Municipal Case Studies:

CLIMATE CHANGE AND THE PLANNING PROCESS

Graham Island

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 governments 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 New Brunswick's Northumberland Strait, 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/engineers and, sometimes, elected officials. Wherever possible, the study included broader community consultation through workshops and focus groups.

Summary

Graham Island is the most northern of the Queen Charlotte Islands, also known as Haida Gwaii, located approximately 100 kilometres off British Columbia's North Pacific coast. The study area — the northeast area of Graham Island — is highly sensitive to future sea-level rise. It naturally experiences extreme environmental conditions, including tidal ranges approaching seven metres, intense wave action, storm surges, and strong winds, typically above gale force. The people of northeast Graham Island are no strangers to the powerful elements of nature and have shown resilience in the face of these natural hazards, which also include strong earthquakes.

The Intergovernmental Panel on Climate Change (IPCC) estimates that global average sea-level rose between 10 cm and 20 cm during the 20th century. On the mainland in Prince Rupert, the sea-level rose 12 cm during that period and is currently rising at a rate of 1.5 mm per year. Recent models predict a further rise in global average sea-level of up to 60 cm by 2100. Though these amounts of rise may seem small, they can cause hazards such as hundreds of metres of tidal encroachment on relatively flat and erodible beaches, for example, North and East Beaches. In addition, extreme water levels and storm surges are rising and will contribute to greater coastal erosion and flooding. The study linked these trends to major cyclical variations in climate, including El Niño, a major warming of equatorial waters in the Pacific Ocean that occurs every four to seven years, and the Pacific Decadal Oscillation that occurs every 20 to 30 years. Both of these weather patterns have become more extreme with recent global warming.

Two communities on northeast Graham Island — Masset and Old Masset Haida Nation Reserve — are low-lying and vulnerable to flooding. An evacuation route for these communities was closed for six months due to inundation and washouts. Further south near the community of Tlell, many property owners have lost land to erosion. The main highway that connects the northern communities to Queen Charlotte City, the ferries, and the Sandspit Airport, is continuously threatened in this area by erosion and flooding.

The study took a local perspective and used an integrated approach to assess human and biophysical vulnerability to climate change. This involved a local focus group to guide the research, in depth interviews with key community members (e.g., emergency and municipal planners, Haida elders, business owners and local residents), a community workshop, and several community research forums. The study examined community resilience and adaptive capacity, as well as environmental sensitivity to climate change, and combined these findings to assess ways to build on existing and potential adaptive capacities at the community and household scale.

This participatory, community-based approach showed that:

- ✓ local knowledge is important in assessing adaptive capacity to climate change and developing effective, longer-term adaptation strategies;
- ✓ remote communities are inherently, geographically vulnerable, but typically have skills and experiences (e.g., hunting, fishing, food gathering, food stockpiling, coping with storms and power outages) that make them resilient in the face of natural hazards and community changes; and

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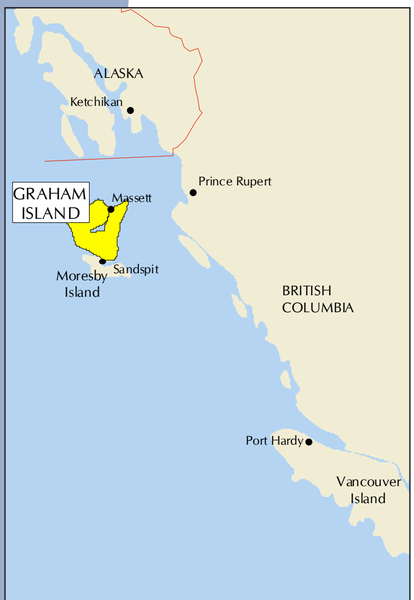
✓ these communities are more prepared to respond to short-term hazardous events, such as extreme storms or earthquakes, rather than to gradual climate change impacts, such as sea-level rise and accelerating erosion.



At the beginning of the study, the research team aimed to involve community members in developing an integrated human-environmental vulnerability index. During the study, however, discussions with community members revealed the difficulty of assigning a numeric index to human values and preferences. The study concluded with several recommendations, based on the three key points above, for enhancing adaptive capacity and reducing the overall vulnerability of the communities of Northern Haida Gwaii to climate change. The conclusions of the study provide highly relevant information that lays the groundwork for developing evaluative tools and planning strategies to enable communities to make their own informed decisions about priorities for action.

Introduction

The world's coastal communities will experience the impacts of climate change. Gradual sea-level rise has been observed and is expected to continue. Although a gradual rise in sea-level may seem a manageable, low-impact change, it is likely to be magnified by extreme weather events, higher tides, storm surges, and increased coastal erosion — the kinds of occurrences to which communities will have to respond. El Niño will be the primary driver, with rising sea level, that will impact this northern Haida Gwaii coast. Depending on their physical location and exposure, as well as their capacity to adapt, different coastal communities will probably experience the impacts of climate change in different ways. Some of the impacts that such communities may experience are:

✓ loss of land, including valuable waterfront in developed areas;

✓ increased flooding of low-lying areas;

✓ erosion of beaches, dunes and other sensitive ecosystems;

✓ damage to water, sewer, transportation, and utility infrastructure;

✓ loss of livelihood of waterfront communities;

✓ compromised drinking water due to the intrusion of salt water into ground water aquifers; and

✓ increased salinity of agricultural areas that may become unsuitable for growing crops.

The Study Area

The Geological Survey of Canada (GSC) classifies the northeast coast of Graham Island as one of the most sensitive in Canada to future sea-level rise. Over the 20th century, extreme storm and water level events increased in frequency and magnitude. When these short-term, intermittent events are superimposed on the longer-term gradual rise in sea-level, related to climate change, they compound the challenges that the 21st century will present.

Scientists have observed Graham Island's East Beach retreating at a rate of one to three metres per year. In extreme years, the beach has retreated by tens of metres. As the sand from East Beach is eroded, some is transported westward around Rose Spit to North Beach, where the coastline is actually growing in a process called progradation.

Significantly, average air and water temperatures have also been rising in the study area. Air temperature in coastal BC has warmed by 0.5°C to 0.6°C over the past 100 years. In northwestern BC, the average air temperature has increased by 1.7°C — about three times the global average, and average ocean temperature rose by 1.6°C during the 20th century — twice the global average.

The Naikoon Peninsula on northeast Graham Island is the area of study, which includes the Villages of Masset and Old Masset, a Haida First Nation community. The aim of the study is to assess both the human and biophysical attributes of adaptive capacity and vulnerability to climate change. The research, conducted on two fronts, assessed:

1. community resilience and adaptive capacity to both environmental and socio-economic changes; and
2. the biophysical sensitivity, resilience and physical impacts of climate change.

Northeast Graham Island is highly sensitive to sea-level rise and subject to extreme tidal ranges, energetic wave action, frequent storm surges and strong gale winds.

The Local Partnership

A team of researchers from the University of Victoria (UVic) and the Geological Survey of Canada (GSC) collaborated with key community groups, municipalities and other government organizations to conduct the study. The groups provided input about local environmental and physical changes, community values and areas of cultural significance. They also provided logistical support and reviewed research products. The participating groups included:

- ✓ Council of the Haida Nation (CHN);
- ✓ Village of Masset (VOM);
- ✓ Old Masset Village Council (OMVC);
- ✓ Skeena-Queen Charlotte Regional District (SQCRD);
- ✓ BC Parks; and
- ✓ Queen Charlotte Islands Chamber of Commerce.

Natural Resources Canada and the Climate Change Impacts and Adaptation Directorate (CCIAD) funded the work, which resulted in a final report from Dr. Ian Walker (UVic Geography) who led the study.

The Setting for This Research

Graham Island is the largest and most northern island in the Queen Charlotte Islands. Northeast Graham Island, the setting for the research, stretches north of Tlell and Port Clements and is surrounded by Hecate Strait, Dixon Entrance and Masset Inlet. Three communities participated in the research: the Village of Masset, Old Masset – a Haida First Nation community, and Tlell – an unincorporated community on Highway #16 in the southern portion of the study area.

Sections of the island's main highway are currently eroding, and close to the high tide elevation, making it vulnerable to inundation and washouts. Culturally significant sites and cemeteries in the low-lying villages of Masset and Old Masset are threatened.

Geophysical Context

Over 100 kilometres of sandy shoreline is backed by dunes and bluffs. East Beach, North Beach and Rose Spit form a dynamic coastline that has developed in response to extreme conditions, including:

- ✓ a *macrotidal* range (tidal range approaching seven metres);
- ✓ energetic wave action;
- ✓ frequent storm surges that can reach 40 to 70 cm; and
- ✓ strong winds that exceed gale force (65 km/hour).

The GSC has classified northeast Graham Island as highly sensitive to sea-level rise. Gradual sea-level rise, in conjunction with extreme weather events, is contributing to the active erosion of the island's East Beach, which is shifting landward at a notable rate of one to three metres per year. In contrast, the same forces are contributing to the build up of North Beach, where new land is being created at a rate of approximately 30 cm per year.

Masset and Old Masset are located on the northwestern tip of the study area, facing Dixon Entrance. Sheltered from dominant and strong SE winter winds, this location is somewhat protected from the fury that often attacks the eastern shores. Nevertheless, these communities have endured exposure to many storms and high winds from the NW over the years. Coastal properties of some residents and businesses in Masset and Old Masset have experienced erosion and flooding. The Masset Sanctuary Road, an emergency evacuation route, was closed between November 2003 and May 2004 due to inundation and washouts resulting from high tides and winds. This area will be flooded more frequently with gradual sea-level rise. The continual erosion of the eastern coastline near Tlell has threatened access of northerners to the rest of the island and caused repeated damage to Highway #16 leading to Queen Charlotte City. This is a critical transportation link — it is the route to the ferry port and regional airport at Sandspit. Ferries and flights bring essential supplies and provide transportation to off-island medical services, including for pregnant women who must deliver their babies off the island.

Most communities in Haida Gwaii are low-lying — roughly one to five metres above sea-level — and vulnerable to flooding. Low-lying sewer and water infrastructure is also at risk, as are cemeteries and culturally significant sites, including Rose Spit, which the Haida consider the birthplace of their people.

Socio-economic Context

The Village of Masset is a former fishing community and Canadian Forces base with a current population of approximately 900 people. It was incorporated in 1961 and is the largest of three incorporated villages on the Queen Charlotte Islands. The village and surrounding area is known for its pristine beauty, sport fishing, beautiful beaches, hiking trails and birdwatching.

Old Masset is a Haida First Nation Reserve with a population of approximately 700 people that has been increasing. The Village of Masset suffered population decline following the devastating closure of a Canadian Armed Forces base in the mid-1990s, after which some 500 to 600 military personnel and their families left the area. Declines in the fishery and forestry sectors have also contributed to the decrease in population, as well as to high unemployment and lower income levels.

The region's large First Nation population is reflected in a strong Haida culture. There is a deep attachment to the land, many culturally significant sites, traditional events and ways of life that include potlatches, ceremonies for repatriation of remains, food gathering and teaching of the Haida language.

The island geography and distance from major urban centres isolate these communities. Access to Graham Island is by plane or ferry, and poor weather frequently causes cancellations and delays. There is no public transportation on the island — residents and visitors rely on personal vehicles, a small taxi fleet and a private shuttle service. The remote location and limited transportation resources limit access to social, health, and education services, as well as to other communities. In some ways, this has promoted development of adaptive behaviours, including food gathering and stock piling, which allow residents to cope with occasional food shortages.

Planning Context

Decision-making and land-use planning are complex processes in the region. These are complicated by historical tensions between communities and governments in the areas of fishing, forestry, service provision and local involvement in decision-making.

The Council of the Haida Nation (CHN) and the Province of British Columbia co-managed a land-use planning process for the Queen Charlotte Islands that has led to the recent signing of the Haida Gwaii Strategic Land Use Agreement. The agreement identifies land areas to support sustainable resource development, as well as ecological, cultural conservation, spiritual and recreational activities. More detailed planning will take place to implement the plan, including coastal zone planning. The planning process to date has not achieved an agreement and has entered "government-to-government" negotiations. Linked to this process is the development of a *Community Viability Strategy,* which was completed in March 2007.

The Village of Masset is preparing to update its OCP. The community has an active emergency preparedness committee and a plan that identifies an evacuation site, promotes self-sufficiency, and addresses the possible impacts of tsunamis, earthquakes and spills of hazardous goods. A survey of over 200 homes in the Masset-Old Masset region showed that while emergency planning was considered important, relatively few respondents were aware of such plans and many felt that practicing them was not necessarily important. In Old Masset, council members make planning and land-use decisions through informed discussion and rely to a lesser extent on documented policies and bylaws. The community is in the process of developing a *Five-Year Human Resources Strategic Plan* with a broad focus on employment, health, education and youth.

The Research Program

Scientific research was carried out to describe the geomorphology of northeast Graham Island. This research provided important background information about environmental and human vulnerability. A summary of the findings follows:

During the *El Niño* event of 1997/98, sea level rose by 40 centimetres and 12 metres of the beach was eroded.

- ✓ Average sea level has been as low as 150 metres and as high as 18 metres above modern levels in the past 10,000 years.

About Sea-Level Rise & Coastal Dynamics

Measuring the increase in sea-level is challenging. Sea-level rise consists of two components:

1. An increase in the amount of water in the oceans, or the eustatic component of sea-level rise. It relates to the quantity of water and largely increases due to melting of ice on land.
2. An increase in the volume of space that water occupies, or the steric component. This occurs because the volume of water expands as its temperature warms.

In addition to the gradual change in sea-level, there is natural short-term variability in the climate. This variability includes extreme weather events such as storms that produce storm surges, increased wave run-up, enhanced erosion and flooding. The effects of this natural climate variability are superimposed on gradual sea rise.

Closely tied to weather patterns, oceans provide moisture, influence air temperature, change atmospheric pressure and generate storms. For example, every three to seven years, a major warming of the equatorial waters occurs in the Pacific Ocean. This large-scale cyclical event is called El Niño and causes shifts in “normal” weather patterns. El Niño is known to produce enhanced storm waves and winds. During the El Niño of 1997/98, scientists observed a regional sea-level rise of 0.4 metres in Hecate Strait, and enhanced storm waves and winds that caused the beach to retreat up to 12 metres.

Wave energy, currents and tides are forces that can move sediments and carry them a considerable distance. Significant sediment transport is changing the shape of the shoreline. Sediment can be eroded from a shoreline or can cause a shoreline to build up, or accrete, in a process called progradation.

- ✓ The current rate of sea-level rise is more than 1.5 mm per year.
- ✓ The northeast coastline of Graham Island is highly sensitive to sea-level rise due to erodible sediments, tidal range, wave action and on-going erosion.
- ✓ East Beach is retreating at a rate of one to three metres per year, and by tens of metres in extreme years.
- ✓ North Beach is growing seaward or prograding, at a much slower rate than the erosion of East Beach.

Residents of the area contributed invaluable local knowledge of social and environmental changes. A community mapping process identified significant cultural features.

Environmental Resilience and Sensitivity

Using this background knowledge and field research, researchers assessed coastal erosion rates, sediment movements, changes in landform and flooding hazards. They used a combination of traditional topographic and bathymetric surveys, high-resolution mapping of the landscape using differential global positioning systems (DGPS), airborne laser imaging (LIDAR), and digital air photography. One key product was a series of flood hazard maps based on plausible scenarios of future changes in mean sea-level. These maps show the extent of coastal and estuarine flooding for the Masset-Old Masset region and allow the community to visualize the potential extent and location of sea-level rise inundation.

Community Adaptive Capacity

In addition to modelling geomorphic sensitivity to sea-level changes, researchers used participatory approaches to gather information from community members on adaptive capacity and vulnerability:

- ✓ *Focus group, 2004*. This session was a valuable start to the data collection phase. It ensured that data gathering techniques were appropriate to the education, literacy and cultural characteristics of the community members.
- ✓ *Community workshop, 2004*. During this day-long session, local knowledge of past social and environmental changes was gathered. Researchers learned how the community responded to past changes and how future responses might be improved. One important outcome of the workshop was the *Northern Haida Gwaii Community Map* that shows locally-valued ecological and social locations and activities. For example, the map, developed using the *Green Map™ System*, identifies the location of cemeteries, food gathering sites and culturally modified trees.
- ✓ *Key informant interviews, 2004/05*. Interviews with 14 key informants provided insights into what local community members perceive to be their strengths and weaknesses for coping with social and environmental changes. Both short- and long-term residents — volunteers, local policy makers, council members, seasonal workers and community leaders — took part in these interviews.
- ✓ *Household survey, 2004*. Approximately 200 door-to-door surveys were administered in four communities (Masset, Old Masset, Tow Hill and Tlell) as another means to gather and assess household and community perceptions of their adaptive capacity and vulnerability to climate change-related changes.

The study helped to identify the attributes of vulnerability and the adaptive capacity of the North Haida Gwaii community.

From this research, attributes of vulnerability to climate change were identified, including:

- ✓ geographic isolation and high exposure to climate change-related hazards and sea-level rise;
- ✓ limited access to essential services (e.g., health care, social services);
- ✓ high dependency on the natural resource sector (e.g., fishery, forestry);
- ✓ economic instability and restructuring;
- ✓ high unemployment; and
- ✓ frequent power outages and short-term food shortages.

In addition to vulnerabilities, local attributes of adaptive capacity in Masset and Old Masset were identified:

- ✓ connection with nature and experience with environmental changes and hazards;
- ✓ high level of informal education and diverse skills;
- ✓ strong Haida culture and traditional knowledge;
- ✓ community cohesion, solid support networks and increasing volunteerism,
- ✓ high degree of self-sufficiency (e.g., food gathering, stockpiling and preserving, high coping capacity with power outages);
- ✓ household income diversification; and
- ✓ development of a Land Use Plan agreement (finalized and signed in 2007).

This component of the study identified the attributes of vulnerability and adaptive capacity, but did not assess or measure them. That step requires further involvement of community members to shape an approach for assessing their adaptive capacity and vulnerability to climate change and develop appropriate and feasible adaptation strategies.

Observations and Next Steps

- ✓ Obtaining and incorporating local knowledge, experience and values through community-based research is key to developing effective climate change adaptation strategies, particularly for remote and/or First Nation communities;
- ✓ Local flood maps of sea-level impacts and erosion/sedimentation assessments are useful planning tools for land use decisions and emergency response planning.
- ✓ Isolated, remote communities are vulnerable as a result of their distance from major centres and their reliance on critical infrastructure, but the lifestyle that accompanies living in remote places also contributes to greater resilience and adaptive capacity in the face of natural hazards.
- ✓ Adaptive capacity building must consider not only physical and technical factors, but also socio-economic and cultural considerations. In addition to investments in emergency preparedness and climate change adaptations, investments are also needed in formal education, skills training, quality social and health services and sustainable employment for residents on islands.
- ✓ Possible steps toward adaptation include identifying natural hazards and vulnerabilities, increasing public awareness of climate change risks and future impacts, improving household emergency preparedness, developing a community-wide emergency plan, and building capacity in a comprehensive manner. Further community-based planning and strategy development will help shape these steps so they become locally relevant.

Adaptations will likely occur in response to an increase in the frequency and magnitude of short-term hazardous events, such as extreme storms, rather than to gradual change in average conditions, such as sea-level rise.

Relevance of This Research

The outcomes of this community collaboration may serve as a model for similar isolated, resource-dependent communities.

The results of this the study will provide an extensive knowledge base, derived from community input and scientific research, for the communities of northern Haida Gwaii to plan and prepare for impacts of climate change, including related natural hazards. In Masset, an active emergency planning committee has plans in place to address events such as tsunamis, spills of hazardous goods and harsh storms. Village staff indicate their work will benefit from local flood maps of sea-level rise impacts. In Old Masset, the research has played a role in raising the level of awareness and knowledge about the potential impacts of sea-level rise.

Relevance for Other Communities

This research illustrates the importance of incorporating local values into community planning for climate change, and suggests ways of doing this. A participatory approach that engages the community, provides its members with a deeper level of awareness and knowledge of the issues, and possible impacts, and equips them to make better decisions and adaptation strategies.

The outcomes of this research may serve as a model for similar isolated, resource-dependent communities, whether in Haida Gwaii, Newfoundland or Canada's north. The research highlights the importance of recognizing the strategies that make communities resilient and vulnerable in the face of emergencies, as well as their reliance on critical infrastructure. This local understanding is essential in developing successful adaptation strategies.

On a practical level, the development of flood maps of sea-level rise will help other communities make land-use decisions — for example, whether and where to put a waterfront boardwalk. Flood maps may also help identify areas at risk of erosion, potential no-build zones and information for preparing better emergency response plans.

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 response capacity to respond may face more risks in the future. But, as this study shows, remote isolated communities often have experience with harsh conditions and emergency situations, providing them with the resilience and capacity to better respond to climate changes.

Historically, planners have been facilitators of change, helping to make progressive choices as societal values, needs, resources and capacities change. Planners will recognize many of the participatory approaches used to engage community stakeholders in this research. Identifying climate-related change, and helping others adapt to it are likely to be the most enduring roles of planners in relation to climate change.

Remote, isolated communities like Masset and Old Masset are unlikely to have a land-use or community planner on staff. In such situations, other municipal staff often undertake planning tasks. In relation to the impacts of climate change, those responsible for planning will be required to familiarize themselves with the science of sea-level rise and shoreline dynamics, and understand the impacts of these changes on the community land base, land-use policies, sewer and water infrastructure and sources of potable water. They will be required to hone skills in emergency response planning because of the expected increase in frequency and magnitude of extreme events. They will be challenged to deal with novel situations — for example, addressing ownership and zoning issues for land that is being created and lost as a result of climate-related shoreline change.

Planners will work with scientists and engineers in these activities, and will be called upon by elected officials, stakeholder groups and the public to communicate scientific and technical findings clearly. Much of this will happen in a public setting — a community hall or a council chamber.

Planners have other skills and tools to help their communities adapt to the impacts of climate change. These might include:

- ✓ changes in policy, such as community master plans that consider climate change impacts and adaptation measures as part of future growth plans;
- ✓ changes in regulation, such as zoning bylaws related to safe and vulnerable land areas for construction and infrastructure placement; and
- ✓ changes in emergency response practices including greater community awareness of the potential impacts and plans for response implementation.

In Conclusion

The study examined the human and biophysical vulnerability of a remote, isolated location — a site that is categorized as highly sensitive to future sea-level rise, experiences extreme conditions and relies on sometimes fragile transportation links and critical infrastructure for its survival. The study is novel in its integrated approach that melds local community knowledge with biophysical knowledge and emphasis on a local scale. As well, the study recognizes the importance of incorporating community values and stakeholder involvement. These are familiar approaches for community planners and are considered good tools for developing plans that are likely to be implemented successfully.

Once completed, the human-environment vulnerability map will provide planners and decision-makers in northeast Graham Island with information at a meaningful scale about the possible extent and location of climate change impacts. It is anticipated that the process followed, with its mapping tool outcomes, will benefit future planning and the development of short-term and longer-term adaptation strategies. The people of northeast Graham Island are no strangers to the powerful elements of nature and have shown resilience in the face of these natural hazards. With the additional learning and tools this study will provide, the communities of Masset and Old Masset will have the opportunity to strengthen their adaptive capacity, and serve as models for other remote coastal communities that will also experience the impacts of climate change.

Sources, Contacts and Additional Resources

The Climate Change Impacts and Adaptation Program, an initiative of the Earth Sciences Sector, Natural Resources Canada, has these objectives: 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 upon 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. **www.adaptation.nrcan.gc.ca/index_e.php**

Canadian Climate Impacts and Adaptation Research Network (C-CIARN) – **www.c-ciarn.ca** – is a national network that facilitates the generation of new climate change knowledge by bringing researchers together with decision-makers from industry, governments, and non-government organizations to address key issues.

Climate Change Scenarios Network, Environment Canada – **www.cccsn.ca/index-e.html** – is an interface for distributing climate change scenarios and adaptation research. Goals of the network include support for climate change impact research and stakeholders requiring scenario information for decision-making and policy development.

Pacific Climate Impacts Consortium (PCIC) — **http://pacificclimate.org/** — is dedicated to stimulating collaboration to produce practical climate information for education, policy, and decision-making in the Pacific Northwest. The Consortium informs adaptation in both operational activities and long term planning in order to reduce vulnerability to climate variability, climate change, and extreme weather events.

The Partners for Climate Protection (PCP) program – **www.sustainablecommunities.ca** – 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. That network comprises more that 600 communities worldwide making similar efforts.

The Tyndall Centre for Climate Change Research – **www.tyndall.ac.uk/general/about.shtml** – brings together scientists, economists, engineers, and social scientists, who together are working to develop sustainable responses to climate change through trans-disciplinary research and dialogue on both a national and international level, not just within the research community, but also with business leaders, policy advisors, the media, and the public.

The UK Climate Impacts Programme (UKCIP) – **www.ukcip.org.uk** – provides scenarios that show how our climate might change and co-ordinates research on dealing with our future climate.

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Glossary of Case Study Terms

- ✓ **Backshore**. The part of the beach, lying landward from the upper limit of the wave swash at high tide.
- ✓ **Foreshore**. The part of the beach lying between the upper limit of the wave swash at high tide and the low-tide shoreline.
- ✓ **Geomorphology**. The study of the evolution and configuration of landforms.
- ✓ **Macrotidal range**. A tidal range between four and six metres.
- ✓ **Progradation**. The regular seaward movement of a coast as a result of sedimentation. Also referred to as accretion.
- ✓ **Sensitivity Index**. A function of rock type, relief, landforms present, sea-level change, wave height, tidal range, and shoreline change.
- ✓ **Sensitivity**. The degree to which a rise in sea-level would initiate or accelerate coastal geomorphic changes given local conditions and other climate change effects (e.g. increased storminess).
- ✓ **Storm surge**. The difference between observed sea-level and sea-level predicted by tides.
- ✓ **Tidal range**. The difference between high and low water in a tidal cycle.
- ✓ **Wave run-up**. The rush of wave water up a slope or structure. The amount of wave run-up is the vertical distance between the still water level and the maximum extent of wave run-up on a beach or structure.

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 are selected from that glossary as terms that will be increasingly used by community planners and municipal engineers.

- ✓ **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, and 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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