Municipal Case Studies:

CLIMATE CHANGE AND THE PLANNING PROCESS

New Brunswick

Natural Resources Canada / Ressources naturelles Canada

Canada

Even though almost everyone grumbles about our local weather, we have become accustomed to it. We have *adapted*. Depending on where we live and the season, we sport umbrellas, snow boots or ball caps. Our homes are insulated, crops are irrigated, and we shop in weather-conditioned, indoor malls. So, when scientists tell us our climate is changing and about to change more quickly, it is difficult to grasp the significance in our daily lives.

Our regional climate, wherever we live in Canada, has always been changing — gradually and naturally. But, in the past 20 years, international scientific research has determined that the pace of climate change is accelerating, with some areas becoming more and more vulnerable. With the early 2007 release of the latest report from the Intergovernmental Panel on Climate Change (IPCC), the reality of climate change and the growing challenges of adaptation are increasingly recognized and accepted. So too is the need for national governments to respond with efforts to mitigate these effects.

Closer to home, in urban and rural settings across the country, discussions will be focussed on what local climate changes are likely, how they will impact our physical and built environments, and how we should respond. It is easier to discuss what is happening locally and what we can do about it, instead of grappling with the monumental global challenge of greenhouse gas emissions. Community planners and municipal engineers will find themselves at the crux of local discussions, especially in relation to assessing potential impacts and developing policy responses. The vocabulary of these discussions will embrace terms such as "vulnerabilities", "maladaptations", "mitigations", "risk management" and "adaptive capacity".

Forward-looking local governments are starting to factor anticipated climate changes into their planning and budgeting. However, few, if any, local governments have climate change researchers within their administrations. Most rely on research undertaken by other levels of government and universities.

Five Municipal Case Studies

In 2004, the Earth Sciences Sector of Natural Resources Canada (NRCan) and the Canadian Institute of Planners agreed to co-sponsor ways to help build capacity at a local government level related to planning for climate change. This partnership led to a number of activities, including this series of case study brochures. The brochures have been produced to help community planners learn more about scientific practices and terminology, along with ways they might approach assessing local risks and developing locally appropriate responses.

There are five case study communities. In different ways and for different reasons, these communities are already experiencing the effects of accelerated climate change.

- In Calgary, warmer weather and changing precipitation patterns are affecting the city's sole water supply.
- In Salluit, a Northern Quebec coastal community, rapidly melting permafrost is threatening to undermine existing infrastructure.
- In Delta and Graham Island, BC and along the New Brunswick coast of the Gulf of St. Lawrence, rising sea levels and increased storm frequency and severity are impacting habitats, property and infrastructure.

Each case study was led by scientists and involved the participation of local planners, municipal managers/engineers and, in some cases, elected officials. Wherever possible, the study included broader community consultation through workshops and focus groups.

Summary

Storm-surge flooding and coastal erosion affect many low-lying areas of Canada's coastlines. The coasts of Nova Scotia, Prince Edward Island (PEI) and New Brunswick in the southern Gulf of St. Lawrence are among Canada's most vulnerable to sea-level rise. The 190 km Northumberland Strait, varying from 14 to 64 km in width, separates Prince Edward Island from New Brunswick and Nova Scotia. In 2000, two powerful and destructive storms ravaged coastal communities along the strait, as well as the southern Gulf. These, and several major storms that followed in short succession from 2001 to 2004, demonstrated existing vulnerability and highlighted the need for adaptation strategies to deal with climate change and accelerated sea-level rise.

"Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick" was a three-year study undertaken by scientists and researchers from over a dozen government and academic groups. The project was carried out in consultation with municipalities and planning commissions, community economic organizations and stewardship groups from Kouchibouguac National Park to Cape Jourimain (the entire Gulf coast of New Brunswick south of the Miramichi).

New Brunswick has approximately 5,500 km of coastline, stretching between the Gulf of St. Lawrence and the Bay of Fundy. Nearly 60% of the population lives within 50 km of the coast. Approximately 70% of the province's tourism, worth nearly three-quarters of a billion dollars annually, is tied directly to the coastal experience, where attractions depend on scenic beauty, as well as clean beaches and waterways.

Coastal features, such as beaches, dunes, barrier islands and salt marshes, act as natural buffers, helping to reduce the impact of storm surges, flooding and erosion. They also provide essential habitat for land and marine plants and animals, some of which are rare or endangered. Some features, such as beaches and dunes, are prone to erosion. Development in these areas can disrupt the natural eco-system balance, causing water-quality problems or greater risk of damage.

The goals of the project were to forecast likely climate changes, anticipate their physical impacts in relation to sustainable management and community resilience, and identify potential adaptation strategies. This involved rigorous scientific research into how the coastal area has changed in past years and making predictions about how it will change over the next 100 years. Using very precise surveying methods, some members of the research team constructed flood-risk maps to identify the extent of flooding for water levels in 10 cm increments, up to four metres above mean sea level. Other members of the team collaborated with local industry, government and community members to obtain an understanding of priorities and local capacity to adapt to accelerated changes.

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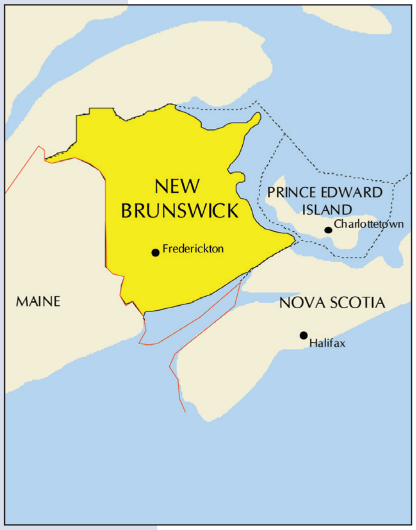

The project had ten sub-components, each headed by a senior scientist:

- sea-level rise and land subsidence;
- storm-surge, wind, wave and sea ice climatologies;
- storm-surge and meteorological modelling;
- elevation surveys and flood-risk mapping;
- coastal erosion;
- ecosystem impacts;
- economic and community impacts;
- adaptation strategies; and
- building adaptive capacity.

The last component integrates results of the first eight, providing valuable information to help with planning for future human settlement along the coast, as well as management of wildlife and plant habitats in the coastal zone. The flood-risk maps are now available to coastal communities and regional planners to assist in developing long-term adaptation strategies. Details of the project, including the project final report, can be found at the *New Brunswick Sea-Level Rise Project* website (**http://atlantic-web1.ns.ec.gc.ca/slr/default.asp?land+En&n=61BB75EF-11**).

Introduction

Rising global sea level is one of the most confidently predicted impacts of climate warming and has major implications for coastal communities around the world. The Third Assessment Report of the IPCC (2001) predicted an increase in global sea level between 1990 and 2100 of 9 to 88 cm, with a central value of 48 cm. Normalized to 100 years, this central value is greater than two and half times the average rate of global sea-level rise during the 20th century. Even if later estimates fall on the low side of the range above, the rate of sea-level rise along the New Brunswick coast will accelerate.

On the night of January 21st, 2000, a deep low-pressure system passed northward across the Maritimes causing havoc in numerous coastal locations. The storm-surge was most severe in Northumberland Strait, and caused record high water levels and flooding along the New Brunswick coast. A striking feature of this storm was the extent of sea-ice ride-up and pile-up onshore. In places, shore ice swept over the crest of coastal dunes, causing significant damage that exceeded any in the recollection of coastal residents. Residents were evacuated; businesses, shopping malls and schools shut down; and elective surgeries were cancelled. Subsequent claims paid by government were almost $1.7 million – a small fraction of the total economic damages.

Eight months later, on October 29th, another powerful "nor'easter" hit the southern Gulf of St. Lawrence coast. Sustained gale-force winds, combined with a high tide, flooded river estuaries to record levels. Along the shore and rivers, numerous buildings and structures sustained damage. Basements were flooded, parts of roads were washed away and telephone poles were toppled. The peak water level in this storm was not as high as in January, but (without sea ice) it was accompanied by powerful waves and caused severe damage to coastal infrastructure and fragile ecosystems. This time, government paid claims of almost $2.4 million.

These were not isolated incidents. Similar storms have occurred since, most notably in late December 2004. The southern Gulf coast will continue to experience extreme weather events, perhaps more often due to climate change and rising sea levels. The primary impacts are likely to be some combination of:

- higher and more frequent flooding of wetlands and adjacent shores;
- expanded flooding during severe storms and high tides;
- increased wave energy in the near-shore area;
- decreased sea-ice protection leading to increased wave attack;
- accelerated coastal retreat, including dune and cliff erosion, breaching of coastal barriers and destabilization of coastal inlets;
- intrusion of salt water into rivers and coastal freshwater aquifers;
- damage to coastal infrastructure — bridges, wharves and roads;
- impacts on bird and wildlife habitats; and
- broad impacts on the coastal economy — tourism, business and personal property.

Extreme winter storms have created havoc along the New Brunswick coast of Northumberland Strait. The low-lying coast is susceptible to inundation and erosion.

Environment Canada acted as the coordinator of all components of the scientific research and community consultations. The following partners had key and lasting roles in the program:

- Beaubassin Planning Commission
- Kent Planning Commission
- Université de Moncton
- Laurentian University
- University of New Brunswick
- Mount Allison University
- Centre of Geographic Sciences (Nova Scotia Community College)
- Dalhousie University
- La Dune de Bouctouche Irving Eco-Centre
- Province of New Brunswick
- Environment Canada
- Natural Resources Canada
- Parks Canada
- Department of Fisheries and Oceans
- Public Safety and Emergency Preparedness Canada
- Government of Canada's Climate Change Impacts and Adaptation Program

The scientific team met at key points during the study to share emerging findings and add new information. During and immediately after the storms of January and October 2000, November 2001 and December 2004, several team members travelled to the most affected areas and gathered invaluable data on flooding, water levels, ice damage, infrastructure damage and coastal erosion. This is unique, irreplaceable information.

All members of the multi-disciplinary research team were involved in a participatory community process at key points in the study.

When this project was initiated, the entire team of scientists agreed the approach would be community-driven, rather than academic; communities would have complete ownership of the process and results and, therefore, have more local capacity to weigh and implement adaptations, because:

- the impacts of climate change vary greatly from locality to locality;
- the range of potential adaptation strategies and their implementation is constrained or enhanced by community resources and capacity, and will be coloured by the values of specific individuals and groups; and
- top-down approaches, without buy-in from the community, can often fail.

The Setting for This Research

Biophysical Context

- The coastal zone of southeastern New Brunswick is home to several threatened species of plants and animals. An important aspect of the ecosystem research is to determine how sea-level rise and future storm events will affect critical habitat and species-at-risk. The natural environment of the study area functioned for millions of years before the first intervention by humans. Nature continues to function as it always has, constantly changing and adapting.
- The coastal plain is underlain by sandstone, mud stone and shale bedrock, and the surficial material consists of glacial deposits. The soils are poorly drained and include clay and sandstone. Poorly drained soils indicate water will remain in the soil longer than in well-drained soils such as gravel or sand.
- The area is low-lying with very little elevation or topographic relief, and the soils are poorly drained. There are no steep hills or escarpments to influence hydrology or climate, and the rivers that drain into Northumberland Strait are meandering and slow moving.
- Various ecosystems and landscapes provide habitat and feeding areas for wildlife. The principal eco-zones are saltwater habitat and coastal habitat. Salt marshes along the coast provide habitat not only for aquatic life such as fish, lobsters and bivalves, but also for migratory birds.
- The southern Gulf of St. Lawrence coast is the longest stretch of barrier coast in Canada, with barrier beaches and spits extending across shallow drowned estuaries. The beaches in Kouchibouguac National Park and the Bouctouche Spit (La Dune) are well-known examples.
- A destructive wave is one with a high run-up and strong backwash, which erodes a shoreline. During storms, the power of the backwash is much greater than usual and the rate of erosion is magnified. Thus, major storms can have catastrophic effects, causing rapid and dramatic changes to the coastline. This is particularly so in places like New Brunswick, where the beaches are thin and the buffering volume of the dunes is small.
- Kouchibouguac National Park is a mosaic of bogs, salt marshes, tidal rivers, sparkling freshwater systems, sheltered lagoons, fields and tall forests. The 25 km of shifting sand dunes attract many species of shorebirds and are witness to colonies of harbour and grey seals.

- The presence of sea ice in the Gulf of St. Lawrence inhibits wave development, thereby reducing erosion during winter storms. As predicted in climate change models, waves are expected to increase if sea ice in the Gulf decreases. Some models suggest that the Gulf of St. Lawrence could be free of ice as early as 2045. This would mean that the length of the wave season would substantially increase and wave impacts would occur year round. The speed of winter winds may also increase and large storm surges may occur more frequently.

Socio-economic Context

- The area began to change with the arrival of the Mi'kmaq peoples. French settlers arrived in the 1600s, followed by English settlers in the 1700s. Throughout the 19th and 20th centuries the economy was based on agriculture, forestry, shipbuilding and harvesting shellfish and other fish. Land clearing along the coastal plain was extensive and the coastal landscape is now devoid of trees. Today's economy is based on services and tourism. Visitors to the beach spend many thousands of dollars on food and lodging. Near-shore and inshore fisheries also provide an income for many households.
- The predominant settlement pattern occurs along primary and secondary roads, with clusters of cottages and permanent housing. The desire for waterfront property is pushing development inland from the coast to linear development along the rivers. (Note: In all of New Brunswick, over the period from 1990 to 1999, 6,268 new coastal lots were created – an average of 627 new coastal properties each year.)
- The Shediac area is within a half hour drive of Greater Moncton. With the continued growth of the city-region, more people are choosing to live permanently along the coast and commute to jobs inland.
- In-filling of salt marshes is taking place along the coastline. This increases sedimentation of watercourses, decreases the ability of marshes to cleanse water, and destroys valuable wildlife habitat;
- Coastal erosion is threatening historic and archeological sites, as well as recently developed properties.

The provincial government has a policy of coastal protection, but its application has been variable. Local governments in rural areas have limited planning powers.

Government Context

- The provincial government has been working to strike a balance between growth and environmental sustainability. In 2000, the Province prepared and released its *Coastal Areas Protection Policy*, which sets out a coastal management approach based on sensitivity to impact. The coastal area was divided into three zones (core, buffer, transition), and the acceptable activities for each zone were identified specifically. Province-wide consultation followed the release of this policy.
- The policy was not adopted through legislation or regulation, but it does set out guidelines for municipal governments to take into consideration.
- The zonal approach enables development officers, municipal officials and landowners to identify where one zone ends and another begins, and allows for different management of the three zones to reflect sensitivity, with the least activity in Zone A and progressively more activity through Zones B and C.
- The local governance structure in New Brunswick provides several categories of local government with varying powers and duties. Municipalities have the most powers and effective tools to regulate land use. Some of the more rural parts of the province have very limited regulatory powers. Consequently, the application of the *Coastal Areas Protection Policy* has been variable.
- The *Community Planning Act* makes provision for municipalities and rural communities to enact a flood risk area bylaw, with the Province's approval. Once an area is designated, a bylaw may set out engineering standards, designs and techniques to be followed in all development within the flood risk area. It may prohibit all development except that which is in accordance with the prescribed standards, designs and techniques.

Research Methods

In Atlantic Canada, the sea level has been rising relative to the land for thousands of years; a result of global mean sea-level rise and post-glacial vertical movement of the land. This relative rise has been slow. Climate warming, through ocean thermal expansion and melting of ice on the continents, threatens to raise the mean sea level on a global scale by several decimetres over the coming century. This is likely to accelerate historical rates of relative sea-level rise in Atlantic Canada. Storm effects, in conjunction with the mean sea level, may have far reaching impacts on infrastructure, property and wildlife habitat.

The overall research program was conducted through nine research components. A tenth component was a detailed integration of the findings of these diverse research studies. A summary of each component follows.

Sea-level Rise and Land Subsidence

To predict future sea-level rise, an accurate picture is needed of how the sea level has changed in the past. This research component, led by Dr. Don Forbes of the Geological Survey of Canada, examined data from tide gauges and geodetic systems, among other sources. The researchers also looked at geological and palaeoecological evidence for past sea-level changes on the floor of Northumberland Strait and in marsh deposits along the coast. By measuring and validating past trends in sea-level rise and vertical movement in the Earth's crust, the team made informed predictions of the net sea-level rise, which became a baseline for many other components of the overall program.

Physical Effect on Coastal Lands

This component involved examination of the physical effects of sea-level rise and climate change on the stability of coastal lands. Researchers used a combination of field surveys, maps, aerial photos, airborne video interpretation, airborne photogrammetry, LIDAR Digital Elevation Map interpretation, and shallow marine surveys to define the sub-marine components of the coastal system. Through this work, researchers were able to measure the past rates of coastline and shoreline changes, and estimate future rates of erosion with an increased sea-level rise. They also identified the cause of local erosion, noting areas of greatest vulnerability. Dominique Bérubé of the New Brunswick Department of Natural Resources led this work.

Storm-surge and Meteorological Modelling

This component predicted trends in water levels during the next century. The project team considered factors such as tides, waves, the presence of ice, weather and storm surges — all of which affect sea level and the likelihood it will cause flooding or other damage. The researchers used historical climate data and real-time observations to calibrate their model, making predictions about the likelihood of flooding under various climate change scenarios. Dr. Hal Ritchie of the Meteorological Service of Canada led this work.

Storm-surge, Wind, Wave and Sea Ice Climatologies

This component, led by George Parkes of the Meteorological Service of Canada, examined tide gauge records, meteorological data, wave records and remotely sensed sea ice data to build a picture of climate variability and extreme events, particularly storms and floods, over the past 30 to 60 years. It examined the nature of storms giving rise to serious impacts on the New Brunswick coast and considered the effects of sea ice on storm-surge heights and impacts.

Elevation Surveys and Flood-risk Mapping

This component, led by Dr. Tim Webster of the Centre of Geographic Sciences, Nova Scotia Community College, involved precise surveying and the production of 3D digital elevation models and maps. Storm surges are typically 0.6 to 2 m in height for this region; therefore technologies with vertical precision significantly finer than these values must be employed to generate flood-risk maps of sufficient resolution. Traditional ground-based surveying, global positioning systems (GPS), and newer LIDAR technology were used. LIDAR mapping involves an aircraft scanning the ground beneath its flight path with laser pulses and measuring the return time of each pulse to determine the precise position and elevation of the point where it was reflected.. Data are then used in computer simulations to see which areas would be flooded when sea levels reach various heights.

Computer simulations were used to determine which areas would flood for events of varying return period, from 2 to 100 years, with and without sea-level rise. Animation sequences were constructed for some areas.

Rising sea levels will impact several aspects of the region's economy, including commercial fishing and eco-tourism.

Flood depth maps were constructed in order to better estimate the potential economic and ecosystem impacts of coastal flooding events. The flood depth maps of the January 2000 flood were used for validating the results of the flood modelling. Additional flood risk maps were generated for 10 cm increments in water level to allow for a more precise estimate of the areas potentially affected by future sea-level rise and storm-surge events. The 10 cm increment flood extents are available as vector polygons that denote the area of flood inundation.

To visualize flooding as a result of a storm-surge event superimposed on sea-level rise, animation sequences were constructed for some areas. These simulate a perspective view of the landscape. The water level associated with a storm-surge or sea-level rise is then increased and flows over the landscape. The water levels for the flood risk animation sequences increase by 10 cm increments to levels of historical flooding and potential future flooding with sea-level rise. This proved to be a very effective way to present the flood-risk modelling results to local government officials and the general public.

Coastal Erosion

This component involved examination of the physical effects of sea-level rise and climate change on the stability of coastal lands. Researchers used a combination of field surveys, maps, aerial photos, airborne video interpretation, airborne photogrammetry, LIDAR Digital Elevation Models and shallow marine surveys to build an understanding of the whole coastal system. Digital analysis of air photographs going back to 1944 provided data on erosion rates over 60 years. Through this work, researchers were able to measure the past rates of coastline and shoreline changes, and estimate future rates of erosion with an increased sea-level rise. They also identified the key processes driving erosion, noting areas of greatest vulnerability. Dominique Bérubé of the New Brunswick Department of Natural Resources led this work.

Ecosystem Impacts

This project component examined the amount and distribution of wildlife habitat, and estimated how the habitat and species-at-risk will respond to sea-level rise and human impacts from such activities as infilling and the construction of seawalls or causeways. Impacts of sea-level rise, drainage and other human activities on salt marsh habitat were examined using historical air photographs. It was shown that losses of salt marsh area ranged from 5% to 35% between 1944 and 2001 at various places along the coast. Beach and dune habitat also declined between 8% and 40% over the past 60 years. Potential impacts of sea-level rise on endangered species such as the Piping Plover, on colonial nesting birds such as gulls and terns, and on rare plants were all considered. As a result, researchers will be able to develop management strategies that will help to minimize negative impacts on coastal ecosystems at future sea levels. Dr. Alan Hanson of the Canadian Wildlife Service managed this research.

Economic and Community Impacts

This component, led by Lisa DeBaie of Environment Canada, considered how economies and communities will be affected by a changing environment. The study examined potential impacts on eco-tourism, cultural tourism, potential property damage costs and societal costs associated with the loss of coastal wetland habitat. This work provided economic estimates of flooding and erosion impacts, and their implications for future development with rising sea levels and climate change. The results can be used to raise awareness of "pocketbook" impacts on local communities and provide a basis for moving toward adaptive practices.

Integration

This part of the project, led by Dr. Liette Vasseur of Laurentian University, integrated information from other project components, making the knowledge generated in the study easier to use. Through consultations with communities and planning commissions, the project team developed a system to provide information and serve as a tool for community decision-making.

Adaptation Strategies and Adaptive Capacity

These components, led by Dr. Sue Nichols of the University of New Brunswick and Dr. Liette Vasseur of Laurentian University, focussed on how people can adapt to the various physical and socio-economic impacts of climate change. It examined how risk management techniques can be used to assess the cost and benefit of various adaptation options, considering these as part of short-, medium-, and long-term strategies. The team also compiled a database of strategies already being tested nationally and internationally. This work will provide tools that help residents, governments and industry to make informed decisions on how they plan to adapt to the effects of climate change. From a community planner's perspective this work may be of considerable interest.

The initial research was focussed on getting community input on:

- how people had adapted in the past to sea-level rise and storm surges;
- what their experiences have been during the recent major storms;
- what future threats did they perceive;
- what measures they have taken (if any); and
- what best practices could be learned from the community efforts.

Information on the communities' adaptation status was mostly gathered through 27 interviews and three focus group discussions conducted in different communities from 2003 to 2005. Participants were also taken to sites with researchers to discuss impacts and adaptation methods. Seven public information sessions were held in different communities to share early research results and build the link with communities, followed by a two-day workshop. Over this period, the researchers observed an increased sense of emergency and a desire to act towards adaptation. They also found that individual property owners had been investing in shoreline protection or making other accommodations. Some groups and government agencies have used a shoreline restoration approach to adaptation.

Adaptation

The process of adjusting to a set of circumstances that have changed the natural or human-made environment. It includes the development of strategies to either counteract a threat to the existing environment or to make use of a positive change. Adaptation, as a process, is also intricately connected to impact analysis, which is a prerequisite.

Overall, researchers found:

- a lack of information on possible techniques and practices;
- insufficient and unequal resources to address the coastal issues;
- a lack of local governance and effective tools to manage coastal development; and
- a regulatory process that is complex, ineffective and applied inequitably.

The analytical part of this component involved creating a decision-making framework to help stakeholders adapt to sea-level rise and climate change. The framework, which includes a process for choosing appropriate adaptation strategies for specific locations, was formed through discussions with communities, examination of key referenced works and analysis of accounts of personal experience. The framework has three objectives:

- to provide those involved in developing adaptation strategies with a guide that emphasizes the importance of community involvement and empowerment;
- to create an approach that would be transferable while making the process applicable to the local constraints and opportunities of unique communities;
- to provide communities with a decision-making tool that helps a diverse group of people to understand the range of adaptation options available to them, with the aim of communally defining options that "protect and enhance the community's well-being".

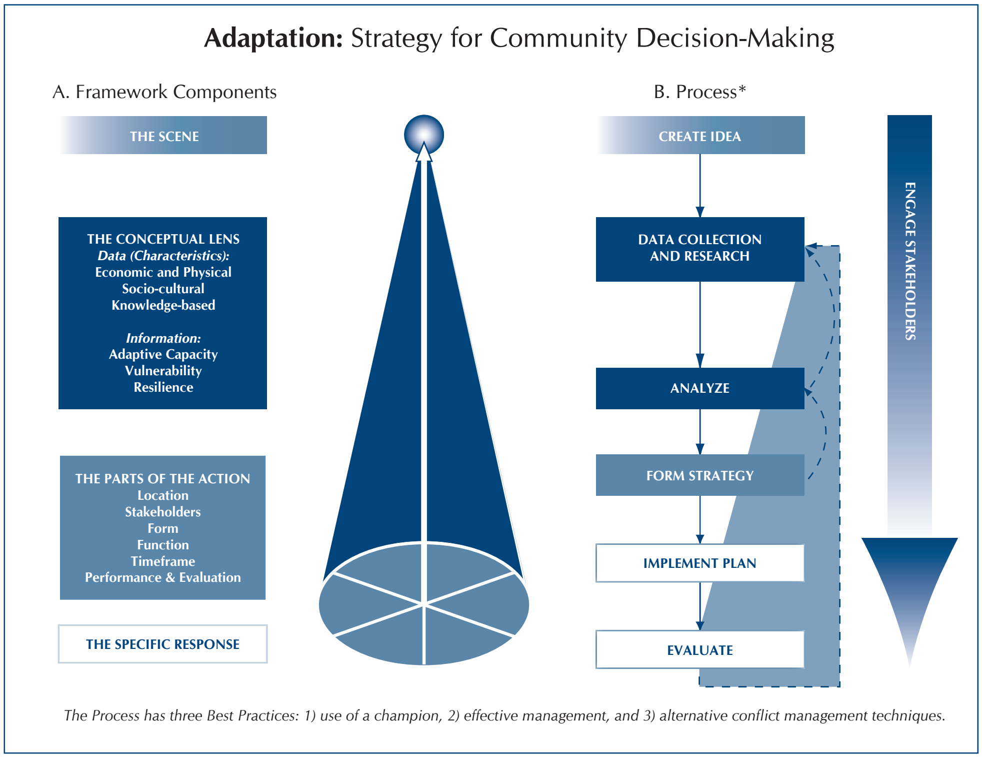

Figure 1 Adaptation: Strategy for Community Decision-Making (after ICCC, [Sutherland 4-6, trad adation 2-4, Mendis et al, 2003 p.45] [2005, (after, [1998, p.79), Lim, B.,E. Spanger-Siegfried, ed.[2005, p.]).

This adaptation framework is composed of two parts: (a) the framework components and (b) the processes. This framework can be used to examine the rationale of previous adaptation strategies or to create new ones. Applied either as an analytical instrument or used as a community decision-making tool, the framework emphasizes the importance of an empowered community approach.

Relevance for Other Communities

This research is relevant to all low-lying communities along Canada's coastlines, especially for rural municipalities, seasonal settlements and communities that are highly dependent on coastal tourism. As sea level rises and storms intensify with climate change, private property, public infrastructure, local economies and even lives will be more at risk. Productive and ecologically sensitive habitats may be compromised or reduced.

This multi-faceted research program has produced a wealth of scientific and technical information that provides an excellent framework for similar studies in other communities. Additionally, the commitment of the entire team to a community-driven approach provides a sound model for other

Role of Community Planners

The ability of Canadian communities to respond effectively to climate change depends on a range of factors, including scientific information, access to financial resources, and the state of existing infrastructure, education, technology, and management capabilities. Some communities with limited capacity to respond may face more risks in the future. The New Brunswick case study reveals several challenges for small towns and rural communities, including lack of information about adaptive measures, insufficient planning tools to protect the coastline and limited resources to minimize future risks to public and private property.

Historically, planners have been facilitators of change, helping to make progressive choices as societal values, needs, resources and capacities change. Recognizing change and helping others adapt to change are likely to be planners' most enduring roles in relation to climate change. In coastal communities, planners will probably continue to do this through stakeholder consultation processes as part of community-wide and area-specific plans. Through these planning processes, planners will help residents, businesses, investors, and other stakeholders learn more about risks and the trade-offs associated with them. In part, because of their communication and organizational skills, Canadian planners are more and more frequently on the front lines in emergency preparedness planning.

In larger municipalities with more resources, some planners may focus their work on environmental issues, including climate change. In the largest municipalities and metropolitan agencies, planning staff may be dedicated to the issues directly associated with climate change.

In addition to their roles as communicators and facilitators of consultation processes, planners have access to policy and, in some provinces, the regulatory measures that, if supported by decision-makers, will help avoid further risks associated with sea-level rise and storm surges. British Columbia's "development permitting process" provides local governments with the tools to fully review development applications in environmentally sensitive areas, provided that local government chooses to identify these in its community (policy) plan.

In some provinces, planners may also have an opportunity to have input into incentive programs that encourage responsible land use and building in flood-prone areas. Additionally, in the future, the insurance industry may call on planners to help design guidelines that advise policyholders how to minimize risks associated with flooding and extreme climate events.

science-based climate impact studies. Through early and ongoing involvement in the three-year research program, community stakeholders began to own the results, recognize their significance, and work together to identify adaptive approaches.

The research also revealed the lack of effective planning tools in the area's communities. Although the provincial government has provided educational materials and a policy framework for coastal protection, rural communities find that they have no direct regulatory authority to implement the guidelines. Planners' ability to influence development activity within the coastal zones is primarily through advising applicants of the risks. Local planning authorities welcomed the findings of this research, as it provides them with more knowledge of likely impacts. The visual tools provided through the research program — LIDAR maps and video simulations of flooding at various risk levels — are also helpful materials for use in public meetings and in discussions with development applicants.

Sources, Contacts and Additional Resources

- *The Climate Change Impacts and Adaptation Program, Earth Sciences Sector, Natural Resources Canada*. The objectives of the program are: to improve knowledge of Canada's vulnerability to climate change; to better assess the risks and benefits posed by a changing climate; and to build the foundation on which appropriate decisions on adaptation can be made. The program supports research to fill critical gaps that limit knowledge of vulnerability; to undertake and support assessment of impacts and adaptation; to enhance collaboration between stakeholders and researchers; and to facilitate policy development. **http://adaptation.nrcan.gc.ca/index_e.php**
- *The Partners for Climate Protection (PCP)* program is a network of more than 132 Canadian municipal governments that have committed to reducing greenhouse gases and acting on climate change. PCP is the Canadian component of the Cities for Climate Protection (CCP) network of the International Council for Local Environmental Initiatives. The network comprises more that 600 communities worldwide making similar efforts. **www.sustainablecommunities.ca**
- *The Coastal Education and Research Foundation (CERF)* is a non-profit corporation dedicated to the advancement of the coastal sciences. The foundation is devoted to the multi-disciplinary study of the complex problems of the coastal zone. **www.cerf-jcr.org**
- *Fisheries and Oceans Canada* is the lead federal government department responsible for developing and implementing policies and programs in support of Canada's economic, ecological, and scientific interests in oceans and inland waters. The Habitat Management Division has published guidelines for protecting fish populations and their habitats from the damaging effects of land development activities. **www.dfo-mpo.gc.ca/us-nous_e.htm**
- *The New Brunswick Climate Change Hub* facilitates the exchange of ideas, information, and resources between government, private sector, and community-based organizations engaged in climate change. **www.nbhub.org/main-e.php**
- *The Irving Eco-Centre: La Dune de Bouctouche* was developed by J. D. Irving Ltd. to protect and restore one of the last great dunes on the northeastern coast of North America. The fine sand dune, extending 12 km across the mouth of Bouctouche Bay, was created since the last ice age by the constant movement of sand due to the wind, tides, and ocean currents. The dune, estimated to be 2,000 years old, changes shape with every major storm. It provides habitat for a wide variety of aquatic plants and animals, and shorebirds and waterfowl, making this a major ecological site. The Irving Eco-Centre contributes scientific knowledge of dune ecosystems along the north Atlantic coast. **www.ifdn.com/Dune/index.html**

- *Kouchibouguac National Park* is a Canadian Heritage protected area. One of two wilderness Canadian national parks in New Brunswick, Kouchibouguac is a mosaic of bogs, salt marshes, tidal rivers, freshwater systems, lagoons, abandoned fields and tall forests, features that characterize the Maritime Plain Natural Region. The 25 km of shifting sand dunes are home to the endangered Piping Plover. **www.pc.gc.ca/pn-np/nb/kouchibouguac/index_e.asp**
- *The Canadian Meteorological and Oceanographic Society (CMOS)* is the national non-governmental organization serving the interests of meteorologists, climatologists, oceanographers, limnologists, hydrologists and cryospheric scientists. CMOS publishes an internationally recognized scientific journal, and a bulletin. It also offers other publications such as books, annual reports and abstracts of presentations at annual congresses. **www.cmos.ca/**

Glossary of Case Study Terms

Sea-level Rise. An increase in the mean level of the ocean. Eustatic sea-level rise is a change in global average sea level brought about by an alteration to the volume of the world ocean. Relative sea-level rise occurs where there is a net increase in the level of the ocean relative to local land movements. Climate modellers largely concentrate on estimating eustatic sea-level change. Impact researchers focus on relative sea-level change.

Storm-surge. This refers to a temporary increase, at a particular locality, in the height of the sea due to severe weather conditions (low atmospheric pressure and/or strong winds). The storm-surge is defined as being the excess above the level expected from the tidal variation alone at that time and place.

Glossary of Climate Change Terms

The Intergovernmental Panel on Climate Change (IPCC) assesses scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. IPCC maintains a glossary of terms used in the science and study of climate change. The following terms selected from that glossary are some that community planners and municipal engineers will use increasingly.

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

Adaptation Assessment. The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency, and feasibility.

Adaptation Benefits. The avoided damage costs, or the accrued benefits, following the adoption and implementation of adaptation measures.

Adaptation Costs. Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.

Adaptive Capacity. The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Aquifer. A stratum of permeable rock that bears water. An unconfined aquifer is recharged directly by local rainfall, rivers, and lakes, and the rate of recharge will be influenced by the permeability of the overlying rocks and soils. A confined aquifer is characterized by an overlying bed that is impermeable and the local rainfall does not influence the aquifer.

Capacity Building. In the context of climate change, capacity building is a process of developing the technical skills and institutional capability in developing countries and economies in transition to enable them to participate in all aspects of adaptation to, mitigation of, and research on climate change, and the implementation of the Kyoto Mechanisms, etc.

Climate. Climate, in a narrow sense, is usually defined as the "average weather" or, more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate, in a wider sense, is the state, including a statistical description, of the climate system.

Climate Change. Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Demand-side Management. Policies and programs designed for a specific purpose to influence consumer demand for goods and/or services. In the energy sector, for instance, it refers to policies and programs designed to reduce consumer demand for electricity and other energy sources. It helps to reduce greenhouse gas emissions.

Ecosystem. A system of interacting living organisms together with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study. Thus, the extent of an ecosystem may range from very small spatial scales to, ultimately, the entire Earth.

Extreme Weather Event. An extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An extreme climate event is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g., rainfall over a season).

Habitat. The particular environment or place where an organism or species tend to live; a more locally circumscribed portion of the total environment.

(Climate) **Impact Assessment**. The practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

(Climate) **Impacts**. Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Infrastructure. The basic equipment, utilities, productive enterprises, installations, institutions, and services essential for the development, operation, and growth of an organization, city, or nation. For example: roads; schools; electric, gas, water utilities; transportation, communication and legal systems would be all considered as infrastructure.

Potential Impacts. All impacts that may occur given a projected change in climate, without considering adaptation.

Residual Impacts. The impacts of climate change that would occur after adaptation.

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

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