevitably places undue emphasis on uncertainties rather than presenting the facts that characterize long-term climate change.

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