



C-CIARN Atlantic

State-of-Play Report

2006-2007



C-CIARN Atlantic – State-of-Play Report

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

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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.

C-CIARN Atlantic Advisory Committee (past and present):

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1. Introduction

C-CIARN Atlantic is a dynamic, collaborative research network. Over the past five years, it has engaged groups and individuals from all sectors, many professions, and numerous academic disciplines to address knowledge related to climate change impacts and adaptation in Atlantic Canada. Its stakeholder-engagement activities have involved representatives from all levels of government, industry, small business, universities and colleges, and a wide variety of community and environmental groups. Scholars from both the natural and social sciences, elected officials, First-Nations leaders, informal community leaders, government bureaucrats, environmentalists, school teachers, and concerned citizens in the Atlantic region have all become increasingly engaged in the impacts and adaptation issues because of C-CIARN.

The C-CIARN Atlantic Regional Office at Dalhousie University's School for Resource and Environmental Studies was managed by Kyle McKenzie as Coordinator. Mr. McKenzie worked under the direction of Dr. Peter Duinker, with assistance first from Dr. Ulrike Lohmann, and later Dr. Martin Willison. In addition, many student research assistants contributed to the accomplishments of C-CIARN Atlantic.

Each year, efforts were made to increase the visibility of impacts and adaptation issues and encourage and promote impacts and adaptation research. Communication with members was achieved through a website, occasional e-mailings, public presentations,

one-on-one discussions, and distribution of printed materials. C-CIARN Atlantic continually worked with the Climate Change Public Education and Outreach Hubs in the Atlantic region to provide province-specific impact information to strengthen the Hubs' messages related to the need for mitigation. As well, efforts were made to engage Aboriginal communities by, for example, including First Nations representatives on the C-CIARN Atlantic Advisory Committee, and working closely with First Nations groups on issues of particular concern to their communities.

C-CIARN Atlantic organized numerous sessions in other organizations' meetings and research conferences and also held a number of workshops both on its own and in collaboration with other C-CIARN offices. The first two Atlantic Regional workshops focused on potential impacts on the region, and led to the development of key impact and research question lists. Subsequent workshops focused on adaptation for specific sectors and resulted in recommendations to funding agencies for specific research programs to address actual problems in the region. Training was also provided to region members on the topics of statistical downscaling of climate scenarios and risk-assessment approaches to adaptation. Also, over the past five years, C-CIARN has assisted numerous stakeholders from across the region to access funding for their individual adaptation and impact-related research initiatives. Considerable effort was expended helping stakeholders in identifying appropriate funding sources, improving upon preliminary project ideas when requested, and gathering

information needed for research funding proposals.

During the meetings, conferences, and workshops, and at other opportunities, the Coordinator and Advisory Committee members liaised with groups with related interests for the purposes of networking, promoting C-CIARN, and looking for opportunities to collaborate. Finally, with the information pulled from the workshops, a poster series was created to address six climate change themes, each available in English and French. The posters have been presented at sessions of various conferences and workshops throughout the region.

2. Key Climate Change Impacts on the Atlantic Region

Many forecasted climate change impacts will play out similarly in communities and ecosystems across Canada. However, Atlantic Canada has characteristics that make it particularly susceptible to climate change impacts: extensive coastal zones; exposure to extreme weather events; vulnerable communities and infrastructure; and many resource-dependent communities. Although there are many other issues of concern, the following discussion focuses on impacts related to these four major categories.

2.1 Coastal zones: sea-level rise, flooding, erosion and marine storms

Given its geography and historical settlement pattern, much of Atlantic Canada is exposed to the ocean. Sea-level rise, coastal flooding, coastal erosion, and marine storms are already posing threats to the region's many coastal communities, infrastructure, and natural

features. A changing climate is expected exacerbate all of these threats.

Atlantic Canada has the longest length of coastline sensitive to sea-level rise in Canada¹; approximately 80% of the Atlantic Region's coast is considered to be moderately to highly sensitive. The Maritime Provinces are considered to be especially sensitive, while Newfoundland and Labrador are less so. Topographic relief, local geology, isostatic subsidence, and the type of coastal landform are key factors in determining coastal sensitivity to flooding and erosion. In Atlantic Canada, this sensitivity results from isostatic subsidence, low-lying coastal plains, and highly erodible shorelines. In fact, even a 10-cm sea-level rise could seriously impact many aspects of life in Atlantic Canada.

Much of the land in Atlantic Canada (all but Northern Labrador) is currently undergoing tectonic subsidence (lowering), as a response to the post-glacial uplift that took place for much of the last 10 000 years. This results in a relative sea-level rise of 20-30 cm per century throughout much of the region. As a result, coastal communities, infrastructure, freshwater reservoirs, cultural and archaeological resources, and sensitive and rare ecosystems are already suffering from ocean inundation. Using computer-based models, scientists predict an increase in global mean sea-level of 9-88 cm by 2100 due to human-induced climate change². Adding an approximate average of 50 cm to the 20-30 cm per century already happening leads to a situation where much of the coastline of Atlantic Canada could be inundated with 70-80 cm of higher sea-level by the end of the 21st century.

As water levels rise, one obvious hazard and impact will be flooding in coastal areas, both from inflowing ocean water and outflowing river

water. Storm surges already put low-lying coastal areas at risk of flooding. Combined with sea-level rise, storm surges may result in additional significant damage to the environment and infrastructure along the coast. They could result in the overflowing of dykes and the flooding of vast areas of productive agricultural land in the upper Bay of Fundy. Many of these dyked areas are already well below high-tide level because of tectonic subsidence and any flooding will go far inland. Additionally, the dykes will hold the salt water in place once the tide and storm surge subside, resulting in additional salinization of fertile soil and requiring extensive pumping and draining.

As water levels rise, and increased flooding occurs, coastal communities may possibly find their water supplies contaminated as salt water begins to move inland. In some areas, salt-water intrusion into freshwater aquifers is happening today. Climate change will only increase these occurrences.

Another effect of higher sea-level is accelerated coastal erosion. As protective ice in the winters becomes scarce due to temperature increases from climate change, erosion may be as high as twice present rates. An area at particular risk of losing sea ice is the Gulf of St. Lawrence, where the Canadian climate model predicts no sea ice after 2050.

Decreases in protective winter sea ice, in combination with increases in storm activity, could further increase shoreline erosion. Storms passing through the region can often cause significant damage to the environment and infrastructure along the coast. However, storm surges and powerful waves could increase the risk of erosion.

The increasing threats from sea-level rise, coastal flooding and erosion, and marine

storms will have impacts on personal security, property (buildings and land), and coastal infrastructure. Coastal erosion will also affect natural coastal ecosystems. For example, beaches and dunes provide habitat for a variety of marine and terrestrial species, including the Piping Plover, a coastal species at risk. Current erosion rates for some dunes are as high as 0.7 m/yr. Beaches are also undergoing rapid landward migration and replacement of sand with cobble. However, coastal development often blocks this landward migration, causing the disappearance of the beaches. The breeding habitat of the Piping Plover is sand beach, which is naturally dynamic and altered by storms. Unfortunately, as Atlantic Canada is faced with increasing coastal dynamism, the effectiveness of the bird species' reproductive attempts may be further reduced.

The Government of New Brunswick has recognized the importance its coastline and developed a 'Coastal Areas Protection Policy for New Brunswick' with the intent of ensuring future viability of coastal areas in terms of economic and community growth through advances in environmental protection. The policy was developed as a result of recognition of increasing pressure for development in coastal areas during the last half of the twentieth century. Climate change may increase such demand, as heat-stressed central Canadians pursue summer recreational properties in cooler locations. As a result of climate change and sea-level rise, coastal development has become a risky business. There is strong interest in Nova Scotia to have a similar policy or other adaptive mechanism.

2.2 Exposure to extreme weather events

In the Atlantic Region, climate change will likely bring an increase in frequency and/or severity of extreme weather, such as heavy rain and

snowfalls, ice storms, prolonged droughts, and high winds. Changing precipitation and storm patterns are not expected to affect overall average annual precipitation, but seasonal distribution patterns are expected to change. For example, an increase in extreme weather may indicate that communities will face a 100-year storm event more often, perhaps every 50, 20, or even 10 years.

Extreme precipitation events may mean larger quantities of water moving into lakes, streams, and estuaries, in turn affecting estuarine processes in the coastal zone. Freshwater resources and wetlands in the region could also be seriously affected by these changes in precipitation. Precipitation timing is also critical to freshwater resources, as rain during a mid-winter thaw, when the ground is frozen, will essentially be lost to the terrestrial hydrologic system³.

Of great concern to all Atlantic Canadians is the vulnerability of communities and ecosystems to extreme weather events. Large quantities of precipitation can often trigger landslides and avalanches. Many communities in Newfoundland and Labrador have developed at the base of steep slopes, where there is risk of damage from landslides and avalanches. These communities may experience increased frequency of such hazards as a result of climate change.

Extreme events during winter are of concern as well. As a warmer atmosphere can hold more moisture, there is the potential for greater snowfalls. Record snowfalls, such as those seen in Moncton in 1992, Halifax in 2004, and St. John's during the last several winters have pushed those communities beyond their abilities to cope and effectively shut them down for days. Higher average temperatures may result in more major ice storms, such as those

witnessed in New Brunswick and Nova Scotia in recent years. More-frequent snow and ice storms will also increase vulnerability, as witnessed in Nova Scotia in November 2004 when a relatively small snow/ice storm did more damage than two previous larger storms; infrastructure, resources, and people's patience had already been pushed to the breaking point. More-frequent and intense heavy snowfalls and ice storms will require greater adaptive capacity in the region or result in lower economic productivity.

Reduced sea ice in the Gulf of St. Lawrence will expose winter air masses to greater moisture, likely resulting in more snow when the moist air passes over colder land masses such as Prince Edward Island, Cape Breton Island, and Western Newfoundland. Where sea ice is still prevalent, coastal ice pushed farther inland by greater and more-frequent storm surges on top of higher sea-levels will result in a greater number of buildings at risk to ice damage, as well as a potential loss of wharves and other coastal infrastructure.

Finally, current projections, based on ongoing studies and simulations of ocean surface waves and currents, indicate a slight increase in North Atlantic storm intensity of summer-autumn extra-tropical hurricanes⁴. This increase is not expected for winter storms. The simulations also indicate a slight tendency for increase (~5%) in number of severe storms in summer-autumn⁵. The warming of coastal waters around Atlantic Canada may permit these storms to maintain their intensity as they approach land, as witnessed with Hurricane Juan in 2003. As well, compared with the current situation, storm tracks in the North Atlantic are expected to move nearer to the coastal zone as the climate changes. This may have an impact on the number of landfall storms hitting Atlantic Canada in the future; a

scenario which would have significant effects on both coastal and inland regions.

2.3 Vulnerable communities, infrastructure, and planning

Vulnerability in this context can be defined as a susceptibility to, or inability to cope with, various adverse effects of climate change⁶.

Vulnerability is a function of exposure, sensitivity, and adaptive capacity. Atlantic Canada is highly vulnerable to climate change because it has high exposure, high sensitivity, and low (economic) adaptive capacity. With such a large portion of the region being sensitive to climate change impacts (e.g. sea-level rise, coastal erosion), and much of the population dispersed across areas that will experience these impacts, it is imperative that economic, social, and ecological systems have the ability to ameliorate adverse effects or take advantage of beneficial effects of climate change.

The adaptive capacity of a community determines its resiliency to impacts. In the case of Atlantic Canada, many of the communities are rural, depopulated, and poor. Many of them are also continuing to depopulate, getting poorer, and in a state of accelerating decline. As such, perhaps little can be done within the means of the communities to increase adaptive capacity, leaving much of this region at risk to the hazards of climate change impacts. Conversely, strong social ties in many rural communities can aid in resiliency as neighbours are more likely to help each other in times of need compared to urbanized regions.

Climatic changes and the impacts of natural hazards on critical infrastructure during weather-related events is a key concern in Atlantic Canada. These changes will have

implications for transportation infrastructure in the Atlantic region. Low-lying roads and railways are vulnerable to flooding and in some communities flooding could result in key emergency infrastructure being inaccessible. In many rural communities, there are few means to prevent or repair damages that many be incurred from sea-level rise and coastal flooding and erosion.

An excellent example demonstrating vulnerability of low-lying roads is the Saxby Gale of October 4-5, 1869. During this storm, the Tantramar marsh (the link between Nova Scotia and New Brunswick) was flooded and nearly caused Nova Scotia to become an island. Today, the socio-economic impacts of this type of flood for New Brunswick and Nova Scotia, in particular, would be huge, as the only major road and rail links between Nova Scotia and the rest of Canada would be incapacitated. Complicating matters are the dykes, which would hold the water in place long after the storm and tide subside. The rail line itself acts as a dyke, so even once it is above water it will retain water over the adjacent interprovincial highway.

As many coastal communities are experiencing increasing flooding and erosion, there is great interest in mapping these vulnerabilities to climate change to help plan for emergency management and better guide future growth. Community groups in Annapolis Royal, Nova Scotia, and Saint John, New Brunswick, both undertook pilot studies and were able to demonstrate to their elected officials and civil servants a critical need for adaptation. As there are many communities with similar situations in other parts of Atlantic Canada that simply do not have the resources and expertise to tackle such challenges, there have often been calls for regional approaches to vulnerability reduction. In addition to the large studies

funded primarily by the federal government (described below), the province of Nova Scotia and the Union of Nova Scotia Municipalities are embarking on a joint project to determine how to reduce municipalities' risks from climate change-driven storm surges and flooding, as well as minimize public expenditures on infrastructure repair.

Another effect of climate change and higher sea-level is accelerated coastal erosion and property loss. In the event of a 0.35-m rise in sea-level, predictions of shoreline erosion show a 50% increase in the present rate of erosion. In an exercise by Don Forbes and Gavin Manson of the Geological Survey of Canada - Atlantic as part of the PEI Sea-Level Rise Project, *Coastal Impacts of Climate Change and Sea-Level Rise on Prince Edward Island*, a representative area in PEI was selected to present the economic consequences of coastal erosion and property loss using present assessed property values⁷. The results showed that at present rates of erosion, a quarter of the property value would be lost, and at two times the present rates, fully one half of present value would be lost. This exercise has been replicated in other parts of the Atlantic region.

The New Brunswick Sea-Level Rise Project, *Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick*, is examining impacts of sea-level rise and climate change on the coastal zone of southeastern New Brunswick. This project, managed by Environment Canada, covers sections of coastline from Kouchibouguac National Park to Cape Jourimain. One important component of the study is a survey of the project area to produce digital elevation models and maps. The digital elevation maps can be used in computer simulations to see which areas would be

flooded when sea-levels reach various heights. Ultimately, the project will “help with planning for future human usage along the coast, as well as management of wildlife and plant habitat in the coastal zone”⁸.

A similar project in Nova Scotia is Climate SMART (Sustainable Mitigation and Adaptation Risk Toolkit)⁹. Climate SMART is a collaborative partnership to help Halifax Regional Municipality and its partners to develop strategies for climate change mitigation and to develop management and planning tools to prepare for adaptation to climate change impacts. A key component of the toolkit includes vulnerability assessments, mapping and modelling to determine potential climate change impacts. Ideally, the lessons learned can be replicated in other municipalities across Canada and elsewhere. These regional and local sea-level rise projects have already proven extremely useful in determining vulnerability to climate change and sea-level rise. There is a need for this type of detailed mapping in many areas along the Atlantic regional coastline.

2.4 Natural resources and resource-dependent communities

Communities in Atlantic Canada have a long history of interaction with the environment, largely due to their primarily resource-based economy. Current variations seen in the climate are immensely important in peoples' lives, as they directly and indirectly affect fisheries, forestry, agriculture, and tourism. It is possible that Atlantic Canada may suffer disproportionately as its economy is heavily resource-based and therefore more susceptible to the economic impact of climate change than regions with manufacturing- or service-based economies. For example, in

New Brunswick and Newfoundland, the forest industry is a major contributor to the economic well-being of the province, and the vulnerability of this resource is of particular concern.

Forests are highly dependent on, even controlled by, climate and the interactions between forests and climate are exceedingly complex. However, while forests respond to a changing climate, they are also conditioned by a host of other influences (e.g., air pollution, human occupation, and timber harvests). Therefore, when it comes to making assessments of how forests will react to a changing climate, all factors must be considered.

Although it is still uncertain how climate change will affect Atlantic Canadian forests, it is possible that the changes will have considerable consequences for communities reliant on forests and forest products for their livelihood. For example, as forests are in dynamic equilibrium with the climate, a significant change in climate may cause the equilibrium to be lost. A loss of this equilibrium may mean a loss of resource productivity and the many values and uses that humans have come to expect from forests.

The Acadian forest, found across Nova Scotia, New Brunswick, and Prince Edward Island, is characterized by elements from both the northern boreal coniferous forest and the deciduous forests to the southwest¹⁰. A major impact to the Acadian forest will be the increase in average annual temperature and changes to precipitation patterns and species composition. Predictions show a northward migration of forest types as the climate warms, leading to a potential loss of Acadian forest species. As the climate changes, the ability of these natural populations to adapt to new climatic conditions will depend upon several

conditions, including the rate of climate change and the specific traits and characteristics of the populations. Unfortunately, most forest companies in the Atlantic region are not adapting their forest regeneration practices to a changing climate. The most common current practice is to regenerate indigenous coniferous species because these are preferred in the marketplace. Such practices do not capture potential advantages, in terms of adaptation to climate change, of regenerating diverse mixedwoods with significant broadleaved components.

Some of the other significant physical impacts of climate change on forests include changes to natural disturbance regimes (insects, fire, and wind), and the impacts from extreme weather events. The effects of climate change on natural patterns of forest disturbance are not well understood in Atlantic Canada, but are nevertheless cause for concern. For example, depending on the extent of decrease, if any, in precipitation experienced in the region, the shallow-rooting trees of central Nova Scotia may experience some negative impact from drought and heat stress. As well, increases in strength and frequency of windstorms and thunderstorms are noteworthy as both can have severe impacts on these same shallow-rooting tree species.

Wind speed is a determining factor in the scope of damage to trees, making larger trees and stands that have recently burned more susceptible to windthrow¹¹. In addition, storms causing widespread damage to forest stands increase the likelihood of pathogen outbreak. To complicate matters further, a period of drought following an ice storm, for example, also increases the probability of fire outbreak¹². Predictions for Atlantic Canada state that there will be a 10-20% increase in frequency of

forest fires¹³. These fires may also become more extensive and severe.

Extreme weather events, such as hurricanes, high winds, heavy snowfalls, hail, ice storms, and prolonged droughts are expected to become more frequent, and more severe. This may change the type and health of Atlantic Canada's forests. Extreme weather events also affect freeze-thaw cycles, snow cover, drought, and blowdowns. More-frequent and severe storms may bring more wind damage to forests in the Atlantic Provinces. An outstanding example is the 1994 Christmas Mountain blowdown in New Brunswick, which felled 30 million trees and cost \$100 million¹⁴. Another example, in Nova Scotia, is the blowdown from Hurricane Juan. In this case, blowdown was extensive, partly because of the thin soils in the region. As the unharvested downed woody debris dries out, Nova Scotia may yet see increased forest fires in the near future.

Warmer climatic conditions may improve conditions for native pests and/or create favourable conditions for invasive and exotic pests not currently present in Atlantic Canada. Some pests may be able to complete more than one life cycle in a year. This could increase both the complexity and cost of pest-control programs. As well, international shipping is bringing pests in more quickly than nature can accommodate, and climate change is allowing them to survive longer (e.g. brown spruce long horn beetle and black legged ticks).

Invasive species can have far-reaching effects on forest health and contribute to shifts in nutrient cycles, forest succession, and herbivory and predation. Non-indigenous species can also cause regional extinctions through hybridization with native species, and

can increase tree mortality if they are vectors of exotic diseases¹⁵.

Another socio-economic implication from the ecological effects of climate change is the increased potential for unattractive forests with considerable dieback and decline. This may in turn lead to reduced recreational and tourist appeal. As well, there is the potential for swings in local wood supplies as there may be more salvage cutting or the need for a massive timber harvest following an insect attack.

Fish-dependent communities, which are already vulnerable to adversity because of recent changes to fisheries, are potentially vulnerable to climate change. Although the impacts of climate change on marine fish species are not well understood, it can be reasoned that any period of transition is likely to reduce productivity, at least in the short term. Already, examples of ecological disconnections are being seen (e.g. erratic spawning times of capelin in Newfoundland) that are leading to lower reproduction success rates for fish species. Changing in timing of fish's life-cycle events can not always be matched by fishers' routines, as species, times and locations for offshore fishing are regulated by the federal government. Thus, fishing regulations may need to change with the climate to maintain fishers' adaptive capacity and protect fish during more vulnerable points in their life cycles.

Adapting to changing fishing conditions is already leading fishers further offshore. Given the economics of fishing, few can afford to upgrade their boats to the more strenuous environment farther from shore. As offshore conditions become more dangerous with a changing climate, these maladapted boats will become less safe for their occupants.

Also offshore, the emerging petroleum industry will face greater threats to its activities as ocean storms become more frequent and intense. While over the long term less ice (icebergs and sea ice) may mean greater exploration and extraction opportunities, in the short term ice is becoming more erratic and posing more of a threat than previously expected. The unusual appearance of a major ice floe in the vicinity of the Sable Offshore Energy Project south of Nova Scotia in 2004, which caused the emergency evacuation of natural-gas production platforms, will doubtless precipitate more careful planning for future developments in the area.

Increased hurricane and winter storm activity may pose greater threats to offshore rigs, tankers, and supply vessels as well. Coastal installations where offshore petroleum comes ashore (natural gas pipeline beachheads, liquid natural gas terminals, and oil tanker docks) and their associated infrastructure (refineries, regasification plants, and by-product processing plants) will be under greater threat from storm surges, flooding, and coastal erosion. Damage to such infrastructure could cause significant threats to the local environment and inhabitants. As this industry is rapidly developing and new infrastructure is being planned now, it is imperative that such threats be made known to the private firms and regulatory agencies responsible.

3. Key Stakeholders

Government decision- and policy-makers, whether they are provincial, municipal, or Aboriginal, are among the most important stakeholders associated with climate change impacts and adaptation. In Nova Scotia, climate change is the responsibility of two departments: Energy, and Environment and Labour. Although mitigation has been exclusively handled by Energy, impacts and adaptation are being addressed by both departments. George Foote of the Department of Energy has been actively involved with C-CIARN Atlantic since its inception as a member of the advisory committee.

Prince Edward Island is the only province in the region to have signed an agreement with the federal government for a provincial climate change coordinator. Although the position is primarily focussed on mitigation, the provincial government is concerned enough about impacts and adaptation to include these aspects in the mandate of the position. The coordinator has been engaged for several years through involvement with the CIARN Atlantic advisory committee.

In Newfoundland and Labrador, climate change is handled by the Department of Environment and Conservation. The Department has been engaged in the issue through frequent dealings with C-CIARN Atlantic and is currently engaging municipalities through a series of workshops on municipal impacts and adaptation. The Director of the policy and planning division has recently joined the CIARN Atlantic advisory committee.

Engaging the New Brunswick government officially has been difficult because of lack of a clear vision internally as to who is responsible

for impacts and adaptation. Unofficially, productive relationships have been established with several planners in the Sustainable Planning Branch of the Department of Environment and the Department of Transportation. C-CIARN Atlantic continues to try to engage the most appropriate person in the New Brunswick Provincial Government.

Municipal governments are key to adaptation because they control much of the infrastructure that will be adversely affected and the emergency management programs that will respond to extreme events. Apart from working directly with major municipalities engaged in specific adaptation projects (e.g. Halifax's ClimateSMART program), C-CIARN Atlantic has found it most effective to work with national and provincial organizations such as the Federation of Canadian Municipalities, the provincial municipal associations, and provincial departments responsible for municipal affairs.

First Nations in the Atlantic Region (Mi'kmaq, Maliseet, Passamaquoddy, and Innu) and the Inuit of Northern Labrador are vulnerable to climate change because they have a closer relationship with the natural landscape and are limited in territory. Individual communities are difficult to engage because they feel they have so many more-pressing matters to deal with. Regional organizations (particularly the Atlantic Policy Congress and the Atlantic First Nations Environmental Network) offer effective mechanisms through which C-CIARN Atlantic has reached Aboriginal communities.

Elected officials are generally not easy to engage in C-CIARN activities. The best approach seems to be to engage the civil servants who advise them. Among these, those with responsibility for policy- and decision-making tend to be receptive to

learning about climate change and tend to have a sense of how it will be relevant to their respective jurisdictions and responsibilities.

Undoubtedly, much of the actual work of adaptation will be undertaken by the private sector through the efforts of consultants and contractors. Apart from the few private firms that are visionary enough to see this need and develop the necessary expertise, the private sector does generally not possess the ability to carry out climate change adaptation projects successfully. The concept of climate change adaptation is only slowly making its way into formal educational systems, so it will be many years before consultants and contractors can be routinely expected to possess this knowledge. Meanwhile, some firms are selling themselves as providers of climate change adaptation services, yet such services often focus on conventional solutions (which may make the problems worse) or mitigation plans couched in terms of what the impacts may be if no mitigation is undertaken.

Until such a time when consulting and contracting firms are staffed with professionals who have been formally trained in climate change adaptation throughout their educational experience, a focus on mid-career continuing education for existing professionals is warranted. An obvious medium for such initiatives is through professional and industry associations. Engineering and planning are two key professions to target. The former has provincial organizations in the Atlantic region, while the latter has a region-wide organization. Both have important roles to play and are generally enthusiastic to take on the challenge. They have been successfully engaged through various channels, but require continuing engagement. Environmental industry associations have branches in three of the four Atlantic Provinces (all but PEI). Engagement in

Nova Scotia led to the formation of ClimAdapt and similar expertise at other firms. This also led to increased interest in New Brunswick, where the association has undertaken activities to stimulate member interest. Engagement needs to continue or the interest may be lost. Much more work is required in Newfoundland and Labrador to engage the industry there.

Non-governmental organizations (NGOs), particularly environmental ones, will also play a role in adapting to climate change because they engage community activists and other volunteers who are eager to do things for the benefit of their communities. Such groups are powerful allies if engaged correctly. Major NGOs in all provinces have been engaged successfully on climate change impacts and adaptation. As well, some ACAPs (NGOs that are part of Environment Canada's Atlantic Coastal Action Program) are powerful allies, and can be addressed as a group through Environment Canada. Each province has an environmental network, which is an umbrella group for all of the environmental NGOs in the province. Apart from targeting the major NGOs, going through the environmental networks is an effective way of reaching the appropriate NGOs.

Unlike Newfoundland and Labrador, which has one large university, the Maritimes have many medium-sized and small institutions of higher learning throughout the region. Therefore, networking of a range of disciplinary researchers is challenging and requires a body like C-CIARN to assist and maintain effective collaboration. Where effective inter-institutional networking of environmental researchers was established, the loss of C-CIARN Atlantic in spring 2006 was viewed quite negatively as it was considered a vital link for researchers at various institutions.

Contact information for key stakeholders is listed in the Appendix.

4. Strategies for Stakeholder Engagement

Over the past five years, C-CIARN Atlantic has used a variety of tools, strategies, and activities to engage stakeholders in climate change impacts and adaptation. All of the following activities were initiated, organized, sponsored or supported by C-CIARN Atlantic at some point over the past few years: public presentations; community and site visits; panel discussions; questionnaires/surveys; e-mails; a website; conferences; seminars; and workshops. Since its inception in 2001, C-CIARN Atlantic staff and volunteers learned a great deal about stakeholder engagement. Generally speaking, C-CIARN Atlantic has learned that there is no one best tool, strategy, or activity for engaging stakeholders, although some broad approaches to engagement appear to be more effective than others. Below are described some features or characteristics of an effective stakeholder engagement approach gleaned from C-CIARN Atlantic's engagement experiences. Many of them, singularly and/or in combination, are worthy of consideration in future stakeholder engagement processes and strategies related to climate change adaptation.

4.1 Building an effective stakeholder engagement approach: general considerations: Understand that there are no best engagement tools, strategies, or activities

The single most important learning is that there is no one best stakeholder engagement tool, strategy, or activity. Because different groups and individuals bring different values, experiences, capacities, and professional or disciplinary biases to the stakeholder engagement context, and because of the dynamic nature of both the stakeholders and the context in which they are nested, different activities may be required for different groups and interests at different times. Additionally, the organized groups and interests perceived by C-CIARN to be stakeholders are not only large in number, but they are also often substantially different from one another in terms of organizational cultures, mandates, goals, approaches, capacities, and perceptions of what constitutes effective or appropriate engagement. This too necessitates that different activities be used for different groups. We have confirmed that an effective engagement approach is one that chooses activities after having considered the needs of each stakeholder or type of stakeholder, as well as the overall engagement context in which each is situated. In other words, when designing engagement strategies or activities, it is important to try to design them such that they are aligned with the needs, expectations, and interests of stakeholders. Simply put, one should start with the experience and needs of the stakeholder.

4.2 Engage and support both the unengaged and the already engaged

Generally speaking, stakeholders belong to one of two types: those unengaged or are at the periphery of engagement; and those engaged and could become more engaged, at least in the perception of C-CIARN. Each type requires a different approach or strategy for engagement. Agencies that aim to ignite or spark engagement in climate change impacts and adaptation must pay attention to both groups. Regarding the former, activities need to be designed such that the unengaged are drawn into the impacts and adaptation issue. Providing reticent stakeholders with relevant and timely information about impacts and adaptation relevant to them is one way to do this. Creating learning opportunities where they can become informed about the basics of impacts and adaptation in a safe and non-threatening environment is also important. Involving such stakeholders gradually in small incremental steps is an approach that can ultimately help to shift a potential partner from disconnection to engagement.

Regarding the latter, current engagement does not necessarily mean ongoing or increased engagement. An entity such as C-CIARN, interested in stimulating engagement, needs to find ways to support such stakeholders so that their interest in and openness to engagement does not wane. Such stakeholders often need engagement support that is quite different from that required of unengaged stakeholders. For instance, they may require specialized knowledge to take their moderate interest in impacts and adaptation to a new level. They may need activities that help them network with other stakeholders who are working in similar contexts and/or who have the same or similar information needs or climate change-related

challenges to address. They may also need information-related resources to act upon decisions already made, something C-CIARN can frequently provide. Regarding the latter, C-CIARN spent considerable time and effort working with both engaged and relatively unengaged stakeholders to help them identify and access sources of funding.

Sometimes it is useful and effective to bring uninvolved and already involved stakeholders into the same learning and sharing environment (e.g. via a workshop). At times, it is better to allow stakeholders of similar background and experience to learn and share together. The general point is that those designing engagement activities need to think about how different types of stakeholders may require different types of engagement support and activities.

4.3 Have reasonable expectations about your ability to engage others

C-CIARN Atlantic believes that its efforts have made a difference in terms of influencing the engagement of stakeholders in climate change impacts and adaptation. However, there are limits to what can be accomplished in this regard, for three reasons. First, because there are so many groups and agencies in Atlantic Canada that could be engaged in the issue, it is unreasonable to expect that a small entity such as C-CIARN Atlantic could effectively engage them all. Second, many of the stakeholder groups have limited resources and low engagement capacity. In other words, even if they desired to become engaged in the issue, they would have difficulty doing so. Third, because there are myriad other forces continuously affecting potential stakeholders – some of which may nudge them closer to engagement while others may pull them back from it – it is not always possible for the efforts of C-CIARN to bear fruit. Simply put, the best

efforts of C-CIARN to nudge an entity in one direction (e.g. towards becoming meaningfully engaged in the issue) can be countered or undone by other competing pressures that push the stakeholder in a completely different direction (e.g. away from meaningful engagement on climate change). In short, despite the work of C-CIARN Atlantic to catalyze interest and action on climate change impacts and adaptation, a stakeholder may opt to do nothing about it due to factors that have little or nothing to do with C-CIARN.

4.4 Scientific and community stakeholders need to be engaged differently

C-CIARN Atlantic has confirmed also over the past five years that stakeholder engagement strategies need to reflect the fundamental differences between scientists and non-scientists. In short, scientists (academic or otherwise) tend to want to focus their energies on understanding the science of the impacts and adaptation issue, especially in the early stages of engagement. However, non-scientists appear to want to effect change as soon as conceivably possible. A science focus, then, works well with scholars and academic institutions steeped in the scientific method. It also tends to work well with government organizations, as they tend to employ scientists and engineers who are trained to examine problems in a methodical and methodological way. Unfortunately, this approach does not work so well with other stakeholders such as ENGOs, community groups, and businesses. While such stakeholders may have an interest in the science dimension of climate change, many do not have the scientific background needed to understand the biophysical complexities of impacts and adaptation. Because they are more interested in climate change from an issue, action, and change

perspective, they find lengthy and detailed scientific explanations wearisome and frustrating. They may quit the engagement process because of an overly scientific focus, especially if they perceive it be delaying real and urgently needed action.

Designers of engagement activities where both types of partners are present need to think carefully about how to ensure that both types of needs are met. One strategy is to separate scientists and non-scientists into two groups so that each can approach the issue in its own unique way. Another is to be upfront about the differences with all involved, and to seek support for a hybrid approach where time is devoted early on in an engagement activity to both the science and the practical realities of impacts and adaptation.

4.5 Don't forget about the money (and resources)

A necessary first step in any stakeholder engagement process is to ignite or deepen stakeholder interest in the issue or topic at hand (e.g. impacts and adaptation research). Once this has been achieved, it is vital that resources be found quickly such that emerging ideas and plans can be realized. If excitement and interest are generated, yet no resources are available to turn them into practical initiatives, interest will wane. This may make it even more difficult to engage the same stakeholders in the future. Thus, when attempting to engage new, or better engage existing, stakeholders in climate change impacts and adaptation, one must ensure that up-to-date and accurate funding-source information is available to share with all. Better yet, if possible, one should have internal resources available for stakeholders to use to improve their funding proposals, such that they are better able to attract outside funding.

Similarly, a small-grants program can propel at least some ideas into development and rapid forward movement. Such a funding program could also be used to capture interest, and support emergent project ideas that arise with extreme weather events and other opportunistic learning opportunities. If and when there are few resources available generally for impacts and adaptation initiatives, one must avoid an engagement process that continuously generates new project ideas as this will ultimately lead to frustration and disappointment.

4.6 Specific/practical engagement ideas worth considering

Identify champions and use existing stakeholders to identify new stakeholders

Identify key motivated individuals within potential or targeted stakeholder agencies and sectors to become front-line contacts for C-CIARN. Use a snowball approach where existing stakeholders help to identify new potential stakeholders.

Take time to understand and build mutual understanding among stakeholders

Work to understand the various interests and positions of all stakeholders; create regular opportunities for stakeholders to share their varying points of view, interests, and positions. The importance of having adequate time to build mutual understanding cannot be overestimated.

Focus on relationships, not activities

Stakeholder engagement is largely about relationship-building. Design activities that have the potential for stakeholders to meet, learn, and act together, consider how best to nurture relationships over time, and spend time developing quality social-capital-building opportunities.

Ensure meaningful participation opportunities

If stakeholders are to be meaningfully engaged, ensure that there are meaningful ways for them to become engaged. Attending meetings or teleconferences is not enough; designing activities that allow people to use their skills and knowledge, and which permit them to grow and learn, are generally considered more meaningful. Having control over decisions related to such activities, and having an ability to show leadership can also ensure meaningfulness.

When appropriate, piggy-back engagement efforts onto existing activities

If resources are limited, attempt to identify initiatives from within the region that one's own engagement efforts can be linked to. Although this is not always an effective strategy, it can help to increase the number (and quality) of engagement initiatives available to stakeholders.

Create opportunities for stakeholders to collaborate

Most engagement activities conducted by C-CIARN included opportunities for stakeholders to consider how best to collaborate with one another on impacts and adaptation endeavours. In other words, the broad engagement approach was one of supporting engaged stakeholder to find new ways to become even more engaged with their colleagues.

Sometimes it might be necessary to relegate climate change to the back seat

Stakeholders who traditionally would not be involved or concerned with environmental issues can be particularly difficult to engage in climate change impacts and adaptation. With such groups it is often necessary to shift the engagement focus from climate change to

climate vulnerabilities they are likely to experience, especially in the formative stages of a process or network. A good strategy is to discuss how such groups can be more prepared (i.e. better adapted) for future impacts. Introducing how a changing climate is likely to amplify these impacts, and questioning whether stakeholders are ready to respond to such impacts, can be a good way to introduce them to the impacts and adaptation issues (Note: this approach worked well at the joint C-CIARN Atlantic/Coastal Zone workshop on coastal trails and boardwalks. The workshop was promoted to trails groups, boardwalk contractors, and responsible agencies as a discussion of how better to protect these assets from storms and other natural threats. Participants remarked after the fact that they learned a great deal about an issue (climate change) that they had never considered and were grateful for the opportunity to participate).

Understand that engagement is more just than attending C-CIARN events – attendance does not necessarily signify meaningful engagement

C-CIARN Atlantic successfully engaged a variety of stakeholders in planned C-CIARN activities. This, however, did not necessarily mean that such stakeholders automatically became engaged or more engaged in the climate change impacts and adaptation issue. Clearly, attending an event, and meaningful engagement, are not the same thing. The former can spark the latter, but it does not guarantee it. The C-CIARN strategy was to plan or design events to be catalysts for action. Simply put, it was hoped that the networking, learning, and camaraderie associated with C-CIARN events would spark additional impacts and adaptation activity outside of the C-CIARN context. This did happen to some extent over the five years of C-CIARN. For

example, on more than one occasion, stakeholders who knew one another from participating in a C-CIARN sponsored workshop collaborated on a joint impacts and adaptation research activity outside of the formal C-CIARN context.

It is difficult to claim credit for engaged stakeholders

Even when C-CIARN Atlantic did help to generate additional engagement activity, it is difficult to sort out cause-and-effect relationships in this regard. Simply put and as noted above, many forces are at play that can cause a stakeholder group to adopt or shun the impacts and adaptation issue. C-CIARN Atlantic feels at least partially responsible for the general growth of interest in impacts and adaptation in Atlantic Canada over the past five years, but is, of course, unable to prove it.

5. Engaged Stakeholders

In general, stakeholders found themselves involved in climate change impacts and adaptation due to the nature of their work or the work of their organization. Relationships between energy, resource-based economies, ecosystems, and climate change were recognized and action was prompted. For example, as part of its mandate, the Bay of Fundy Ecosystem Partnership is now involved in sharing information on important issues such as climate change.

Another example is the province of PEI. Both government and NGOs on PEI became engaged in climate change impacts and adaptation issues because the province is an island and the coastline is extremely susceptible to erosion. As well, the majority of

industrial activities on PEI are resource-based (e.g. agriculture, fisheries, tourism) and are therefore reliant on stable climate.

Many of C-CIARN's key stakeholders have been involved with climate change issues since before C-CIARN was created. Initiatives such as the Nova Scotia Environmental Industry Association's climate change adaptation initiative, the Aquatic Nuisance Species Task Force, the Agriculture and Agri-Food Industry Discussion Table of the Climate Change Secretariat, and the Canadian Council of Ministers of the Environment have all been working directly or indirectly with climate change in mind either prior to or independent of the existence of C-CIARN. However, since the creation of C-CIARN, most of the key stakeholders in the region have been approached directly and involved in workshops and networking opportunities presented to them by C-CIARN Atlantic.

As awareness of climate change impacts and adaptation grew in the Atlantic region, stakeholders also became aware of a growing need for additional knowledge of impacts and possible solutions. Issues began to surface, such as the need for communities to be more aware of sea-level rise; a fundamental need to respond to and be prepared for extreme events (e.g. hurricane Juan, white Juan); the disproportionate focus on mitigation activities to the detriment of dealing with current and impending impacts; the question of how to position industry in a changing environment; and determining best management practices in agriculture, fisheries, and forestry.

Stakeholders in Atlantic Canada were also driven to become engaged because of a perceived lack of regional knowledge. Overall, there seems to be a feeling that mitigation will be insufficient to stop climate change impacts

from happening. For example, in south-eastern New Brunswick, the coastal areas were facing a development crisis that had to be dealt with. Organizations in the area sought information to deal properly with the inevitable strain of increasing development in combination with the unknown impacts of increased storm activity in the region.

In terms of adaptation decision-making, several factors have helped Atlantic Canadian stakeholders. A major influence in decision-making was having adequate information on specific impacts relevant to their respective sectors and regions. In large part, this information was gained through exposure to other companies, jurisdictions, and organizations and their work and expertise in the area. Some stakeholders feel that through networking and interacting with researchers, for example, at C-CIARN workshops, they now possess a good general understanding of the long-term nature of the problem, and a general understanding of sectoral and provincial impacts. Similarly, one stakeholder found it useful to conduct consultations with workers in the field in which the decision-making was situated.

Through common sense, and prioritization of known impacts as they related to the specific work of each organization, some stakeholders were able to formulate and operationalize their own decision-making framework for risk management. ClimAdapt, a consortium of consulting companies in the Halifax area, has been involved in the creation of its own strategic adaptation frameworks and a suite of adaptation tools for various clients in the region.

Other stakeholders feel that effective decision-making with regard to climate change adaptation is still a struggle, and that there is little progress on adaptation within their

respective organizations. This may be due to a lack of cooperation outside of government. However, even within some government departments, adaptation decision-making is still difficult and rare. In the case of one provincial department, the representative stakeholder felt that although there is some recognition of the potential long-term impacts of climate change, the department has not yet reached the next step beyond consideration of these impacts. In general, there seems to be a serious disconnect between knowing what may happen and what needs to be done. As well, there has not been a broad recognition of the potential benefits and costs of innovation in adaptation.

Several tools have been used to guide adaptation decisions in the Atlantic region. Interprovincial information-swapping is ongoing to provide advice regarding shared potential impacts, such as sea-level rise and coastal erosion. In this way, stakeholders can use the best practices of jurisdictions that have already taken action on an issue. Other tools included: tools created by ClimAdapt member agencies; coastal analysis/assessment by Pacific International; Municipal Risk Management Toolkit and Municipal Emissions Reductions Toolkit; a Sustainable Mitigation and Adaptation Risk Tool; a Climate-oriented EIA tool; a Climate-oriented EMS tool; a Climate-oriented Risk toolkit for the built environment (infrastructure); the IPCC and Canada Country studies; the use of technical specialists, consultants and consultations; and GIS and mapping tools. As well, many non-government stakeholders also recognize the utility of the federal government's tools, such as Environment Canada's scenario and downscaling work.

Finally, one stakeholder has stated a view that many tools may be of potential use, but they

are either locally unavailable or difficult to use without training. It was suggested that keeping in touch with researchers in the area can help keep stakeholders better informed about potential impacts, such as changes to coastal processes and features. As such, the opportunities that have presented themselves at the workshops and events of C-CIARN Atlantic have been an invaluable resource for all those who attended, and who will attend future workshops.

5.1 Outstanding needs of engaged stakeholders

Stakeholders in the Atlantic region seem to agree that before effective decision-making with climate change impacts and adaptation in mind can take place, the following steps must first be taken: increasing awareness on region- and sector-specific impacts and what actions can and should be taken; dealing with a lack of focus on adaptation (as opposed to mitigation); coordinating and fostering cooperation among policy-makers at all three levels of government; and dispelling the continuing widespread myth that climate change is not an issue of concern. Regional and sectoral impacts need to be described to decision-makers with regard to timing of events, specific scenarios, and downscaling, and putting costs and benefits into real time. This information must be put forward in a format that is understandable to decision-makers and policy analysts. As well, for stakeholders making decisions in the field, a consistent message from the federal government regarding the importance of climate change adaptation is absolutely necessary. A lack of leadership from higher levels of government hinders municipalities from taking appropriate action.

Many important decisions relating to climate change adaptation are common (or public) rather than individual (or private). In this

regard, it has been expressed that the most significant impediment to moving forward on climate change impacts has to do with low buy-in from public servants working in a decision-making capacity. If policy-developers and decision-makers at all three levels of government are not willing to accept current scientific advice and move on that information, then it will remain difficult to incorporate climate change into management and policy decisions.

As well, it may be beneficial to incorporate not only a research-based focus, but also to establish initiatives that incorporate the objectives of stakeholders and decision-makers. This could potentially lead to public outreach programs, and an increase in policy- and decision-making initiatives. One difficulty is the deficiency of good institutional memory. A significant amount of information is lost over time; a problem when trying to answer long-range questions.

Of particular note, however, is that in some sectors, a lack of funding is a major impediment to putting existing knowledge into action. For example, some of the actions required by the agricultural sector require significant financial expenditure, such as a growing need for irrigation (or rather drought-resistant crops) in regions such as the Annapolis Valley of Nova Scotia. Although minor changes are possible with little cost to farmers, effective changes do require financial input and incisive knowledge of future needs to be successful.

6. Unengaged Stakeholders

Stakeholders are likely to become quickly engaged after a major extreme-weather event that clearly illustrates their vulnerability to climate. A case in point is Halifax Regional Municipality, which was eager to undertake the Climate SMART (Sustainable Mitigation and Adaptation Risk Toolkit) project after a year in which three extreme events (spring rainfall and flooding, fall hurricane, and winter blizzard) inflicted significant physical damage and exceeded the community's ability to cope. A similar situation occurred in Charlottetown in January 2000 when a winter storm surge flooded the city's waterfront. It was only then that the city saw value in the storm-surge prediction model (an adaptation tool) under development for the P.E.I. Sea-level Rise Study.

Some unengaged stakeholders, while not actually sceptical of climate change in general, are sceptical of the value of adaptation (regardless of their views on mitigation). They feel that unless the federal government engages them in adaptation through either regulations or financial incentives, the issue is not important enough to deal with. Some have even pointed out that some federal environmental funding programs do not recognize, or in the case of EcoAction specifically exclude, climate change adaptation. Beyond research funding through programs such as CCIAP, there is no funding for routine adaptation projects.

In the early years of C-CIARN, many unengaged stakeholders expressed concern that climate change mitigation was enough of a challenge for them that they could not engage on adaptation as well. As they have become

more comfortable with mitigation and more aware of the immediate threat of climate change impacts, they have become more open to incorporating adaptation into their regimens as well. Unfortunately, there are still some who believe that adaptation and mitigation are mutually exclusive approaches and therefore choose to pursue one or the other (usually mitigation) exclusively. A small contingent of the environmental activist movement views adaptation as an excuse by government not to mitigate climate change and therefore preaches against it. Education on the relationship between the two approaches is needed to improve engagement of these stakeholders.

7. Unanswered Research Questions

When asked whether there were any important research questions that remain unanswered, researchers and advisory-committee members for C-CIARN Atlantic unanimously responded affirmatively. These questions cover a large variety of different aspects of climate change impacts and adaptation in Atlantic Canada, but generally fall into seven broad categories: regional impacts, air quality and health, adaptation and communities, coastal and watershed processes, extreme events, resources, and cumulative impacts.

Climate change researchers in Atlantic Canada are adamant that climate models must be improved to provide finer-scale scenarios at local levels. This is not a matter of refining general circulation models of the atmosphere, but rather a need for better regional models that focus on Atlantic Canada in as fine detail as possible. A greater understanding of ecosystem health, projected impacts, and stresses to current systems on a regional scale is needed to understand impacts and adaptations as well as next steps in developing response models and to prevent damage. We are now at the point where we have a good general picture of impacts and adaptation; we should now be looking at specific problems in specific areas. For example, although some work is already being done to map the extent of coastal impacts in limited areas (for example, using LIDAR), this type of work would be highly beneficial for much more of the coastline of Atlantic Canada.

Further work is needed to improve predictions of climate change on air quality. As well, further studies on health effects of combined air

pollution and increased air temperatures are needed. There remain many questions regarding impacts of air quality and heat warnings on behaviour and health of Atlantic Canadians, including specific questions surrounding climate change implications for pollen levels (currently only a few species have been examined), and how increased flooding and unusual patterns of precipitation may affect mould species and growth. Finally, it would be beneficial to examine the health consequences of various mitigation activities, including the increasing production and use of biofuels.

In Atlantic Canada, information on all aspects of adaptation is important for communities. Creating and compiling such information should be a priority because of the huge uncertainties associated with impacts and adaptation. Themes for unanswered questions include: adaptations that can be implemented in one community and replicated in another; linkages between human development (especially on the coast) and stress amplification due to climate change (e.g. sea-level rise and cottage development on the coast); policies and guidelines that should or could be adopted by communities to reduce potential impacts due to climate change; helping communities interpret climate change impact predictions to make the necessary planning decisions regarding infrastructure and settlement patterns; population-level impacts (e.g. major population shifts) and the necessary adaptive strategies; and impacts to community water resources. There is a need to ensure that any and all recommended adaptation strategies put forward be relatively effective, affordable, and easy to implement.

Atlantic Canadian researchers felt that there are several significant unanswered questions regarding climate change impacts to coastal

and watershed (including wetlands) processes. These questions include what exactly coastal changes will look like and what kind of preparation and adaptation work is needed. Sea-level rise and its impacts on the coastal zone, as well as upstream in watersheds, require clarification and further research. Finally, as a result of changing coastlines, further research into wetlands, salt marshes, and habitat in coastal and estuarine ecosystems is needed to help determine impacts as well as effects of other adaptation work.

An issue closely related to coastal and watershed impacts is extreme events. There are also many unanswered questions around this issue, as it is still unclear to what extent sea-level rise and impacts of increased intensity and frequency of extreme events will affect Atlantic Canada. There is continued uncertainty around the question of hurricanes and their intensity, frequency, storm tracks, etc. Questions also arise regarding ecosystem and community threshold in relation to these impacts; specific changes in storm frequency and severity; and the location and extent of impacts from storm surges. In general, researchers are looking for more effective predictability of extreme events.

It is understood that there will be economic and environmental impacts on the resource sectors. However, again, more-specific knowledge of the impacts on each resource sector is needed (e.g. forestry, agriculture, water resources, parks and protected areas). For example, information is still missing on the impacts on agriculture and consequent effects on the food supply (as well as potential adaptation to these effects). Further work on the extent of saltwater intrusion on freshwater resources and the vulnerability of the interactions of ecosystem components to

changes in water resources is also required. Finally, there seems to be little research on adaptation in the energy sector as well as the social and economic consequences of impacts to this industry.

Finally, despite a growing knowledge base on general climate change impacts and adaptation for most areas of Atlantic Canada and the interaction of sectors and themes, there remains a lack of knowledge on the cumulative impacts (compounding effects of one impact on another) of climate change. Similarly, the combination of other major changes with climate change (e.g. fuel shortage affecting transportation combined with a climate impact such as severe weather) could have unforeseen impacts that may be of real consequence in the region. One specific and complex example of cumulative impacts is that of increases in forest fires due to drought and increases in temperature. From these changes, a decrease in vegetation canopy will affect how thermoclines change in adjacent lakes, how wind velocities increase in the areas, and how nutrient runoff regimes in the area will change. Together, these will all have severe and direct consequences on the surrounding water bodies, and on the aquatic flora and fauna, yet there is little research addressing these types of cumulative impacts. Further research into potential cumulative and unforeseen impacts is necessary to aid effectively in adaptation projects in the affected areas.

8. Advancing the Impacts and Adaptation Issue

From the perspective of C-CIARN Atlantic and its members and advisory committee, there are five key matters standing in the way of progress on climate change impacts and adaptation in Canada. These factors include: need for better regional predictions (e.g. regional climate models or downscaled models); the perception that climate change is still just a research issue; the perception of adaptation versus mitigation; the need for reallocation of funding for actual projects (as opposed to research projects); and the need for more focus and commitment from all levels of government to impacts and adaptation.

The need for better regional predictions has been mentioned both as an impediment to climate change decision-making and as a research need. Members have indicated that the research being conducted on climate change is of value in the long term. Research is especially valuable when it can be applied to real-world problem-solving. However, the long-term nature of climate change makes it so difficult to act upon. The public perception that climate change is something that will happen far into the future is contrary to the true nature of the situation: climate change impacts are crucial immediate concerns for Atlantic Canadians. It is therefore in the best interest of C-CIARN Atlantic (and its possible successors) and its members to focus more efforts in bringing research to the forefront for decision-makers. Although many important research questions remain unanswered, there is significant understanding currently to justify immediate adaptive action on the ground.

There remains in Canada today a split in climate change work between mitigation and adaptation. More often than not, the emphasis lies on mitigation. Although mitigation is a necessary step in dealing successfully with the issue, adaptation is also an absolute necessity. The two need to be taken together to allow for an appropriate and effective approach to be developed when addressing climate change. Due to the high sensitivity and vulnerability of the coastal zone in the Atlantic Provinces to climatic events, it is important to raise awareness of adaptation to climate change, while concurrently encouraging activities to mitigate impacts and thereby prevent further damage. Building linkages between the two sides of the climate change issue is essential for taking effective action on an issue so complex.

While government funds for research are always needed, much more is needed. The government is only one party working on climate change, and the entire Atlantic community should be working to decrease the region's vulnerability. Various levels of government in Canada have taken action on climate change and much of the funding allocated for climate change work goes towards science-based research. This is indeed necessary, but it is important to recognize the need for a broader base of support for, and attention to impacts of and adaptation to, climate change. Funding to help build the foundation upon which appropriate decisions on adaptation can be made is desperately needed.

Some C-CIARN members felt that there is a lack of long-term commitment from government on the issue of climate change. The need for stronger leadership and a more consistent and focused approach to impacts and adaptation issues has been recognized. Federal

government departments such as Environment Canada and Natural Resources Canada, in theory, share responsibility with provinces, municipalities, First Nations, and citizens to address climate change. However, in reality, there is a disconnect in this chain. Those who want the projects done, those who have the authority to do them, and those who can afford them are not one and the same. Because the federal government has limited means of reaching municipalities, there may be a need for more-detailed agreements with provincial governments. In the Atlantic region, dealing with four separate provincial governments, all of which have limited resources, is difficult. In addition, the frequent rebranding of climate change programming leaves provincial governments and municipalities either without programs or footing the bill.

The role that C-CIARN plays in assisting governments is that of a liaison among governments, researchers, and stakeholders. This role has been identified by network members as invaluable - it facilitates and strengthens the capacity for coordinated action on adaptation, incorporates adaptation into policy and operations, promotes and coordinates research on impacts and adaptation, supports knowledge-sharing networks, and provides methods and tools for adaptation planning.

9. The Future

For the period July 2006 to June 2007, C-CIARN Atlantic is operating under a program extension funded by Natural Resources Canada. During this period it continues to provide the full range of networking services that have made it successful since its inception. Having met the goals set for it more than five years ago, C-CIARN has laid a firm foundation for continued research networking in Atlantic Canada.

What might the future hold for facilitation of such research networking? We have considered the merits of continuing C-CIARN vs. establishing some sort of successor organization (vs. dropping the facilitation function altogether, an option that C-CIARN stakeholders do not support). Great advantages in both effectiveness and efficiency are associated with continuation of C-CIARN Atlantic, given how well connected it is with myriad climate-change stakeholders throughout the region. It is also keenly in tune with what the public is saying about impacts and adaptation work in the region. Thus, C-CIARN Atlantic's long-term commitment to build trusting relationships, as well as to engage stakeholders and sustain their dedication, could be used in a transition to a new phase and mandate founded upon the credibility that was built up over almost six years of C-CIARN Atlantic's activities.

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Appendix:

Key Stakeholder Contacts

	New Brunswick	Newfoundland and Labrador	Nova Scotia	Prince Edward Island
Provincial government departments	Still undecided internally	John Drover (Environment & Conservation) (709) 729-1090 jdrover@gov.nl.ca	George Foote (Energy) (902) 426-8168 Andrew Murphy (Environment & Labour) (902) 424-4936	Erin Swansburg (Environment, Energy & Forestry) (902) 368-6111 eoswansburg@gov.pe.ca
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