CANADIAN COMMUNITIES' GUIDEBOOK FOR ADAPTATION TO CLIMATE CHANGE

Including an approach to generate mitigation co-benefits in the context of sustainable development

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First Edition

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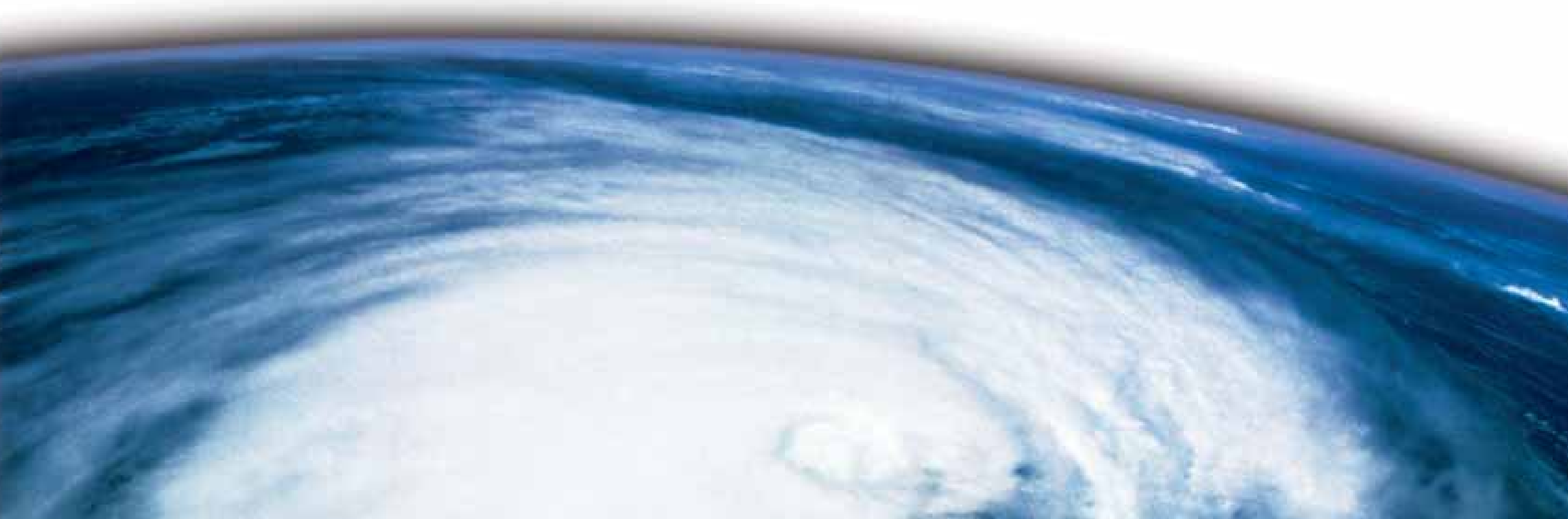

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foreword

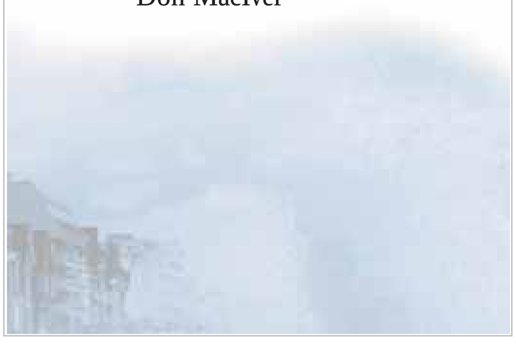
Since the Brundtland Commission Report published in 1987, in both developed and developing countries, the term 'sustainable development' has become an important concept among the science and policy making communities. In the first few years, it was more predominantly within all economic sectors. Gradually 'sustainable development' has evolved as a multidisciplinary topic where every discipline has a stake.

Climate change has emerged as one of the most crucial environmental challenges of the 21st century. Researchers, policymakers and practitioners are concerned that climate change is a significant threat to 'sustainable development'. In the IPCC processes, it has received increasing importance and currently the deep and multiple links between development and climate change are acknowledged, emphasizing the need to move climate policy into the broader context of development, equity, poverty reduction and sustainability. However, this is a challenging task.

This Guidebook builds on the rich experiences of researchers within Environment Canada's Adaptation and Impacts Research Division (AIRD) working with decision-makers on practical projects focused on climate change and sustainable development. It provides a process closely tied to on-going planning cycles to help decision-makers incorporate climate change science, impacts, adaptation and mitigation solutions into their sustainable development initiatives. This Guidebook provides the needed assistance in help Canadians interpret the potential consequences of climate change impacts in the local context and how to develop adaptation actions and responses to address the anticipated consequences. Our intent was to produce this Guidebook as a tool for planners, decision-makers, local practitioners and investors to help build wealthier, healthier, safer and more resilient communities.

Around the world local governments and communities are taking a leading role in adaptation and mitigation to climate change. I am hopeful that this Guidebook will strengthen our abilities to assess impending impacts from a changing climate, develop adaptation strategies that are coupled with mitigation co-benefits and foster actions that will ensure a sustainable future.

Don MacIver



executive summary

Many local governments have already begun working on decreasing greenhouse gas (GHG) emissions. Recently, a growing number have begun examining ways to adapt to climate change – the act of reducing climate change impacts that are already underway. This Guidebook is intended to help those who are looking for ways to reduce the impacts of climate change (increasing heat waves, water shortages, intense storms and sea-level rise) while decreasing GHG emissions and ensuring sustainable development for their communities. Several different methods can be used to adapt to climate change. Some of these methods contribute to reducing greenhouse gas emissions while increasing long-term sustainability. Expanding the tree canopy in urban centres, for example, helps to reduce the impact of an increasing number of hot days and heat waves. It also reduces the need for air conditioning, and so reduces greenhouse gas emissions from fossil-fueled electricity generation. Healthy trees also decrease the impact of intense rainfall, stormwater runoff and pollution – increasing sustainability for our communities.

Climate change impacts will affect societies in complex and broad-ranging ways as technological, economic, social and ecological changes take place across regions, groups and sectors. Ecological impacts have cascading effects on social and health outcomes. Infrastructure problems have profound economic effects, such as the estimated $10 billion US price tag resulting from North America's 2003 power outage. Cities, regions and countries are linked through the global political economic system so that impacts in one area of the world may affect other areas through economic forces, such as prices for agricultural products, or pressures including international migration.

In North America, vulnerability to climate change will depend on the effectiveness and timing of adaptation, as well as the distribution of coping capacity. While Canada has considerable adaptive capacity when compared to many less developed nations, vulnerability and adaptive capacity are not uniform across our society. Socially and economically disadvantaged populations are likely to have less adaptive capacity than the population as a whole, and climate "surprises" may bring weaknesses in adaptive capacity to light that were not previously recognized (e.g., the 1988 Ice Storm, Hurricane Katrina or the 1995 Chicago heat wave). Community attributes, including social networks, social cohesion, volunteerism, economic and income diversification, contribute to adaptive capacity and resilience. Societal impacts will therefore depend on factors such as wealth, infrastructure quality, emergency preparedness, healthcare, community vitality, economic and governance system structure, and population growth.

Adaptation, Mitigation and Sustainable development (SAM) are often developed separately at the local government and community level. Recognition of the need to integrate climate risks into development priorities and decision making is the principal driving force behind the development of the SAM project. A number of methods are possible for the integration of adaptation and mitigation in the context of sustainable development. This Guidebook provides one such method.

GUIDELINES FOR LOCAL GOVERNMENTS

The following guidelines promote the development of adaptation responses with mitigation co-benefits and are tailored to local long-term priorities aiming to help build resiliency within communities. The guidelines include the following major steps:

STEP 1 **Identify the focus and objectives of a SAM initiative**

STEP 2 **Assess present status and trends. Where are we heading now?**

a. Examine current development challenges, planning principles and capacities
b. Estimate impacts of climate change

STEP 3 **Develop a vision of the future. Where do we want to be in the coming decades?**

a. Identify future development priorities based on the principles of local sustainability and community planning
b. Assess impacts of climate change and the potential for adaptation and mitigation within community goals

STEP 4 **Set trajectories to meet priorities. How can we get there?**

a. Identify actions to achieve the vision of the future
b. Develop capacities and institutional linkages to support implementation

STEP 5 **Monitor, reassess and adjust. Reexamining the identified actions in a project or addressing new challenges**

sommaire executif

Bon nombre de gouvernements locaux s'intéressent déjà à la réduction des émissions de gaz à effet de serre (GES). Ces derniers temps, de plus en plus de gouvernements locaux ont commencé à chercher des moyens de s'adapter aux changements climatiques, en réduisant notamment l'impact des changements climatiques qui sont déjà en cours. Ce manuel est destiné à ceux qui cherchent des façons de réduire les effets des changements climatiques (tels que les vagues de chaleur de plus en plus fréquentes, les pénuries d'eau, les tempêtes intenses et l'augmentation du niveau de la mer) en diminuant leurs émissions de gaz à effet de serre et en assurant un développement durable pour leur collectivité. Différentes méthodes peuvent être utilisées pour s'adapter aux changements climatiques. Certaines de ces méthodes contribuent à la réduction des émissions de gaz à effet de serre tout en augmentant la durabilité à long terme. Augmenter les couverts arborés dans les centres urbains, par exemple, aide à réduire l'impact des jours et des vagues de chaleur plus fréquents. De telles initiatives réduisent également les besoins de climatisation et, de ce fait, diminuent les émissions de gaz à effet de serre engendrées par la production d'électricité au moyen de combustibles fossiles. En outre, des arbres sains permettent d'atténuer les répercutions des pluies abondantes, de l'écoulement des eaux pluviales et de la pollution, tout en augmentant la durabilité de nos collectivités.

Les manières, complexes et variées, dont les changements climatiques touchent les sociétés, diffèrent en fonction des changements technologiques, économiques, sociaux et écologiques que rencontrent les divers groupes, régions et secteurs. Et les conséquences écologiques ont à leur tour des répercutions sur la société et la santé. Les problèmes d'infrastructure affectent profondément l'économie comme le prouve la facture estimée à 10 millions de dollars à la suite de la panne de courant de 2003 survenue en Amérique du Nord. Les villes, les régions et les pays sont tous liés entre eux par le système politico-économique mondial. Cela implique donc que les problèmes d'une région du monde peuvent avoir des incidences sur d'autres régions, notamment par les forces économiques telles que le prix des produits issus de l'agriculture et les pressions comme la migration internationale.

Le degré de vulnérabilité de l'Amérique du Nord face aux changements climatiques dépendra de sa capacité à s'adapter de manière rapide et efficace, mais aussi de la répartition à différents niveaux de la capacité d'adaptation. Bien que le Canada ait une capacité d'adaptation considérable, comparativement à bon nombre de pays moins développés, on constate néanmoins que la vulnérabilité et la capacité d'adaptation ne sont pas les mêmes dans toute notre société. Les populations désavantagées sur le plan économique et social ont potentiellement moins de capacité d'adaptation que le reste de la population, et les imprévus climatiques peuvent mettre en évidence des difficultés d'adaptation qui autrement resteraient inconnues (p. ex. la tempête de verglas de 1998, l'ouragan Katrina ou la vague de chaleur de Chicago de 1995). Les attributs de la société, tels que les réseaux sociaux, la cohésion sociale, le bénévolat et la diversification économique et des revenus, contribuent à la capacité d'adaptation et à la résilience. Par conséquent, les répercussions sociétales dépendront de facteurs tels que la richesse, la qualité des infrastructures, la préparation aux situations d'urgence, les soins de santé, la vitalité des communautés, la structure du système de gouvernance et économique, et la croissance démographique.

Souvent, l'adaptation, l'atténuation et le développement durable sont élaborés séparément au niveau du gouvernement local et de la collectivité. Le fait de reconnaître qu'il faille mettre les risques climatiques dans les priorités de développement et les prises de décisions est ce qui motive l'élaboration de ces trois aspects. Beaucoup de méthodes sont envisageables dans le cadre de l'insertion des concepts d'adaptation et d'atténuation dans le contexte du développement durable. Ce manuel offre l'une de ces méthodes.

LIGNES DIRECTRICES POUR LES GOUVERNEMENTS LOCAUX

Les lignes directrices suivantes favorisent l'élaboration de réponses concernant l'adaptation et recevant les bénéfices de l'atténuation, et elles sont adaptées aux priorités locales à long terme visant à renforcer les collectivités. Les lignes directrices incluent les principales étapes suivantes :

ÉTAPE 1 **Déterminer l'orientation et les objectifs d'une initiative axée sur l'adaptation, l'atténuation et le développement durable.**

ÉTAPE 2 **Évaluer l'état et les tendances actuels Où en sommes-nous maintenant?**

a. Examiner les défis concernant le développement, les pratiques et les capacités de planification.
b. Estimer les répercussions sur les changements climatiques

ÉTAPE 3 **Élaborer une vision de l'avenir. Où voulons-nous être dans les prochaines décennies?**

a. Établir les futures priorités liées au développement en se basant sur les principes de la durabilité de l'environnement au niveau local et la planification des collectivités
b. Évaluer les répercussions des changements climatiques et le potentiel d'adaptation et d'atténuation dans le cadre des objectifs de la collectivité

ÉTAPE 4 **Définir la direction à prendre pour répondre aux priorités. Comment pouvons-nous y arriver?**

a. Déterminer les mesures à prendre pour atteindre la vision de l'avenir
b. Développer les capacités et les liens institutionnels afin d'appuyer la mise en œuvre

ÉTAPE 5 **Surveiller, réévaluer et ajuster. Réexaminer les mesures déterminées au sein d'un projet ou répondre à de nouveaux défis.**

introduction

Climate change is a global problem, affecting us all. Searches for causes and solutions have brought together worldwide communities of scientists, governments, private sectors, special interest groups and civil society. The effective management of climate change presents an unprecedented challenge. How can all these groups and interested parties possibly work together towards a set of solutions?

Over the years since the United Nations Framework Convention on Climate Change was first signed in Rio de Janeiro in 1992, there have been a number of efforts led by national governments attempting to address the problems of climate change collectively. Unfortunately, these efforts have progressed slowly. One feature of these negotiations was the fragmentation of the climate change issue into sustainable development, adaptation and mitigation. Adaptation is urgently needed now in many places where the adverse impacts of climate change are being felt. Mitigation is also urgent, but is viewed at a global level and a longer-term scale. Both adaptation and mitigation are necessary to achieve sustainable development. It is widely understood that present patterns of development cannot be sustained, but it is much less clear what changes are most needed and how the problems are to be resolved.

There is a temptation for those faced with the issues of climate change at the local level to become frustrated, remain indifferent or focus their attention on more "pressing" problems. However, it is at this local level where practical knowledge and experience can be drawn from, where integration can begin. This does not mean that a solution is easy to achieve. Conflicts of interest are always present, but at the local level they can be seen and assessed more readily; the possibility for agreement and action are much greater than at the global level. It is this line of reasoning and the acknowledgement that adaptation, mitigation and sustainable development are often developed separately, and need to be considered together, that brought about the SAM initiative.

SAM (Sustainable development, Adaptation and Mitigation) emerged from a number of seminars and discussions, including two workshops held in British Columbia in 2006 and 2008 involving a group of academic researchers, government scientists and local community representatives. These concepts were revised and further developed for practical application in consultation with community and provincial level stakeholders. To date, SAM has been piloted in two case studies in British Columbia in the communities of Richmond and Quesnel.

This Guidebook promotes adaptation and mitigation in the context of sustainable development at the local level and provides a set of consecutive steps and information that are:

- **Proactive:** SAM approaches are proactive in that they help local governments create responses that prepare communities for future climatic, policy and development challenges.

- **Collaborative:** SAM approaches are collaborative; they bring together stakeholders from different departments of the local government, researchers from various expertises, the private sector and many others.

- **Integrative:** SAM approaches integrate long-term local development plans with present priorities, while exploring synergies between decisions and responses to climate change.

- **Flexible:** SAM approaches provide flexibility and can be initiated at several stages of a project.

- **Practical**: The SAM Guidebook provides additional reference materials, including: information on how to interpret the consequences of climate change; potential adaptation options available; an extensive list of published guidebooks; and several other resources available for consultation.

Climate Change

Climate is defined as the average temperature, precipitation and wind over a period of time[1]. Statistically significant variation in this average state for an *extended* length of time is referred to as climate change. This change may be due to natural or anthropogenic changes in the composition of the atmosphere or changes in land use (IPCC 2001). Global and regional observations of climate change have been recorded worldwide. From a global perspective, eleven of the 12 warmest years on record (since 1850) have occurred between 1995 and 2006. The global average surface temperature has increased by 0.74°C over the past 100 years (Field et al. 2007). It is important to note that warming may not occur steadily over time and will likely vary by season, even in the same location. Extreme temperatures, such as daily and seasonal maximums and minimums are also likely to change at different rates, with minimum temperatures increasing at a greater rate than maximums in many locations. Table 1 presents a summary of observed and projected changes in climate for Canada.

TABLE 1. SUMMARY OF OBSERVED AND PROJECTED CHANGES IN CLIMATE IN CANADA

Climate factors	Observed Climate Trends since 1900 (unless otherwise indicated)	Climate Change Projections to 2100
TEMPERATURE	• Canada has warmed an average of 1.3°C over the past 50 years – approximately twice the global average • Stronger warming of daily minimum temperatures than daily maximum temperatures • Nationally, 8 fewer frost days over the period 1950-2003 • Increasing trends in heat spells (of one or more and three or more days) in S. Quebec where daily minimum temperatures are above 22°C, but decreasing trends in heat spells where maximum temperatures exceed 30°C	• 2 to 4°C increase in global average temperature by 2100 • Average temperature increases in Canada from 3°C on the East and West Coasts to 5°C in the North • Springtime warming up to 10°C in the far North • Temperature increases greater in winter than summer • Greater warming of extreme minimum temperatures than extreme maximum temperatures and reduced daily temperature ranges • Increased frequency of winter freeze-thaw cycles in cold climates, decreased frequency in milder climates

1 The classical period is 30 years.

TABLE 1. SUMMARY OF OBSERVED AND PROJECTED CHANGES IN CLIMATE IN CANADA

Climate factors	Observed Climate Trends since 1900 (unless otherwise indicated)	Climate Change Projections to 2100
TEMPERATURE	• Annual average precipitation increased by 12% for Canada since 1950; 25-45% in Nunavut; 5-35% in Southern Canada. • Increase in number of small to moderate precipitation events and more days with precipitation • Increase in fraction of precipitation falling as intense events increasing in Northern Canada and decreasing in Southern Canada • Decrease in number of days with snowfall and increase in proportion of precipitation falling as rain instead of snow in Southern Canada. • Increase in total snowfall and frequency of heavy snowfall events in Northern Canada.	• 0-10% increase in precipitation in the South and 40-50% increase in the high Arctic • Summer precipitation increase in Canada's North and decrease in Southwest and Great Lakes regions • Winter precipitation increases across Canada with larger increases of up to 30% in North • Decline in snow depth across Canada except for areas around the Arctic coast • Changes in extreme daily precipitation rate greater than changes in mean annual precipitation rate • Probability of extreme precipitation events in 2000 increases by factor of 2 by 2100
FROZEN GROUND	• Increase in permafrost temperatures up to 2°C • Decrease in permafrost extent by 7% , with springtime decreases up to 15% (Northern Hemisphere) • Decrease in permafrost depth by 1 to 4 cm per year • Increased extent of thermokarst terrains • Increased permafrost active layer depth • Decreased extent of seasonally frozen ground by up to 15% in spring • Delayed ground freezing dates by 5 days	• 30 to 50% increase in the depth of the active layer in Arctic permafrost regions, with the greatest increases occurring in the northernmost areas • Shifts in the zones of continuous, discontinuous and sporadic permafrost • 20-30% reduction in NH permafrost extent • Increased soil moisture early in the century followed by decreased soil moisture toward the end of the century as the permafrost active layer increases
SEA/LAKE ICE	• Late summer Arctic sea ice decreased in extent by 8% since 1979	• 12 to 42% decrease in mean annual NH sea ice extent. • Continued decline in Arctic sea ice extent with some areas seasonally ice free by the end of the century. • Shorter ice season on Great Lakes

TABLE 1. SUMMARY OF OBSERVED AND PROJECTED CHANGES IN CLIMATE IN CANADA

Climate factors	Observed Climate Trends since 1900 (unless otherwise indicated)	Climate Change Projections to 2100
STREAMFLOW AND LAKE WATER LEVELS	• Decreased annual mean streamflow, particularly in Southern Canada • Trend toward lower water levels in upper Great Lakes • Increases in monthly streamflow in March and April; decreases in monthly streamflow for other months • Earlier break-up of river ice and earlier spring freshet	• Earlier snowmelt and increases in spring freshet peaks in snow-driven watersheds • Decreased low flow volumes in summer • Decreased Great Lakes levels
DROUGHT	• Increased evapotranspiration and widespread drying trend in soil moisture over North America since the middle 1950s	• Decreased soil moisture in summer
CYCLONIC STORMS	• Likely an increase in intense tropical storm activity in some areas since 1970	• Decrease in total number of storms but increase in number of intense events

Sources: Bonsal et al. 2001, Christensen et al. 2007, Hassol 2004, IPCC 2007b and 2007c, Khaliq et al. 2007, Kharin and Zwiers 2005, Kharin and Zwiers 2005, Lambert 1995, Lambert 2004, Mortsch et al. 2006, Vincent and Mekis 2004, Vincent and Mekis 2006, Warren and Egginton 2008, Yamaguchi 2005, Zhang et al. 2000, Zhang et al. 2001

Climate Change and Sustainable Development

Sustainable development can be defined as an approach to development that balances economic, social and environmental dimensions. This concept incorporates the notion that for continued human progress, development must find pathways that achieve economic goals, find a balance with the physical environment and promote social well-being, while using political strategies to reach these priorities. Linking the concept of sustainable development to climate change provides an opportunity to explore long-term societal responses to global environmental change.

Since industrialization, we have been significantly increasing the concentration of GHGs in the atmosphere. Despite technological progress and available clean technologies, we have failed to reduce our environmental impact or drastically reduce emissions. In many instances, development has placed more of an emphasis on present and short-term well-being at the expense of future generations. The significance of sustainable development options in increasing capacities to adapt and reducing GHG emissions leads to an important message that could help guide responses to climate change at the level of local governments: there is a strong link between climate change, increasing GHGs and our development decisions.

Furthermore, only those responses to climate change that meet the criteria of sustainable development and help build resilient communities will be effective in the long-run. Our current choices are not sustainable. Building more green roofs, using hybrid cars and increasing habitable space to protect communities from flooding are desirable changes, however, they will have little impact if we continue to drive more, consume more and extensively develop on floodplains and vulnerable coasts. Sustainable, low-emission development actions occur at two different levels: first, large collective decisions that will determine the framework within which we adapt and mitigate, including urban form, land use, transportation infrastructure, energy and water systems; and second, cultural, social and psychological dimensions of values, lifestyle and consumption behaviour (Robinson, 2008).

Working toward resilient and sustainable communities will require promoting climate change responses within sustainable development strategies and actions. However, even if we achieve low GHG emissions globally, we will still experience changes in climate due to the presence of historical emissions, therefore, actions that help us adapt to climate change are necessary.

Responses to climate change: adaptation and mitigation

There have been two main responses to climate change: mitigation and adaptation. In the context of climate change, mitigation is defined as “implementing policies to reduce greenhouse gas (GHG) emissions and enhance sinks”, while adaptation to climate change is defined as, “[an] adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC 2007). There is increasing recognition that the world’s current progress on reducing greenhouse gas emissions is not occurring rapidly enough to avoid impacts from climate change in the coming century. Because of this, the world is “committed” to a certain level of global warming and therefore, subject to a degree of impacts that will require adaptive responses by nations and communities. Examples of types of adaptation are listed in Table 2.

TABLE 2. TYPES OF ADAPTATION

Type of Adaptation	Example	Level of Involvement
ANTICIPATORY	Diversifying rainfall removal by promoting rainwater storage, permeable surfaces and drainage pipelines	Community and personal
REACTIVE	Expanding drainage infrastructure as a major way to accommodate heavy precipitation events	Community
SUPPLY-SIDE	Building water reservoirs to collect rainwater	Community and production systems
DEMAND-SIDE	Water-metering to support water conservation	Community and personal
TOP-DOWN	Changing national standards, such as building codes, to address changes in climate	National
BOTTOM-UP	Developing community by-laws to regulate building construction, such as increasing habitable space, and increasing areas of permeable surfaces to minimize pressure on sewage system and flooding	Community and productions systems
AUTONOMOUS	Farmer’s decision to change timing and species planted based on observed weather changes	Individual and community
NON-AUTONOMOUS (PLANNED)	Changes in water resource allocation to ensure biodiversity protection, agriculture and drinking water supplies	Community, production systems and individual

Climate change mitigation and adaptation have been considered separately in the global climate change discussion. However, there is increasing recognition that both mitigation and adaptation efforts are necessary in order to decrease climate risks and capture co-benefits. At the level of actual actions, adaptation is needed now and can provide immediate and short term benefits. Mitigation is equally urgent in order to prevent future anthropogenic interference with the climate system, and will only begin to have an effect on global mean surface temperature decades from now. The benefits of mitigation are not immediate. But, both adaptation and mitigation are essential: adaptation to reduce impacts in the near term and mitigation to reduce long term impacts. One could imagine that adapting to a several metre rise in sea level might be a theoretical possibility - it would mean massive economic losses and substantial displacement of population – not something we want to envision as our future development pathway.

Linking mitigation and adaptation at the local level is likely to highlight interactions between these two types of climate change actions. Mitigation measures can increase local vulnerability to climate change, and measures for adaptation can increase the local emissions of GHG – unless they are considered together. For example, efforts to reduce GHG emissions could include the concentration of housing development with renewable energy close to a town centre, while an adaptation strategy could dictate that if the town centre is located close to a river prone to flooding it would be desirable to locate new housing sufficiently far away from the centre.

From a practical point of view, designing local responses that simultaneously address the issues of climate change and sustainability is a challenging task. To help identify possible synergies and trade-offs between mitigation and adaptation activities, it may be useful to consider the four categories of interactions presented in Figure 1. Activities that fall into the lower left quadrant are unsustainable, resulting in both increased GHG emissions and vulnerability to climate impacts. Activities that fall into the upper right quadrant represent the opposite condition: activities that build on the synergies between adaptation and mitigation and reduce both climate vulnerability and GHG emissions. Water conservation is an example of this type of activity and it is also an example of a sustainable development measure. The other two quadrants represent trade-offs created by focusing solely on mitigation or adaptation and, consequently, further increasing vulnerability or levels of GHG emissions (Cohen and Waddell, 2009).

Figure 1 does not capture the factors that will likely challenge the progress toward a sustainable development pathway. These include competing priorities, limited resources and different understandings of sustainability. In the next section, we outline a process to help local communities navigate these challenges while defining development strategies that will enable them to minimize their vulnerabilities to climate change (adaptation) and respond to regional and global greenhouse gas reduction efforts (mitigation).

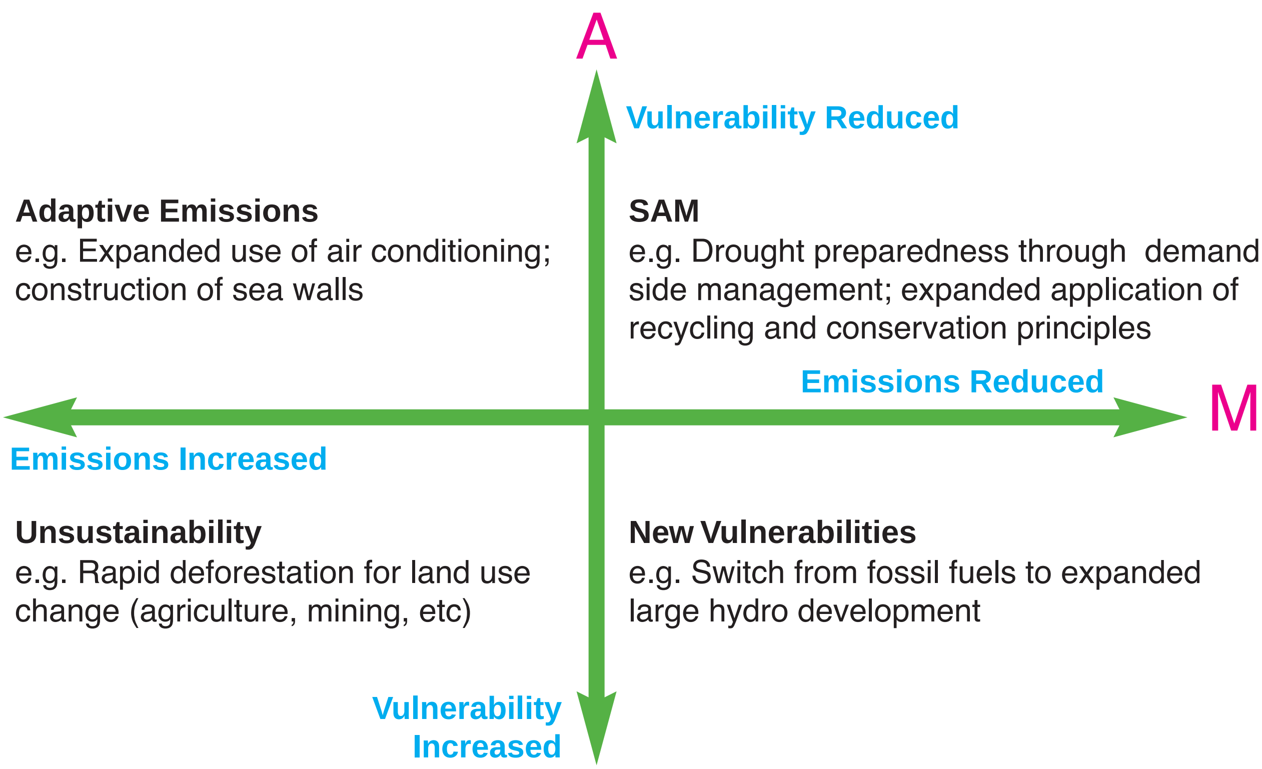
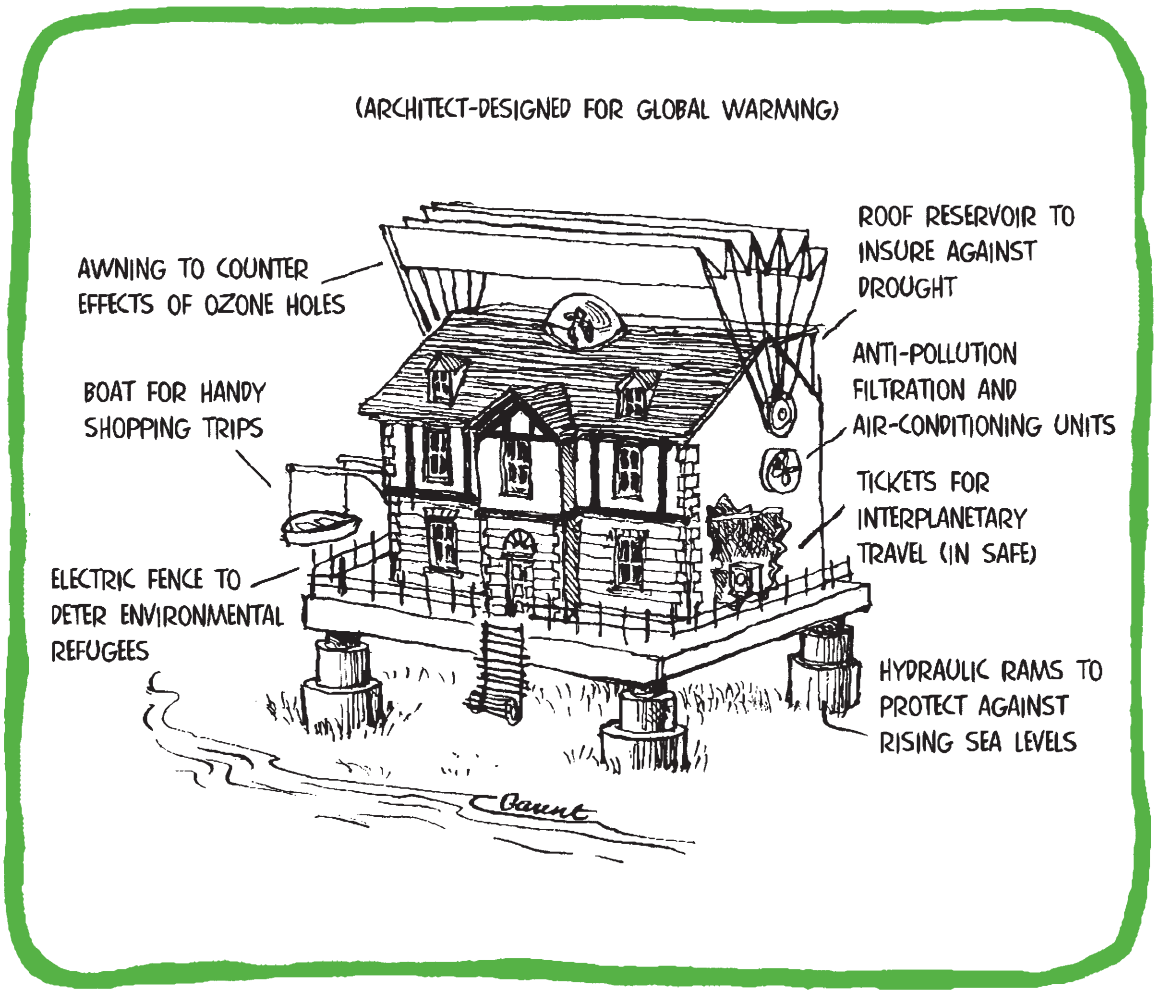
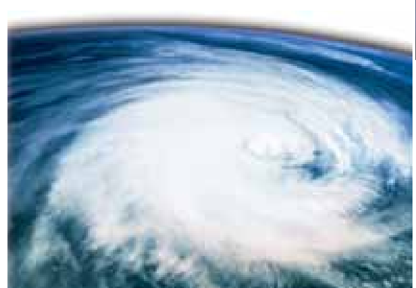


FIGURE 1. Linkages between adaptation and mitigation, in the context of sustainable development (Source: Cohen and Waddell, 2008)



A cartoonist's interpretation of the future of housing in a warming climate.
Reprinted with permission. Source: Tiempo, 2006.

GUIDEBOOK FOR ADAPTATION TO CLIMATE CHANGE



SETTING THE STAGE

An anecdote by David Diamond

In May of 2007 I was working in a small northern Manitoba community called Wasagamack. To get there, one flies from Winnipeg in a Dash-8 due north for about an hour to St. Teresa Point. From there transport is a small boat with an outboard motor for 30 minutes to Wasagamack – a community to which almost everything must travel by plane and then boat.

One morning I was having breakfast with some of the organizers of the work. I picked up a jar of jam that was on the table. French Jam. French mango and pineapple jam. Wait a minute, I thought to myself, mangoes and pineapples don't grow in France. How many times has whatever fruit there is in this jar been around the planet to make it into my hands in Wasagamack? And worse than that – if I wasn't preparing for a project on global warming, this thought would likely never have entered my mind. Why? Because for some reason, I am entitled to eat mango and pineapple jam from France.

So, there I was spiraling into a vortex of guilt and despair and, not wanting to endure that alone, decided to share the thought with my colleagues at the table; social justice activists each and every one of us.

Upon doing so, one of them, in a very weary voice said, "Can't we just have breakfast?" Understanding and sympathizing with the fatigue….I shut my mouth. The voices in my head that don't want to be seen to always be a bother, that want to be liked, that are also tired and panicked at the enormity of the global warming issue, convinced me, against my true better judgment, to be silent.

Of course governments need to develop clear and well thought out policies to deal with this most important issue. Likewise, corporations must change their destructive behaviour on the planet. I have questions, though, if either of these necessities will have much meaning if each and every one of us humans don't confront our own expectations, entitlements and patterns of behaviour that create the intricate web that both supports, and is, the unsustainable culture in which we live.

David Diamond is a co-founder and the Artistic and Managing Director of Headlines Theatre. In 2007 and 2008 Headlines Theatre organized a series of intimate evenings of theatre (without a play) about global warming *2º of Fear and Desire – an intimate evening of theatre (without a play)* grew out of a particular moment in time. For more information: www.headlinestheatre.com.

overview of the guidebook

Potential users of this Guidebook

This Guidebook is designed to assist local governments in incorporating climate change adaptation and mitigation into planning and operations. The users include local governments, planners, policy-makers and community leaders who aim to address local development issues in a sustainable way and are concerned about climate change. The approach outlined in this Guidebook advocates for creating partnerships with civil society members, researchers and other experts in the climate change impacts and responses field.

Purpose of the Guidebook

- To facilitate and promote the utilization of an integrated approach to climate risks centred on sustainability, and in this way to help avoid maladaptive and short-term responses to climate change.
- To ensure the adaptation strategies, policies and measures are compatible with, and supportive of, the need to mitigate by reducing greenhouse (GHG) emissions.
- To help address both adaptation and mitigation in the context of sustainable development - a good balance of adaptation and mitigation is the essence of local, regional and global sustainability – and in this way help to build low-carbon and resilient communities;
- Provide support for decision-makers in identifying key capacities needed in order to carry out successful adaptation actions.

Suggestions on how to use the Guidebook

This Guidebook provides a description of a method that can be applied to existing planning processes, both at the individual project and on a strategic level. We suggest working with these guidelines together with relevant development plans, planning policy frameworks and acts that aim to promote local sustainability (see Appendix).

The Guidebook outlines a series of steps that lead to the development of locally-specific responses to climate change. We suggest reading through all the steps first, and then following each step based on the outlined instructions. The description of each step starts with its main goal, followed by suggestions for methods and actions that help you reach the goal. The last paragraph lists the outputs that lead to the next step. Each step includes diverse case studies to provide examples to help illuminate the goals and outcomes of each step. The listed cases represent real local activities in which adaptation, mitigation and sustainability were involved to different extents. We tried to select case studies that have all the elements, but because of the early stage of the work on climate change adaptation at the local government level, we were not always able to find cases with all elements of the SAM.

At the end of the step-by-step guidelines is a list of adaptation options (examples of SAM). Lastly, the Appendix contains numerous supporting materials including: a list of suggested methods with examples of their application in climate change-related projects, potential local consequences from changes in climate variables, provincial mechanisms to promote local sustainability, climate change adaptation resources including already published guidebooks and resources and a glossary. These additional materials aim to provide information in order to facilitate the development of a SAM project. Not all of these materials are directly referred to in the text, so please consult them throughout the process.

step-by-step guidelines

The following framework aims to promote development of adaptation responses with mitigation co-benefits that are tailored to local long-term priorities. To achieve this aim, we suggest a framework of five major steps starting with the selection of the focus of the SAM project and ending with a strategy to implement the actions and define potential follow-up activities. The framework includes the following five major steps:

STEP 1 **Identify the focus and objectives of a SAM initiative**

STEP 2 **Assess present status and trends. Where are we heading now?**

a. Examine current development challenges, planning principles and capacities
b. Estimate impacts of climate change

STEP 3 **Develop a vision of the future. Where do we want to be in the coming decades?**

a. Identify future development priorities based on the principles of local sustainability and community planning
b. Assess impacts of climate change and the potential for adaptation and mitigation within community goals

STEP 4 **Set trajectories to meet priorities. How can we get there?**

a. Identify actions to achieve the vision of the future
b. Develop capacities and institutional linkages to support implementation

STEP 5 **Monitor, reassess and adjust. Reexamining the identified actions in a project or addressing new challenges**

The following section presents the five steps, briefly describing suggested methods, process and outputs. Each step

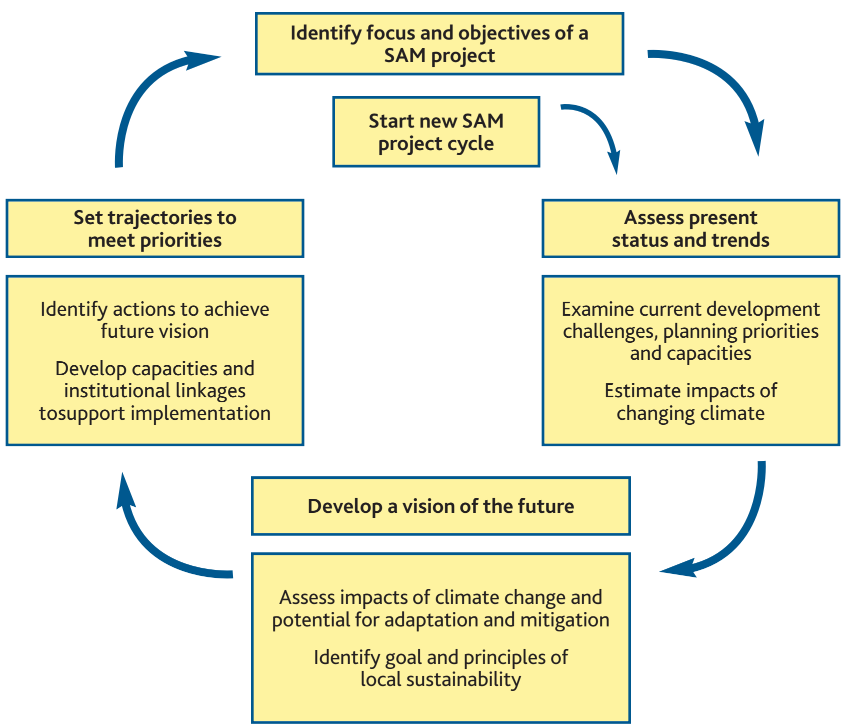


FIGURE 2. Main steps of the SAM framework to address climate change adaptation and mitigation in the context of local sustainable development.

is illustrated with case studies from Canada, which will help in visualizing how the steps were carried out in real-life situations. We suggest referring to the appropriate appendix when going through each step. Appendix 1 contains methods suggested throughout the Guidebook; Appendix 2 provides further information on understanding the consequences of climate change impacts; Appendix 3 gives examples, by province, of mechanisms that promote local sustainability; Appendix 4 lists references to readily available resources for climate change adaptation; and Appendix 5 is a glossary that provides definitions for terms contained in the Guidebook.

Examples of SAM measures

1. **Cool roofs** or 'white roofs' have a coating of light-coloured water sealant that reflects and radiates more heat than dark surfaces. This way cool roofs help lower the urban heat island effect and the need for mechanical cooling systems. They are most effective on buildings with high roof-to-volume ratios, such as one or two storey buildings. Cool roofs are less expensive than green roofs, however, they do not provide the same benefits with regards to storm water runoff, air quality or nature conservation.
2. **Sustainable Urban Drainage Systems** (SUDS) mimic natural drainage patterns and act to reduce surface water runoff and impacts from flooding events, recharge groundwater stores, lower urban heat island effects, protect water quality and provide biodiversity benefits. Examples of SUDS include: rainwater harvesting, filter strips and swales, infiltration devices (i.e. soakaways), green roofs, permeable and porous pavements, gravel, and grass, basins, reed beds, and ponds
3. **'Cool' or 'porous pavements'** address issues related to urban temperatures and water/flooding by: increasing surface reflectivity and evaporative cooling; increasing rainfall permeability and reducing stormwater runoff; recharging ground water resources; and providing water to surrounding vegetation (reducing need for irrigation)

TYPES OF SAM PROJECTS:

1. An overall SAM local strategy approach: an initiative assessing adaptation and mitigation across a number of sectors in local communities to develop integrated community-level strategies. Strategies have already been developed in cities such as Vancouver, Halifax, Boston, Seattle and New York (Penney and Wieditz, 2007). These initiatives involved a number of sectors, including collaboration between local government practitioners - focusing on identifying local vulnerabilities, adaptation and mitigation options (Case study 1 – King County, Washington's adaptation plan).
2. A SAM project-base approach: an initiative identifying specific vulnerabilities, capacities and responses in the context of particular local development projects. This approach explores 'windows of opportunities' as they occur in the community. For example, when drainage, sewage, drinking water infrastructure are being renewed, transportation networks are being (re-)developed, residential areas or coastal zones are being developed, and when investments for economic diversification are being allocated. When addressing potential infrastructure capacity issues associated with climate change, the potential costs of adapting to climate change can also be reduced by building resilience into major infrastructures, for instance during the construction of new buildings or roads. Carefully designed infrastructure could also help in climate change mitigation efforts. However, this is likely to be a staged process, taking use of the following opportunities (TPCA, 2007 and LGA, 2006):

   a. When infrastructure is upgraded;
   b. When development plans or other plans come up for regular review;
   c. When assessments are undertaken as part of a wider sustainability review; and
   d. Before service providers are forced to act by a sudden event or mounting maintenance costs.

STEP 1 Identify the focus and objectives of a SAM initiative

This first step is targeted on selecting the focus, key objectives and stakeholders of a SAM project within the local government. The work on climate change adaptation and mitigation should focus on areas that are considered important in the context of local development.

In the listed case study examples, questions about climate change and development were investigated in collaboration with researchers working closely with local governments. For

STEP 1: METHODS AND ACTIONS

At this step, we suggest identifying the focus of the SAM project and potential team members. To help identify the focus of the SAM project we suggest the following actions:

1. Identify the risks that the community is facing or has experienced recently
2. Identify relevant projects and initiatives that have been or could be vulnerable to weather-related events and/or non-climatic hazards
3. Based on your knowledge of the local system, identify the areas where capacity is lacking to address stresses that are currently posed by changes including by weather-related events
4. Identify the important stakeholders within the local government and research communities that need to be involved in order to carry out the initiative
5. Assess if there is funding available for your project. Is the funding agency supportive and will it allows for any additional costs resulting from integration of adaptation and mitigation in the project?
6. Identify responsible department, staff, approvals that may be needed for implementation within the local government (department, level, etc.). Does the initiative need a champion?

The collaborative work between local governments' and researchers provides significant opportunities for local governments, including:

- Obtaining information on the areas of interests and facilitating integration into policy-making (including extreme events, maps of local flooding and hazards, updated future hydrological scenarios, local specific information about precipitation, timing of snowmelt)
- Getting examples of changes in climate variables such as increases in temperature and changes in precipitation patterns which are important for local hydrology, habitat and construction
- Getting help in understating the sources of uncertainty in data
- Developing credible costing information, such as the cost of inaction and cost of adapting at the local level
- Accessing examples from case studies from communities and transforming lessons learned to the local level
- Developing and testing indicators to measure the effectiveness of adaptation and mitigation activities.
- Strengthening institutional networks and forming partnerships that may extend into the future

researchers, this provides an opportunity to engage in so-called 'usable science' - combining knowledge-driven, applied and interactive science to achieve a balance between what we need to know to understand complex problems and what in these examples local governments perceive to be their immediate needs for making decisions.

Local authorities are advised to adopt a precautionary approach when assessing development proposals in those areas identified as at risk from impacts such as flooding, pest infestation, heat waves and land instability due to erosion, as well as, for their potential contributions to GHG emission reductions.

Completing the outlined actions will help to identify those areas of local development that are vulnerable to the current climate, that lack capacities to deal with potential climatic and non-climatic stresses, and that have the potential to contribute to the long–term development of the region.

To identify the team, practitioners already working together on sustainability, planning, engineering and climate change issues should be involved. Based on the focus of the SAM project, the team could include members of the local government, project developers and NGOs. The team may need to collaborate with scientists and consultants. Also, experiences from local government initiatives on adaptation to climate change show that having a champion within the local government helps to ensure that the project receives sufficient attention and support within the local government. While capacity to address climate change issues may exist in isolated pieces in departments of the local government, the nature of this challenge requires coordination across departments.

Local governments, including Kativik Regional Government, The Resort Municipality of Whistler and Toronto Public Health, initiated the examples listed in this Guidebook. The remaining cases are from non-governmental organizations and organizations closely collaborating with local government such as the Inuvik Regional Health Centre, the Clean Annapolis River Project (CARP) and the Sheltair group. In each of these cases, collaboration with scientists working on different aspects of climate change were established.

By completing this step, the focus of the SAM project will be defined and basic information about the objectives will be identified. The core team that will carry the project through the next steps will be identified as well.

CASE STUDY 1
King County, Washington's adaptation plan

In late 2005, the King County Executive established a "strike force" to develop plans for tackling both climate change mitigation and adaptation efforts for the County. This group – now called the Global Warming Team – is led by the Deputy Chief of Staff, and meets every two weeks to coordinate research and planning for both mitigation and adaptation activities. The group includes representatives from the budget office, water planning, solid waste, air quality, parks, transportation, land-use planning and building codes, economic development, public health and executive services (which includes emergency management). They are charged with "reviewing every county business line, operation and capital plan to identify challenges and opportunities and to recommend concrete options for infrastructure and service adaptation". The Team reports to the King County Executive.

Source: Penney and Wieditz (2007)

CASE STUDY 2
Forest renewal strategies in Quesnel (BC)

Focus and objectives of the SAM project: To develop a renewal strategy for the mountain pine beetle (MPB) infestation that integrates local priorities for sustainability with economic diversification. The focus also addresses adaptation needs, because of linkages between the MPB and climate change and exploring opportunities for renewable energy production from biomass (mitigation). To address these issues the process was initiated with local government in collaboration with forestry companies and small business' representatives in the area.

Current vulnerabilities and capacities: In the short term, the MPB epidemic is increasing economic activity for many communities since the lodgepole pine timber harvest levels are increasing due to the need to use the dead trees before they decay and lose their commercial value. This short-term surplus of harvestable timber will be followed by a significant reduction in the cut as the epidemic runs its course and dead trees reach the end of their economic usefulness. The loss of future timber supply presents a very significant challenge to the communities affected because of pine making up over 50 per cent of the harvestable timber from which 80 per cent could be killed by 2013, and well over half the pine trees could be dead by the summer of 2007.

Estimated potential impacts of changing climate: Forests of mature lodgepole pine are prime habitat for the MPB. The beetle also thrives under warm weather conditions. The interior of British Columbia has an abundance of mature lodgepole pine. The area has experienced several consecutive mild winters and drought-like summers. Beetle populations in many parts of interior B.C. have increased to epidemic levels as a result.

Long-term goals and principles: From the community perspective, the long-term focus is on promoting local social sustainability of renewal options by accounting for local needs, such as job and training requirements and effects on local industries. The long-term goal is helping to create a sustainable community and healthy forest.

Responses to climate change and their implementation: Potential responses include diversification of planted trees to increase adaptability to climate change, which includes a decrease of pine and an increase of hard wood. It will also include using wood waste material and small-scale wood planting for bioenergy production. The activities also suggest diversification of community businesses to rely less on forestry industry. This include activities such as expanding tourism, maintaining naturally valuable areas, services for retirees and increasing a level of wood-processing within the community.

Source: British Columbia's Mountain Pine Beetle Action Plan 2006-2011 (2005)

CASE STUDY 3
Ice Monitoring Program, Northern Quebec

Focus, objectives and team in the SAM project: In 2004, the Kativik Regional Government, in conjunction with the University of Laval, the Ouranos Consortium and local researchers, launched an integrated community-based ice monitoring program to "contribute to local population's abilities to cope with climatic change and maintain traditional harvesting activities" in the region.

The program combines Traditional Knowledge (TK), local observations, and scientific methods to develop a more accurate understanding of sea ice experiencing climate change. Scientific ice monitoring data is collected on an ongoing basis to record local ice conditions.

Responses to climate change and their implementation: The short-term, local adaptation is the production of weekly maps that illustrate principal and alternate trails as well as 'risky areas' around each of the participating communities. This information is distributed to the public through a website published in English, French, and Inuktitut. Long-term goals of the program include the identification of ice safety indicators that can help model ice behaviour in climate change conditions. Local researchers have received monitoring training, with the intention that monitoring activities will progressively be adopted by community members.

Source: Tremblay et al. (2006); Tremblay et al. (2007)

STEP 2 Assessing present status and trends. Where are we heading?

2A: Examining current development challenges, planning principles and capacities

This step is focused on examining local vulnerability and available capacities. By looking at currently applied principles and projections in local development (population growth scenarios, planned coastal and flood plain development, zoning, changes in the use of agricultural land, green spaces and parks) and assessing them for their potential to address current and future challenges from climatic and non-climatic stresses, local vulnerabilities and adaptive capacities can be assessed. Attention needs to be given to evaluating the extent of collaboration between different departments, since addressing climate change and sustainability requires moving away from 'silos' and instead promoting collaboration between sectors.

Investigating the linkages between current decisions in the context of development challenges and climate change are important, because:

- Inclusion of climate change impacts in the local development planning process has implications for much more than climate or environmental policy. Local taxes, infrastructure investments, land-use regulations and budget planning processes all have major implications for local or regional development paths, and therefore for adaptation and mitigation options and impacts.

- The local context frames adaptation and migration options. There are a number of ways to respond to climate change impacts and reduce GHG emissions. For example, to respond to flooding we could think of flood attenuation and storage; upstream land management; permanent flood defences including ring dikes around vulnerable areas; diversion of flood flows; setting back river edge flood defences to make space for water; changing the configuration of the coastline; green roofs; widening drains; managing flood pathways; raising floor levels; free-standing flood barriers; removable household products; and increasing habitable space. However, the option selected depends not only on the impact, but also on current and future local priorities.

- Responses to climate change very often require harmonization between decisions of different departments to avoid trade-offs and to benefit from synergies. Many local governments have already created working groups on sustainability in which they strive to avoid narrowly focused policies that often neglect social or environmental benefits. Similar approaches are needed to progress with the responses to climate change.

- Finally, obtaining information about the community will help to establish which measures are feasible in the short and long-terms, with regard to current and future development plans and available capacities.

The completion of these actions will provide information about the state of local development, capacities and local vulnerability. To address them, a number of methods can be utilized. We suggest conducting a series of interviews, but these actions could also be discussed using focus groups (details about both methods are in Appendix 1). To do this, the project team could collaborate with researchers to help conduct the analyses and summarize the results. This exercise will help to determine capacities and applied principles, and scenarios in local planning. One way to proceed further is to discuss the report in a meeting involving a project team and the researchers working on the SAM project. This could be used in the workshop setting to create a common ground for completing the list of actions.

A project team should gather information on a series of issues and develop a report on the assessment of current areas of strengths and weaknesses in responding to current challenges, including weather-related events. This step provides information about whether current plans and priorities are effective to address current vulnerability and what are the available capacities to address these vulnerabilities. It also provides important inputs for the next step by listing information needs of the practitioners in regards to climate change impacts.

STEP 2A: METHODS AND ACTIONS

We suggest the following list of actions in order to estimate current development challenges, planning principles and vulnerabilities:

1. Identify the climatic and non-climatic (if needed) variables or factors that affect the problem you are looking to address with your SAM project. Consider changes in level of GHGs as well.

2. Identify socio-economic scenarios that are currently used in local planning processes. What are the assumptions that form the basis of these scenarios?

3. Assess to what extent current plans, policies and regulations account for the identified set of variables and their further changes. Are there measures that are presently enforced that are able to provide a buffer against expected future changes, including climate changes? How flexible are they? How do they present challenges or barriers?

4. Identify impacts of present day weather patterns (temperatures, precipitation, etc.) and severe weather events (windstorms, heat waves, cold snaps, rainstorms, thunderstorms, snowfalls etc.) on sector/infrastructure related to the focus of your initiative

5. Discuss examples of responses to major weather events (flood, windstorm, thunderstorm, heat wave) that have occurred in the past. Were they effective? Why / why not?

6. Identify information that you need gather in order to make effective decisions about adapting to climate change in issues related to the focus of your initiative (i.e., changes in design or operation of current systems to cope with changing weather patterns expected because of climate change).

This could include:

- Local projections of climatic variables (precipitation, sea level rise, wind, flooding, snow melt);
- Local consequences of the impacts (changes in local river hydrology, changes in ground water availability, impacts on slope stability, occurrence of pest and diseases etc.)
- Best practices for adapting to climate change, that have been applied in similar conditions to your location
- Information on low-carbon technological options that could address climate change impacts

7. Identify departments that have the most flexibility or capacity to develop and implement new programs to cope with climate change impacts

CASE STUDY 4
Storm surge mapping on Canada's east coast

Focus, objectives and team in the adaptation initiative: To use storm surge mapping to predict the impact of the design storm at current and projected sea levels. The project was initiated in 1998, by the Clean Annapolis River Project (CARP), a non-governmental organization in collaboration with the town of Annapolis Royal, focused on mapping storm surge.

Current vulnerability and capacities: With an average tidal range of 10 metres and an average frequency of two hurricane-type storms every three years, the Bay of Fundy and its surrounding coastal towns are susceptible to storm surges. Much of the inhabited land bordering the Bay is at or below sea level, having been reclaimed by Acadian settlers in the 17th century with an elaborate system of dykes. The dykes, which now protect a large population and economically significant agricultural lands, have been maintained and upgraded based on a historical design from 1869. However, if projected impacts of climate change lead to unprecedented storm surges, they would surpass the dykes and overwhelm the coping capacity of the communities.

Estimated impacts of changing climate: CARP encountered many obstacles in their efforts because the data critical to the completion of the exercise, like elevation maps with reasonably small contour intervals, were either non-existent or difficult to access. Nonetheless, they succeeded in generating maps, which indicated that much of the town would be flooded, and that critical infrastructure such as the fire department could be marooned from the rest of the community.

Responses to climate change and their implementation: Resulting adaptations in the risk management strategy included the re-distribution of some emergency response equipment and the purchase of a boat by the fire department. The maps also led to the organization of a mock disaster scenario to engage the public in disaster management planning. CARP has since pursued some saltmarsh restoration in the Bay, a natural solution that can help reduce the impact of storm surges. The maps indicated the need for changes in town planning and protection strategies. Presently, adaptation strategies include reviewing the emergency preparedness plans, improving the early warning system and collaboration with a number of departments and institutions to ensure the effectiveness of the early warning systems.

Sources: Belbin and Clyburn (1998); Danard, Munro and Murty (2003); McKenzie (2006)

2B. Estimating impacts of climate change

The purpose of this step is to estimate the impacts of climate change in the context of the SAM project. The previous two steps set the context for the climate change impacts. Except in areas of high vulnerability, climate change is usually not a major driver of changes in development policies and plans. Even so, it can act as a significant stressor that may influence the direction of local development and vice versa. In particular, climate change is most likely to have significant implications for development by interacting with other stresses on sustainable development. For example, in areas where the aging infrastructure is under pressure because of the growing population and limited resources for maintenance, further stresses due to climate change could lead to severe consequences.

STEP 2B: METHODS AND ACTIONS

We suggest the following list of activities to estimate current and past experiences with weather-related events to help identify future impacts of a changing climate:

1. Identify the changes in climatic variables estimated by climate model simulations
2. Estimate impacts of changing climatic variables on a resource-base that is relevant for the focus of the SAM project (hydrology, forestry, coastal land flooding due sea-level rise etc.)
3. Assess the potential consequences of estimated impacts that could be relevant in designing future development activities, adaptation and mitigation measures
4. Identify areas of future vulnerability in the context of relevant plans, policies and regulations

The important part of a climate change impact assessment should be not only obtaining information about changes in basic climatic variables such as temperature and precipitation, but also information on what these changes mean for the resources, infrastructure and vulnerability of areas relevant for the local government. From the adaptation and vulnerability reduction point of view, these consequences arevery important for the design of actual adaptation actions because they relate changes in climate variables to socioeconomic and ecological dimensions of local development.

After completing steps 2A and B, the major vulnerabilities to climate change should be identified. This could be done in a meeting or workshop in which the climate impacts and their consequences are presented. Based on the current vulnerabilities and capacities, major future vulnerabilities can be identified. To discuss the current and future vulnerabilities, a method such as 'what-if' analyses could be used (see the Appendix 1 for more details).

By this stage of the SAM project, the study on major climate change impacts relevant to your community has been completed and major future vulnerabilities have been identified.

CASE STUDY 5
Water Management and Climate Change in the Okanagan Basin, British Columbia

Focus and objectives of the adaptation initiative: The goal of this initiative was to develop integrated climate change and water resource scenarios for the Okanagan Basin and engage stakeholders in dialogue on the implications of climate change for water management in the region.

Current vulnerabilities and capacities: The Okanagan Basin is characterized by a semi-arid climate and rural agrarian landscape and is a significant producer of tree fruits, wine grapes and other horticultural products. The region has also experienced rapid population growth and urbanization in the past two decades, with populations increasing from 210,000 in 1986 to 310,000 in 2001. Population growth is expected to continue, reaching 450,000 by 2031. Long-term climate records in the region indicated a significant warming trend, particularly in winter and spring, leading to earlier onset of spring snowmelt. Increased precipitation has also been observed in spring and summer, along with a reduction in the proportion of precipitation falling as snow at lower elevations. Low snow pack and hot dry summers led to drought conditions in 2002-2003, causing forest fires and impacts on water supplies in many parts of the basin affecting the ability to meet agricultural, residential and ecological water demands.

Estimated potential impacts of a changing climate: Climate and hydrological modeling indicates that the region can expect earlier onset of spring snowmelt, a tendency toward a more rainfall driven hydrological regime, and reductions in annual and spring flow volumes in the 2050s and 2080s. Inflow to Okanagan Lake is estimated to decline to approximately 69% of historical inflows by 2100. Agricultural water demand is expected to rise by 12-20% in the 2020s, 24-38% in the 2050s, and 40-61% in the 2080s over the baseline modeled crop water demand of 200 million m^3. Residential water demand is also expected to rise as a function of population growth, housing density and climate change.

Long-term goals and principles: Sustainable development is a major concern in the Okanagan Basin. In particular, there is a desire to maintain the rural agrarian landscape, while coping with increasing population growth and density. In this context, there is also a widely recognized need to address impacts of climate change on water supply and demand. Increasing water use efficiency by all sectors, maintaining agriculture's access to water and providing adequate water for fish habitat are all important priorities for water management.

Responses to climate change and their implementation: The issue of climate change impacts on water supply and demand has gained a profile in the region over the past several years. As a direct result of this research, climate change projections were incorporated into a sub-regional water management plan and the topic has become has become a major part of sustainable development dialogue processes. A provincially-funded basin-wide water supply and demand study is underway to more accurately characterize current and future water supply and demand and support planning and management decisions. The Okanagan Basin Water Board has also been given greater powers to examine basin-wide water supply and demand issues, explore water, energy and resource conservation issues to promote sustainability in the fast growing region.

Source: Cohen et al. (2004); Cohen and Neale (2006)

STEP 3 Developing a vision of the future. Where do we want to be in the coming decades?

3A: Identifying goals and principles of local sustainability

This section is focused on examining future development priorities that are articulated in local planning documents such as Official Community Plans (in British Columbia) and sustainable development plans. Local plans developed under the guidance of these documents provide an opportunity to reflect on local priorities in the context of current planning goals, principles and the expected impacts of climate change.

This step will provide an umbrella for identifying actions to respond to climate change in the SAM project to meet overall long-term priorities and help build a resilient community for the future. The step requires creating a vision of the future. Local planning documents very often provide key directions and trajectories for a desired local development path, but often remain very generic and leave space for diverse actions to be included to achieve the goals. In Case Study 6, the desired local development goals were diversifying the local economy by extending tourist activities throughout the whole year.

STEP 3A: METHODS AND ACTIONS

We suggest the following list of questions to highlight long-term development priorities and visions at the local level in the context of the focus and objectives of an adaptation initiative:

1. Based on community development priorities, identify the particular short and long-term priorities relevant for the focus of the SAM project
2. Assess how these priorities help to build a resilient community
3. Identify what planning and design challenges have been created as a result of these priorities
4. Assess the challenges created by the future impacts of climate change on the attainment of these goals

We suggest collecting the relevant planning documents and convening a meeting or facilitated workshop to discuss the long-term development priorities and what they mean for the focus and the objectives of the SAM project. If such documents are not available, then the community could engage in creating a long-term local development scenario(s).

At this step, the future sustainable development priorities in the context of current trends and future climate impacts for the SAM project should be selected. This will help to frame the selection of adaptation and mitigation options discussed in the next step.

Smart Growth and Climate Change in British Columbia

Land use is the key factor affecting our quality of life. We can reduce transportation greenhouse gas emissions marginally through more efficient vehicles and cleaner fuels, but the only way to really address the issue is to reduce the total amounts we drive. This can only be accomplished by more efficient land use and the development of compact, complete communities.

'Smart growth' is a collection of land use and development principles that aim to enhance our quality of life, preserve the natural environment, and save tax resources over time. The ten smart growth principles are:

1. Mix land uses so that living, working, and shopping occur in close proximity.
2. Build compact neighbourhoods and communities by identifying growth areas.
3. Provide a variety of transportation choices as alternatives to driving.
4. Create diverse affordable housing opportunities so that residents from all family types, life stages, and income levels can live in the same neighbourhood.
5. Encourage investments in infrastructure and servicing such that new developments do not take up new land.
6. Preserve open spaces, wetlands, grasslands, and other environmentally sensitive areas.
7. Protect and enhance agricultural lands.
8. Utilize green infrastructure, alternative development standards, and green buildings.
9. Foster a unique neighbourhood identity.
10. Nurture engaged citizens.

Creating smart growth communities means planning for the long term. Policy tools such as Official Community Plans (OCPs) and Regional Growth Strategies (RGS) create opportunities for communities across BC to incorporate smart growth principles into guiding the future development of communities to be more resilient and adaptable to climate change. Currently, the planning process in BC requires that landscape hazards be identified and the location of a community's future development considers these hazards. Flooding, sea level rise, avalanche risk, and other climate change scenarios could (and should) be incorporated into this planning process to ensure that future development occurs in the safest places possible.

Recently, the Government of British Columbia introduced new strategies and legislation that support the principles of smart growth and will encourage local and regional governments to grow smarter. These include the Brownfields Renewal Strategy, the Carbon Tax, Bill 27, and a revised Building Code. Once Bill 27 comes into force, local governments will be required to include GHG emission targets, policies and actions in their Official Community Plans and Regional Growth Strategies and will be able to use regulatory tools to promote energy and water conservation, and to waive or reduce charges for green development.

The research on urban form and climate change impacts and adaptation may be only beginning to emerge, but the links are already clear. Smart growth communities are more walkable and better able to provide efficient transit, which is increasingly important as the cost of fuel rises. They are surrounded by productive and protected farmlands to provide residents with increased food security. Carbon sinks such as forests, wetlands and other naturalized areas are conserved. They redirect and encourage a strong local economy by keeping small businesses in town centres alive and thriving.

Cleary, the 'where' and 'how' of climate-resilient communities tomorrow will be based on smarter growth today.

(Contributed by Ione Smith)

CASE STUDY 6
Economic Diversification and Sustainability Planning

Focus, objectives and team in the adaptation initiative: The Resort Municipality of Whistler (the municipal administration) and Intrawest Corporation (the resort operators) have been actively developing their non-winter tourist opportunities, hence diversifying the local economy and making the community more resilient to climate change.

Current vulnerability and capacities: Current vulnerability and capacities: Investments have been made into several "off-season" activities, most notably to the thriving mountain biking industry. This activity ideally complements the ski season: it operates when conditions do not support skiing (during the spring, summer, fall, and even warm winter spells), and much of the same infrastructure (such as ski lifts) can facilitate both sports. Other summer offerings include golf, horseback riding, hiking, and white water rafting. Whistler's investments have resulted in steadily increasing room revenue over the past several summers.

Long-term goals and principles: The municipality has also developed a comprehensive sustainability plan, entitled *Whistler 2020*. One of the goals of the plan is to ensure ongoing economic viability through a continued focus on diversification and other activities. Indicators also monitor changes in GHGs, energy use and effectiveness of conservation and recycling efforts. Developers of the plan have identified several measurable indicators of economic viability, and monitor these indicators regularly. Outputs from *Whistler 2020* monitoring allows residents and town planners to verify that economic adaptations are actually improving the resilience of the municipality to climate change.

Responses to climate change and their implementation: However, *Whistler 2020* is a strategic adaptation that complements the economic adaptations previously pursued. The monitoring of economic indicators, as determined by the plan, could help ensure that present and future economic decisions shape a robust and sustainable economy as Whistler encounters climate change. Recent activities to reduce GHG emissions are being introduced including waste recycling, energy efficiency, conservation, increased use of renewable energy and offsetting carbon emissions. It is important to note that Whistler has a distinct advantage over other resort municipalities and tourism businesses because of its status as a well-established, corporately-owned facility with a big budget and substantial political leverage.

Source: RMOW (2006); RMOW (2007)

3B. Assessing impacts of climate change and potential for adaptation and mitigation

A number of options are available to adapt to expected climate impacts and similarly, there are number of ways to reduce GHG emissions. In this step, we focus on identifying a portfolio of responses to climate change that fits within the focus of the SAM initiative. Building on the close linkages between climate change related measures, capacities and local development goals, the aim of the SAM project becomes one of avoiding "dangerous" local situations by identifying adaptation options and assessing them in order to determine which are most viable. Mitigation measures can increase local vulnerability to climate change, and measures for adaptation can increase local emissions of GHGs – unless they are discussed together. This could be achieved for example by conservation measures and producing renewable energy.

We suggest the following list of actions to develop a portfolio of adaptation and mitigation responses to climate change and identify synergies between them:

1. Estimate impacts of climate change and vulnerabilities of the local system that require adaptation. What kind of expected impacts do we need to adapt to?
2. Identify measures that could provide adaptation to estimated impacts of climate change in the development context of your adaptation initiative (see also Section 6.6)
3. Identify the current and expected emission reduction targets, involved sectors and considered mitigation measures
4. Assess the opportunities for emission reduction that are feasible under expected impacts of climate change
5. Assess how the measures identified can be adjusted or modified to maximize both mitigation and adaptation benefits
6. Identify the social, environmental and economic benefits and costs for the community if the SAM project promoted measures linking both adaptation and mitigation

SAM projects focused on issues with a long lifespan, (transportation, infrastructure, expansion, urban development, reforestation, responses addressing adaptation needs, and mitigation potentials) could foster efficient use of resources sustained with even stricter emission reduction policies and bigger impacts of climate change.

For already implemented measures in Canada, an example linking adaptation and mitigation could be the use of photovoltaics (Case Study 7). They provide a source of clean energy (mitigation) and a source of energy during power outages (adaptation). Another example is the Toronto Heat Alert system (Case Study 8), which presents an adaptation response to heat waves in the city that relies mostly on public cooling centres; and in the long-run suggests the importance of sustainable responses such as expansion of green spaces and green roofs in the city.

STEP 3B: METHODS AND ACTIONS

This step requires development of adaptation options that offer mitigation benefits that address current vulnerability and the impacts of climate change, while helping to achieve the long-term priorities of the community. Methods are available—including expert judgments and portfolio analyses—to discuss potential adaptations (see the next section on adaptation examples). We suggest that the project team organize a workshop within the local government while inviting departments related to the focus of the project. The project team could also consider inviting representatives from neighbouring municipalities or experts on the issue related to the focus of the initiatives (for example, dikes if you deal with flooding, forest system if you deal with reforestation etc). During the workshop, adaptation options with mitigation co-benefits will be identified. To help, the next section lists adaptation options by sector. We suggest the following workshop agenda to develop a portfolio of adaptation responses:

1. Present a focus of the SAM project and relevant long-term development priorities

2. Present the outcomes of the scoping study, including the consequences of the impacts and identified areas of major vulnerabilities

3. Use a list of suggested adaptation options and involve the workshop articipants in identifying a list of responses to climate change (through group discussion) that fits within the focus of the SAM project

4. Create a list of potential responses to climate change

5. Finally, based on the identified list of responses to climate change, discuss further information that may need to be collected about these options in order to be considered for implementation

At this step of the SAM project, a list of adaptation options, with mitigation co-benefits that minimize trade-offs between adaptation and mitigation and are feasible at the local level, have been developed.

CASE STUDY 7
Distributed generation using photovoltaics

Focus, objectives and team in the adaptation initiative: Evaluating the feasibility of distributing the generation of energy amongst many small-scale producers is one adaptive strategy that can build resilience against climate change impacts.

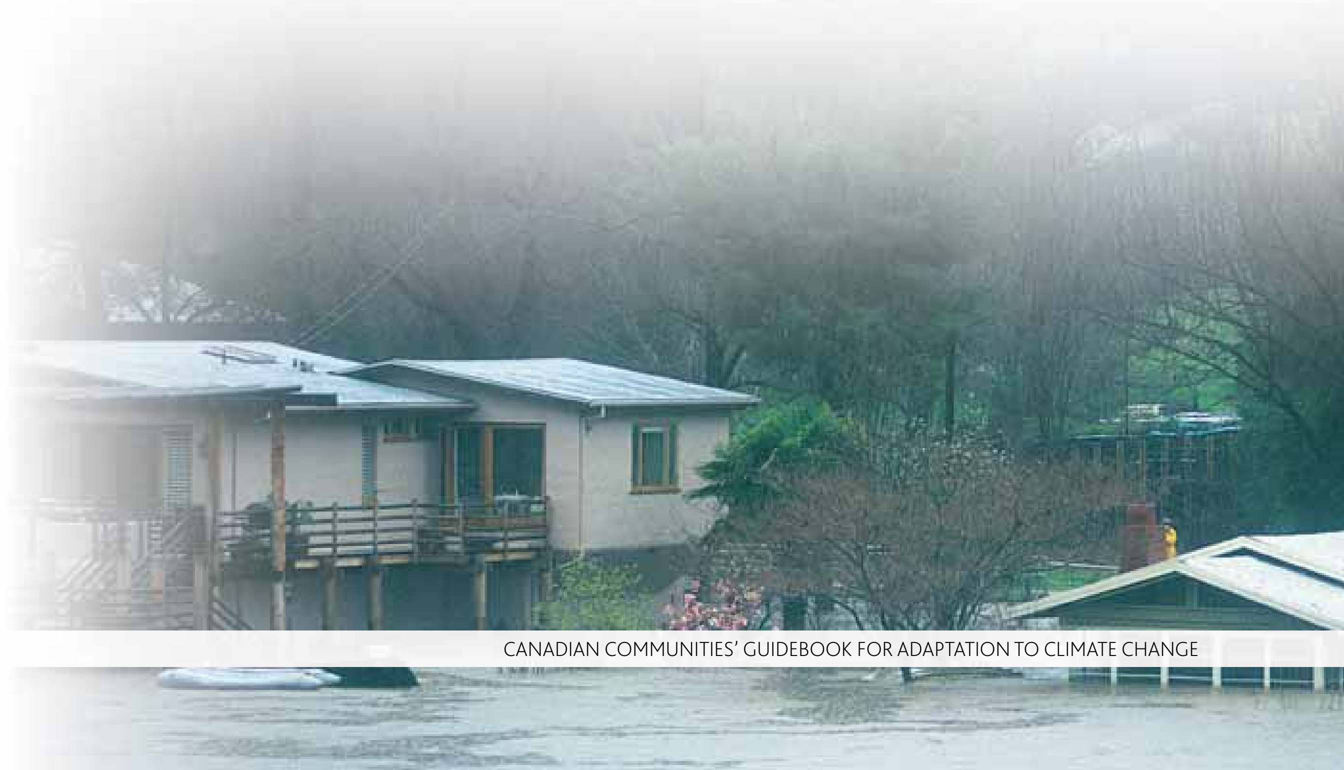
Current vulnerability and capacities: Autonomous (stand-alone) systems are not connected to the energy grid and they can provide resilience for building owners. One off-grid homeowner noted that, after the ice storm, his family returned to regular functionality much faster than his neighbors. Grid-connected systems can act as an adaptation for the energy sector as a whole, reducing the disruptive potential of an extreme weather event – if smaller systems fail, fewer people are affected. Hybrid systems offer the best of both options, because they are connected to the utility, but have an emergency back-up battery in case of grid failure. The PV market in Canada is expanding steadily, with more than 50% growth between 2002 and 2004.

Estimated impacts of changing climate: Climate change will likely shift and in some cases increase the peak energy demand in Canada from winter to summer, which requires adjustments in our infrastructure

Long-term goals and priorities: PV systems generate the most electricity during the heat of the day, thus reducing the vulnerability of central generation plants. They were not designed as a response to climate change, nor are they often identified as a potential adaptation. However, a well-designed DG network could be a powerful and far-reaching "no regrets" adaptation. Unfortunately, uptake of this technology is occurring slowly because grid-tied systems are economically uncompetitive, while stand-alone systems are only competitive in certain circumstances. Government support of this industry could be invaluable.

Responses to climate change and their implementation: Energy generation is one of several contentious issues that polarizes the "mitigation" and "adaptation" agendas. Many adaptations to extreme weather involve the consumption of energy (like air conditioners, for example), while traditional production of energy adds to climate change. Distributed generation of renewable energy could bridge that divide by improving the resilience of the energy grid while concurrently mitigating GHG emissions.

Sources: Dignard-Bailey (2002); Oke (2007)



STEP 4 Setting trajectories to meet priorities. How can we get there?

4A: Identifying actions to achieve the vision of the future

Experiences in developing responses to climate change showed that placing greater responsibility on planning bodies and collaboration among government officers and stakeholders to resolve planning issues promoted greater local ownership of policies and an increased commitment to their implementation (UKCIP, 2001). To progress toward policies and implementation, the options identified need to be communicated in a language that speaks to the target audience. Action is best enabled when it fits into the current mandate and activities of decision-makers, or when it is linked to the goals expressed in existing planning documents.

In terms of implementation, adaptation options may be considered on different time scales. Short-term "no regrets actions" are those actions where society would benefit from their implementation, even if anthropogenic climate change did not take place.

STEP 4A: METHODS AND ACTIONS

To move from the list of adaptation options in the previous step to implementation, we suggest using the following list of questions:

1. Identify the 'preferred options' that reach the overall development priorities for the future development pathway in the context of the adaptation initiative
2. Investigate if there are actions that provide win-win and/or no-regrets solutions both in the context of climate change and the adaptation initiative
3. Identify short-term measures that are needed to implement the selected option
4. Identify long-term measures that are needed to ensure the implementation
5. Assess what capacities are needed to ensure that the planned actions could be implemented effectively. Who will be responsible for implementation?
6. Estimate how progress will be measured and evaluated. Are there existing systems in place to monitor the progress?
7. Assess what procedures are needed to incorporate lessons learned into future planning and best practices

The case studies listed in this Guidebook provide examples of implemented actions that include diverse short-term and long-term measures. These actions include building water storage facilities (Case Study 9), building public cooling facilities and distributing water (Case Study 8), and installing devices to generate electricity (Case Study 7). The identified adaptation often requires setting up long-term goals that will be implemented continuously, such as funding programs for local communities (Case Study 9), development guidelines for economic diversification to minimize dependence on services or forestry sensitive to weather and climate (Case Study 2) and ensuring long-term monitoring of sea ice changes and distributing this information to community users (Case Study 3).

At this step you need to evaluate our list of adaptation options (Table 4 and 5) to climate change, select the most feasible options and transform them into actual actions. There are several methods (see Appendix 1) that can be used to select adaptation options, including:

- Trade-off analyses
- Multi-criteria analyses
- Experts' judgments
- Cost assessments: including cost-benefit analyses, assessment of cost of adaptation, cost of inaction, and cost-effectiveness analyses

To conduct any of the suggested methods, criteria will be needed that will provide information about the trade-offs between different responses, the urgency of needed responses and the availability of resources - both financial and institutional for implementation (table 3). A consultant may also be required.

By this step of the SAM project, you will have created a list of adaptation responses that are a priority for the short, medium and long term.

TABLE 3. SUGGESTED CRITERIA FOR EVALUATING CLIMATE CHANGE RESPONSES

Category	Criteria	1 (low)	2 (medium)	3 (high)
SUSTAINABILITY: SOCIAL, ECONOMIC, ENVIRONMENTAL	Mitigation co-benefits	Result in increased greenhouse gas emissions	Would not affect greenhouse gas emissions	Would reduce greenhouse gas emissions
	Environmental impacts	Result in net environmental costs	Result in no-net loss of habitat or ecosystem services	Result in net environmental benefits
	Equity	Benefits to few people	Benefits to many people	Significant benefits to many people
	Implementation Cost	Cost of implementation is high relative to cost of inaction	Cost of implementation is moderate relative to cost of inaction	Cost of implementation is low relative to cost of inaction
	Operating and Maintenance Cost	Cost of operation and maintenance is high	Cost of operation and maintenance is moderate	Cost of operation and maintenance is low
EFFECTIVENESS	Robustness	Effective for a narrow range of plausible future scenarios	Effective across many plausible future scenarios	Effective across a wide range of plausible future scenarios
	Reliability	This measure is untested	Experimental but has expert support	The effectiveness of this measure is proven
RISK AND UNCERTAINTY	Urgency	Risks are likely to occur in the longer-term	Impacts are beginning to occur, or are likely to occur in the near- to mid-term	Impacts are already occurring
	Degree of risk or impact	Future risks are minor and reversible	Future risks are moderate and reversible	Future risks are potentially catastrophic or irreversible
	Precautionary	The risk is generally understood	Some uncertainty exists	The risk is not well understood
OPPORTUNITY	Ancillary benefits	This measure will contribute little or not at all to other goals for the community	This measure will contribute somewhat to other goals for the community	This measure will contribute significantly to other goals for the community
	No-regret option Piggybacking	This measure will have little or no benefit if climate change impacts do not occur	This measure will have some benefits regardless of actual climate change impacts	This measure will result in significant benefits regardless of actual climate change impacts
	Window of Opportunity	There is no window of opportunity currently	A window of opportunity could be created	A window of opportunity exists to implement
IMPLEMENTATION	Public acceptability	Likely to face public opposition	Not likely to receive much public attention	Likely to receive public support
	Funding sources	External funding sources are required but have not been identified	External funding sources are required and likely to be secured	Funding is available
	Capacity (info, technical, staff, resources)	Current capacity is insufficient and gaps cannot be easily addressed	Gaps exist in one or more areas but can be addressed	Current capacity is sufficient
	Institutional	Implementation requires coordination with, or action by, other jurisdictions	Implementation requires external approval	Implementation is within local control

4B. Developing capacities and institutional linkages to support implementation

To achieve successful implementation of the adaptation initiative, it is important to ensure that the various agencies that may be involved in, or affected by, the activity are supportive. Local governments in Canada are required to comply with a host of regulations, guidelines and standards that are developed by other levels of government or regulatory bodies that govern professional practice. Additionally, many issues, such as the management of drinking water supply and demand, involve multiple agencies at municipal, regional, provincial and federal government levels. Existing statutes, regulations, bylaws, building codes and professional best practices may not currently support or allow for unconventional or innovative development that may be required by the SAM project to meet adaptation, mitigation and sustainable development goals. It is therefore necessary to build collaborative relationships and teams so that the project can be implemented and that the lessons learned can be translated into best practices at all levels.

STEP 4B: METHODS AND ACTIONS

1. Identify how the implementation of measures will be funded. Does the budget for current and forthcoming years enable actions to be implemented?
2. Identify staff that will be responsible for implementation within the local government (department level, etc.)
3. Assess whether project implementation has support from all levels (council, senior management, operations, etc.) and departments (planning, engineering, bylaw enforcement, etc.) within the local government. If not, how can support be enhanced?
4. Assess whether there are adequate human and material resources. If not, where can resources be obtained?
5. Gather information about the public awareness and support of the project. Is an education and outreach program required? Is a communication strategy required?
6. Estimate linkages to other agencies outside of the local government. What involvement or buy-in from other agencies is needed for successful implementation?
7. Assess whether the project is entirely within the jurisdiction of the local government or do other levels of government need to be engaged by the project team.

It would be beneficial to consider some of these actions throughout the SAM project's process, as they may influence who is engaged as part of the project team and to help avoid pitfalls during the implementation stage. Outcomes of the evaluation from the previous step will provide valuable information on what capacities are needed to implement the SAM project. In the listed cases focused on emergency preparedness (Case Studies 4 and 8) additional capacities were needed in order to implement a plan. In Case Study 9, additional capacities were needed to maintain facilities and the program.

It is also important to consider that with climate change progressing, more adaptation and mitigation actions will be needed. Therefore, developing a capacity to address future challenges should be considered when the capacity needs are defined. The questions in this step and the outputs from the previous step could be addressed in discussions with the project team.

After the completion of this step, the SAM project team will have a clear picture of what adaptation options with mitigation co-benefits will be implemented and what are the capacities for successful implementation.

CASE STUDY 8
Heat Health Alert System

Focus and objectives in the adaptation initiative: Develop and implement an emergency preparedness plan to mitigate the effects of high summer temperatures often exaggerated by humidity and urban heat island effect.

Current vulnerability and capacities: High summer temperatures, particularly when sustained over consecutive days or when coupled with other factors such as humidity, are correlated with many negative health implications. In an urban setting, high temperatures are exacerbated by the Urban Heat Island (UHI) effect, leading to even more health implications.

Estimated impacts of changing climate: Climate change predictions show increasing occurrence of heat waves with possible negative impacts on human health.

Long-term goals and priorities: To increase the resilience of the city by preparing the population for impending heat through emergency preparedness and by minimizing the local sources of urban heat.

Responses to climate change and their implementation: In light of these projections, the Toronto Public Health partnered with the Toronto Atmospheric Fund to develop a Heat Health Alert System. When forecasts predict that the threshold of certain pre-determined high-risk climate criteria will be breached, the alert system is triggered. Warnings are advertised on the radio, television and internet, and a web of social service organizations are contacted in an attempt to convey warnings and advice to vulnerable populations. Bottled water is distributed to the homeless; shelters allow people to stay inside during the day; and a service performing house calls to at-risk individuals is made available on request. 99 libraries and 81 community centres, all of which are air-conditioned, provide relief from the heat. During extreme heat alerts, four civic buildings are made available as designated cooling centres.

This program should ideally be complemented with some long-term adaptation actions to reduce urban heat, such as the expansion of green spaces, the increase of porous city surfaces and the facilitation of green roofing.

Sources: Penney and Wiedtz (2007)

CASE STUDY 9
Tank loading facilities

Focus, objectives and team in the adaptation initiative: Through a cross-jurisdictional partnership between the National Water Supply Expansion Program (NWSEP), provincial counterparts have worked with communities and individual farmers across the country to support preparation for water shortages in agriculture and in the community.

Current vulnerability and capacities: In response to adverse weather in 2001 – 2002, farmers typically exercise a variety of coping methods - from altering irrigation and watering techniques, to planting alternative crops, to changing the end product – with qualified success.

Estimated impacts of changing climate: Climate model scenarios project changes in precipitation, increasing occurrence of drought and heavy rainfall over a short time.

Long-term goals and priorities: Providing security to local agriculturalists and communities in the event of increasingly frequent periods of water stress.

Responses to climate change and their implementation: A tank-loading facility is a non-potable community well built in an area of stable groundwater supplies, as identified by hydrological investigations. At a cost of $1.00 for approximately 908 litres, farmers can use the facilities to fill portable water tanks, which can be hauled back to the farm for a variety of agricultural purposes - from livestock watering to spray operations. As an added bonus to the community, the facilities also provide extra water for emergency response when necessary, an important safeguard during drought when the risk of fire increases. As of spring 2007, four facilities have been completed and twomore are under construction. These responses should also be accompanied by measures promoting increased water efficiency and conservation in irrigation and other activities.

Source: Belliveau et al. (2006)

STEP 5 Monitoring, re-assessment and adjustments

In addition to good planning and good information, good decision-making also involves revisiting a decision as new information becomes available. Scientific understanding of climate change at the local level embodies many uncertainties that are multiplied during the translation of climate data into scenarios of future impacts on hydrology, changes in biodiversity or impacts on agriculture. Scientific knowledge in the climate change field is progressing rapidly and it is expected that more detailed localized data will be available in the coming years. In addition, human capacities and governance are also changing at all scales. This may create new opportunities or lead to setbacks as political and social preferences change and new issues overshadow old ones. Close monitoring of the adaptation initiative after implementation by both practitioners and policy-makers creates opportunities to address challenges as they appear.

STEP 5: METHODS AND ACTIONS

To proceed with this step, we suggest using the following list of questions:

1. Identify emerging development challenges and policies that have the potential to create new vulnerabilities with regard to climate change
2. Assess new information as it becomes available that could provide insight into or change best practices in local planning processes
3. Identify the aspects of the project that require follow-up and monitoring. How will monitoring be done and linked with reporting procedures?
4. Identify activities that require follow-up

It is important to maintain contact with the project team and scientists so they can up-date you on the latest developments and provide data about impacts and responses to climate change. Because climate change is a rapidly evolving issue in research and practice and because local, national and international policies are continually developing, opportunities may arise for follow-up activities on the adaptation initiative or new projects that demonstrate practical 'on the ground' solutions to climate change in the context of local development may be identified.

Monitoring the performance of the implemented adaptation actions is one of the important priorities of this step. A potential list of indicators to monitor the performance of the implemented adaptation options could include:

- Average carbon emissions for heating, cooling and transport per unit of new buildings
- Amount of housing and commercial development permitted in flood risk or vulnerable coastal areas
- Average permeable and non-permeable surface area in permitted developments
- Total renewable energy and /or electricity supply (energy or electricity supplied)
- Average domestic/freight trip length/total distance per person/vehicle per annum
- Average level of waste recycling per type of waste in the community
- Average level of outdoor and indoor water use per person, household or hectares
- Average increase/decrease of green spaces and trees

Many of these indicators are already being monitored and many of the currently used indicators can be used to assess the effectiveness of the implemented adaptation measures.

It is important to communicate the results of the SAM project as it progresses with other local governments and agencies to promote information exchange and to increase your capacity to address future events. This communication can also help to identify future opportunities and initiatives to tackle climate change and promote sustainability. These new projects may require involvement of new stakeholders such as representatives of other levels of government, neighbouring communities, non-governmental organizations or professional organizations.

Examples of SAM Actions

The following tables list a number of adaptation actions applicable to various sectors. As suggested by Wilbanks et al. (2007), these actions are separated into the following: City and Community, Water, Forestry, Food, Biodiversity-related, Coastal Area and Floodplain, Health, Energy, and Recreation. In addition to the adaptation response examples provided below, examples of potential maladaptation have been included for further reference at the end of the section (Table 5).

TABLE 4. EXAMPLES OF ADAPTATION ACTIONS

PRINCIPLES OF CITY AND COMMUNITY ADAPTATION	• Ensure effective governance that integrates different aspects of development with environmental and social perspectives • Introduction of mainstreaming is suggested to facilitate consistency between adaptation initiatives and other programs, such as sustainable development planning • Internalize climate change into the market mechanism using economic instruments such as taxes, emission trading, and insurance to promote adaptation and mitigation policies • Implement general capacity building programs, market development, and local enterprise and finance development (e.g. soft loans, micro credits, and educational and training programs) • Encourage a strong sense of community and interests in natural resources conversation • Develop an Official Community Plan (OCP) to identify a comprehensive community vision for the long-term • Increase resilience of urban system physical and linkage infrastructures and allocate financial mechanisms for increasing resiliency • Change location choices, migration behaviour while promoting low carbon and resilient alternatives • Strengthen markets and other information exchange processes, including support of human and social capacities • Formalize flow of communication between local governments' departments (i.e. planning, engineering, parks, emergency management) and levels of government (i.e. federal, provincial, municipal) to coordinate adaptation goals and efforts • Implement 'mainstreaming,' the integration of climate change vulnerabilities or adaptation into related government policy (e.g. integration of climate information into vulnerability or hazard assessments, broad development strategies, macro policies, sector policies, institutional or organizational structures, development project design and implementation)
INFRA-STRUCTURE	• Encourage developers to meet Leadership in Environmental Design (LEED) standards • Create green roofs to extend roof life (i.e. green roofs can almost double the life expectancy of roofs by protecting roofs' waterproofing membranes) and lower development costs (i.e. storm management afforded by green roofs can reduce the number of drainage outlets required on buildings) • Use sustainable drainage systems (SUDS) • Promote 'cool' or 'white roofs' to minimize damage to infrastructure. Cool roofs reduce damage from ultraviolet radiation and daily temperature fluctuations, which cause repeated contraction and expansion • Planting vegetation (i.e. planting trees and vegetation to avoid subsidence in shrink-swell soils and erosion of sandy soils)

TABLE 4. EXAMPLES OF ADAPTATION ACTIONS

WATER SECTOR	• **Demand and Supply Strategies:** Introducing usage metres and market pricing • Developing and implementing education campaigns • Encouraging adoption of technological changes in water-consuming processes and devices (e.g. low-flush toilets, water efficient taps and micro irrigation) • Requiring introduction of water conservation measures and sustainable drainage systems for all development projects • Planting xeriscaped gardens that incorporate plants selected for their water efficiency • Establishing upland and lowland reservoirs, both natural and manmade, to ensure sufficient water supplies during summer while reducing potential for downstream flooding during periods of heavy rainfall • Reservoirs also provide important aesthetic, recreational, and ecological benefits • Managing point source pollution to reduce water quality risks • Increasing river basin planning and coordination, including capacity for inter-basin transfer • Harvesting rainwater to reduce water demand, lower risk of flooding (i.e. harvesting water buffers the amount of precipitation entering drainage systems), and collect water for toilet flushing, car washing, irrigation, etc. • A $100m^2$ roof can catch 500L of water from a rainfall of just 5mm • Disinfecting treated wastewater through practices such as lagooning and micro-filtration so water can be reused • Developing checkdams (anicuts) to stop/slow down water runoff in gullies and facilitate groundwater recharge • Greywater recycling involves reusing water from sources such as baths, sinks and laundry for other purposes, such as toilet flushing. Filtration and disinfection mechanisms must be in place. These systems require maintenance over the long-term. • **Reduce flooding events and minimize flooding impacts:** Establishing and protecting green infrastructure in urban areas, such as open spaces, woodlands, street trees, fields, parks, outdoor sports facilities, community gardens, village greens, private gardens, and green or living roofs and walls to attenuate peak flows and inhibit flash flooding • Using 'cool' or 'porous pavements' • Preserving land that is required for current and future flood risk management • Providing financial compensation to farmers who provide 'blue services' by allowing their agricultural land to be flooded • Re-creating functional floodplains • Introducing participatory risk assessment as a part of long-term local and regional development planning • Planning for increased frequency of extreme events to promote long-term resilience
FORESTRY, FARMING AND RANCHING	• Apply urban forestry (i.e. creating parks, planting trees along streets, growing trees within residential compounds) • Encourage smaller farms engaged in lifestyle farming • Promote community gardens • Employ no-till agriculture to reduce erosion, water quality issues and release of methane from soils • Implement agro-forestry (i.e. incorporation of multi-purpose trees and leguminous species) • Conserve native forests as their characteristically high biodiversity levels and native species contents afford them greater resilience to environmental conditions resulting from climate change • Reuse greywater for agricultural and horticultural irrigation • Provide financial incentives/mechanisms for increasing resiliency, removing impediments, and improving information systems (e.g. concessional credit lines to support agricultural equipment purchases) • Assure market linkages and integration to strengthen response capacities and share risks • Fallow fields (i.e. leave agricultural fields to rest and accumulate moisture every other year) • Rotate crops

TABLE 4. EXAMPLES OF ADAPTATION ACTIONS

FORESTRY, FARMING AND RANCHING	• Improve the effectiveness of pest, disease and weed management practices through wider use of integrated pest management, development and use of varieties and species resistant to pests and diseases, and improvements in quarantine capabilities and sentinel monitoring programs • Diversify income by integrating other farming activities such as livestock raising • Increase inputs of organic matter to improve soil fertility, enhance soil water holding capacity and reduce soil erosion • Match ranching stocking rates with pasture production • Rotate pastures
BIODIVERSITY CONSERVATION-RELATED	• Encourage conservation plantings • Create and protect green infrastructure in urban areas, such as open spaces, woodlands, street trees, fields, parks, outdoor sports facilities, community gardens, village greens, private gardens, and green or living roofs and walls, to garner not only biodiversity but also recreational, temperature, energy, flood storage, noise reduction, and air purification benefits • Return land with low fertility to forest in order to decrease land degradation and water stress • Alleviate 'coastal squeeze,' the pinning of natural salt marsh against man-made flood defences by rising sea levels, by breaching existing hard, coastal flood defences (e.g. seawalls) and allowing salt water back onto land originally reclaimed by such defences • Create and protect blue spaces, such as rivers, lakes and urban canals, to provide habitat for native species, help manage rising temperatures through evaporative cooling, and mitigate flooding by providing storage areas for excess water • Enhance or replace lost ecosystem services (e.g. manual seed dispersal, reintroduction of pollinators, application of pesticides) • Enhance natural resilience to climate change by reducing threats such as habitat fragmentation or destruction, over-exploitation, eutrophication (i.e. over-enrichment of water bodies, leading to organic growth and depletion of oxygen), acidification, pollution and introduction of alien species
COASTAL AREAS AND FLOODPLAINS	• As noted above with regards to biodiversity, allow breaching of existing hard coastal defences to allow salt water back onto land originally reclaimed by such defences to alleviate 'coastal squeeze', thereby allowing local vegetation to disperse wave energy during storm events, reducing coastal erosion, and providing habitats for coastal flora and fauna • Implement integrated coastal zone management (ICZM) (i.e. integrate and balance multiple objectives in the planning process, consider resilience of coastal systems at broader scales) • Introduce marine protected areas and 'no take' reserves
HEALTH SECTOR	• Encourage biking and use of public transit (e.g. create networks of bike trails, improve transit service coverage and frequency); these transportation modes lead to improved air quality through lowered emissions and improved public health • Establish and protect green spaces and features, such as street trees, courtyards, green corridors, smaller open spaces, and green/living roofs. These features help to reduce urban temperatures through evapotranspiration and shading, help purify city air, lower noise pollution and improve quality of life • Creating networks of cool roofs • Employing 'cool' or 'porous pavements' • Building narrow streets and orienting buildings and streets to reduce excessive solar gain and catch breezes, which helps reducing the need for cooling • Constructing thermal chimney vents and louvres to move warm air away from working and living spaces with benefits in minimized cooling • Employing advanced glazing systems to reduce solar heat gain • Increase health indicator monitoring and data accessibility to potential users • Employ strategies to manage and respond to high temperatures, such as establishing and protecting blue spaces such as ponds, roadside swales, flood balancing lakes, swimming pools, fountains, rivers, lakes and urban canals to lower surrounding air temperatures through evaporative cooling

TABLE 4. EXAMPLES OF ADAPTATION ACTIONS

ENERGY AND INDUSTRIAL SECTOR	• Encourage ground-source heat pumps: Soil and groundwater temperatures 10-50m below ground are relatively cooler than surface conditions in the summer, therefore, ground-source heat pumps can serve as an adaptation measure for space conditioning in the summer
	• Construct green roofs to provide cooling in summer and thermal insulation in winter, reducing energy consumption and fuel costs
	• Lay out communities in a linear arrangement of open and built space to allow buildings optimum solar gain in winter and cooling breezes in summer
	• Use greywater recycling to reduce upstream energy and environmental costs
	• Increase urban densities to minimise travel distances and create opportunities for community energy schemes with advantages for emissions reduction
	• Employ innovative techniques to minimize energy consumption and costs in building construction and maintenance, such as:
	  • Creating walls from hemp and chalk blocks, thereby using materials that require less energy for their creation and installation and that help regulate temperatures naturally and efficiently throughout the year
	  • Constructing internal door systems to help retain cool air in the summer and warm air in the winter
	  • Developing roof beams that overhang the sides of buildings, offering shading and helping to maintain a cooler internal temperature
	  • Installing dark-coloured air extraction ducts that absorb heat from the sun, helping air inside rise up and out of the building, and light-coloured ducts that draw fresh air in from the roof
	  • Installing ceiling panels cooled by water streams passing through them, thereby allowing the panels to cool surrounding air
	  • Using thermal storage or mass to allow heat absorption during hot periods and dissipation during cooler periods (e.g. thick, concrete ceilings)
	  • Constructing floor vents that allow building occupants to control flow of incoming fresh air
	  • Developing deep balconies and recessed terraces on building facades to provide space for plantings that provide shade and evaporative cooling
	  • Constructing aluminum fins over windows facing the sun and louvres to reduce solar heat gain and provide shading
	  • Installing sunroofs that incorporate solar panels, reducing long-term maintenance costs and contributing to lower energy usage
	  • Encouraging natural ventilation and daylighting to increase continued facility occupancy during power outages
	  • Change location and sources of electricity generation (e.g. co-locate greenhouses and centres of electricity demand to offer higher security for the infrastructure)
	  • Deploy renewable energy systems as they are relatively invulnerable to grid and fuel-supply disruptions and can, therefore, enhance electricity-system reliability (e.g., micro-hydro, wind, solar thermal, and solar electric power)
	  • Protect and conserve watersheds
	  • Watersheds with diverse vegetation are buffered from rapid influxes of runoff more effectively than deforested watersheds
	  • If rapid influxes are prevented, reservoirs are likely to produce more power on an annual basis because operators are then able to move more water through turbines instead of spilling it during heavy runoff episodes
	  • Watersheds with reduced siltation have greater overall storage capacity, thereby preventing overflow flooding and extending the lives of facilities
	• Promote 'cool' or 'white roofs' to minimize damage to infrastructure. Cool roofs reduce damage from ultraviolet radiation and daily temperature fluctuations, which cause repeated contraction and expansion
	• Planting vegetation (i.e. planting trees and vegetation to avoid subsidence in shrink-swell soils and erosion of sandy soils)
	• Deploy efficient refrigeration systems in order to maintain low temperatures significantly longer during power outages

TABLE 4. EXAMPLES OF ADAPTATION ACTIONS

ENERGY AND INDUSTRIAL SECTOR	• Mitigate heat islands in order to reduce demand for air-conditioning and to extend the habitability of structures during heat waves • Prioritize energy efficient strategies that act synergistically with climate change adaptations (e.g. reduce rooftop ice damming with better insulation and increase fire-resistance and reduce incidences of breakage from flying debris in windstorms with energy-efficient window systems)
RECREATION SECTION	• Create and protect recreational green spaces to improve quality of life while concurrently providing biodiversity, health, energy, flood storage, noise reduction, and air purification benefits • Protect critical environments and landscapes • Establish upland and lowland reservoirs, both natural and manmade, to provide not recreational, flood management and biodiversity benefits • Diversify tourism revenues that also increase local sustainability and provide low-carbon alternatives to conventional tourist activities

Adaptation responses that, if designed carefully, could be SAM actions

The following list of adaption measures can contribute to the reduction of GHGs and to sustainable development *if* designed properly. For example, by selecting environmentally friendly materials; promoting energy, water and other resource conservation; promoting re-use and recycling; minimizing waste generation; protecting habitat and addressing needs of marginalized groups.

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

PRINCIPLES OF CITY AND COMMUNITY ADAPTATION	• Introduce adaptation policies that compensate for any climate change losses that individuals may experience in relation to basic needs

INFRA-STRUCTURE	• Incorporate infrastructure adaptation into the planning, maintenance and replacement cycles of new and existing infrastructure (e.g. construction of the Confederation Bridge between New Brunswick and Prince Edward Island was built 1m higher than required to accommodate sea level rise over its hundred year lifespan)
	• Demolish and replace unsafe structures
	• Relocate at risk communities
	• Avoid or regulate development in vulnerable locations
	• Prioritize and develop adaptation solutions such as retrofit technologies for the most critical regions and most critical existing infrastructure types
	• Review existing engineering practices in light of the changing climate
	• Address issues surrounding current infrastructure codes and standards, including
	  • Enforcing compliance to codes and standards for new infrastructure
	  • Updating safety factors in codes and standards to reflect increasing uncertainties and increased variability or range of extremes in values and growing risks for new infrastructure under changing climate conditions
	  • Considering standards for maintenance practices to increase the reliability of structures over time
	• Apply a “diversified lifetime” approach to building construction
	• Design buildings for disassembly so their uses can easily change over time
	• Ensure key long-term parts of buildings are able to cope with predicted climate change and design short-term components for minimal climatic change but maximum flexibility
	• Manage access to and safety of roadways through snow clearance, sanding and salting in the winter

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

INFRA-STRUCTURE	• Manage land stability issues such as subsidence, heave, erosion and landslip, through such practices • Constructing strong foundations that extend below zones affected by seasonal variations in moisture content • Infilling foundations • Adopting flexible timber-framed construction techniques that divide larger structures into smaller units with expansion and compression joints between them • Components can be efficiently assembled, allow flexibility of design, and facilitate changes through the lifetimes of infrastructures thereby facilitating application of the “diversified lifetime” approach • Introducing gaps or joints into foundations, structures or services to compensate for strains • Carefully consider size, species, and placement of vegetation • Implementing managed realignment and avoidance of development in areas at high risk • Reinforcing and re-grading slopes to prevent/minimize erosion and landslips • Developing surface erosion control structures (e.g. retaining walls and fences) • Creating stronger, deeper, better drained retaining structures • Maintaining drainage systems (e.g. channel management) • Implementing cross-shore structures (e.g. groynes) and toe protection structures • Removing shotcrete (shotcrete provides the illusion of stability rather than support as it covers but does not bond to slopes) • Introducing moisture control systems/soil rehydration Encourage practices that reduce potential impacts to infrastructures from flooding events, such as: • Raising floor levels, electrical fittings and equipment • Installing rainproofing and overhangs to prevent infiltration of heavy rain around doors and windows • Constructing buildings from flood resilient materials that can withstand direct contact with floodwaters without sustaining significant damages (e.g. concrete, vinyl and ceramic tiles, pressure-treated timber, glass block, metal) • Purchasing removable household products like flood boards, air brick covers and flood skirts that temporarily protect properties during flooding events • Using expandable/inflatable bungs to temporarily block pipes, drains and toilets to prevent backflow • Replacing impermeable wall finishes with limewash to encourage drying after inundation • Converting suspended floors to solid, flood resistant floors • Sealing gaps around pipes and cables and joints between walls and frames of doors and low level windows • Installing pump and sump systems below ground floor • Introducing floating homes • Note: several adaptation measures listed above with regards to land stability are also relevant to flooding
WATER SECTOR	• **Demand and Supply Strategies:** Building new water treatment plants and increasing retention tanks • Installing desalination plants • **Reduce flooding events and minimize flooding impacts:** Introducing silt detention structures, gully plugs, and gabions to stabilize gullies, preventing settlement build-up downstream, slowing movement of water, and increasing infiltration • Diverting flood flows away from vulnerable areas • Building hard, permanent flood defences and barriers and constructing pumping systems to reduce vulnerability to storm surges and anticipated sea-level rise

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

WATER SECTOR	• Establishing a second layer of setback flood defence behind original barriers - this approach is often used with managed realignment • Widening drains to increase drainage capacity • Raising dikes • Removing 'pinchpoints' from flood pathways to allow heavy rainfall to drain efficiently • Setting back river edge flood defences to make space for water • Inserting one way valves into drains and sewage pipes to prevent backflow • Developing separate drainage systems for surface and foul water so surface water can directly return to watercourses, reducing water treatment efforts • Dredging and widening of rivers • Allowing rivers to expand into side channels and wetland areas • Flushing drainage systems • Directing downspouts to lawns to encourage infiltration • Increasing depression and street detention storage

FORESTRY, FARMING AND RANCHING	• Use drought resistant varieties or clones to reduce vulnerability of trees to drought and water stress
	• Enhance soil organic matter content to increase moisture retention and soil fertility thereby reducing vulnerability to drought and moisture stress
	• Promote regeneration of native species through the protection of degraded natural forest lands
	• Promote multi-species plantation forestry incorporating native species in place of monoculture plantation of exotic species
	• Alter hardwood/softwood species mix
	• Adopt short rotation species in commercial or industrial forestry
	• Incorporate multiple silvicultural practices
	• Adapt strategies to control insect damage (e.g. prescribed burning, non-chemical insect control, adjusted harvesting schedules, thinning)
	• Incorporate fire protection measures to reduce vulnerability of forests to fire hazard due to warming and drought
	• Alter species density and management intensity
	• Change location of production
	• Change product use practices
	• Control stresses other than those from climate change
	• Improve knowledge regarding forests' responses to climate change
	• Apply land restoration practices to reduce flood/mudslide risk
	• Salvage dead timber
	• Access seasonal climate forecasts (e.g. farmers can use highly detailed information on weather conditions to adjust crop and variety selection, irrigation strategies and pesticide application)
	• Encourage purchase of insurance or create local financial pools to cover impacts of climate change and extreme weather events
	• Adjust silvicultural treatment schedules to suit climate variations
	• Apply rotation method of irrigation during water shortages
	• Alter fertiliser rates to maintain grain or fruit quality consistent with the climate
	• Shift location of production
	• Alter mix and/or diversity of species
	• Employ species able to cope with possible changes and stresses, including
	    • Drought and heat shock resistant species
	    • Cultivars that require longer times to mature (i.e. crops tend to mature faster under warmer climates, thus resulting in less time available for carbohydrate accumulation and grain production)
	    • If the particular climate scenario considered consists of both warmer and drier conditions, longer-maturing cultivars, which require sufficient precipitation over the extended growing season to sustain grain filling, will not likely work
	    • Cultivars with a reduced need for vernalization (i.e. the requirement for set periods of cold temperatures during the vegetative stages of crops to induce bud formation in spring)

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

FORESTRY, FARMING AND RANCHING	• Increase conservation plantings or re-vegetation (e.g. amelioration of dryland salinity)
	• Adjust timing of planting and harvesting operations (i.e. plant spring crops early to take advantage of changes in planting windows caused by advances of last-frost dates and to provide heat and drought stress avoidance in the late summer months)
	• Shift from rainfed to irrigated agriculture
	• Water availability, cost, and competition from other sectors must be considered
	• Encourage accumulation of commodity stocks as economic reserves
	• Promote spatial separation of crop plots to diversify exposure
	• Assure agricultural and veterinary services to respond to changes in conditions
	• Modify grazing times
	• Alter forage and animal species/breeds
	• Alter integration of mixed livestock/crop systems, such as:
	  • Using adapted forage crops
	  • Re-assessing fertilizer applications
	  • Ensuring adequate water supplies
	  • Using supplementary feeds and concentrates

FISHING	• Provide financial assistance for increasing resiliency • Increase acceptable catch size • Increase use of aquaculture
BIODIVERSITY CONVERSATION-RELATED	• Remain aware of environmental changes to allow for adjustments in parks management strategies • Expand protected areas (e.g. reserve systems can reduce vulnerability of ecosystems to climate change and should be designed with consideration of long-term shifts in plant and animal distributions and natural disturbance regimes) • Manage areas outside of protected areas (i.e. greater species diversity occurs outside protected areas that are more extensive) • Secure water rights to maintain water levels through droughts • Maintain high genetic diversity and population size • Increase heterogeneity and redundancy of populations (i.e. multiple, widely dispersed populations of individual species minimizes the probability that localized catastrophic events will cause significant negative effects) • Restore habitats currently under serious threat or create new habitats in areas where natural colonization is unlikely to occur; however this is an expensive approach and most often knowledge of ecosystem interactions and species requirements is lacking • Assist species relocation and/or regeneration • Protect migration corridors (e.g. coordinate with other levels of government and private landowners to ensure high connectivity) • Apply controlled burning to reduce fuel load and potential for catastrophic wildfires • Reduce uncertainties about valuation of ecosystem services • Invest in seed/gene banks
COASTAL AREAS AND FLOODPLAINS	• Regulate hazard zones (e.g. regulate setback distances for coastal infrastructure) • Increase public awareness and political will to discourage development on existing shorelines • Encourage co-ordination among oceans-related agencies • Provide short-term training for practitioners at all levels of management • Increase land-use planning, including attention to climate change risks • Protect, preserve, reclaim, and restore critical areas (e.g. manage and restore wetlands and dunes as they provide protection from storm surges, demark coastal territory not suitable for human settlement, use land acquisition programs to acquire coastal lands damaged/prone to damages by storms) • Re-vegetate coastal zones (e.g. plant salt tolerant vegetation in saline discharge areas)

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

COASTAL AREAS AND FLOODPLAINS	• Relocate existing development from at-risk coastal areas • Develop an effective early warning communication and response system for coastal storm events • Map areas prone to flooding

HEALTH SECTOR	• Strengthen public health care systems in areas of vulnerability
	• Increase protective interventions
	• Enhance public education on climate-change-related health matters
	• Improve forest management to reduce fire risk, flooding, and retention of disease vectors (e.g. FireWise and FireSmart programmes promote wildfire safety in the US and Canada)
	• Promote energy-efficient water disinfection for disaster recovery (e.g. "Ultraviolet (UV) Waterworks" requires less energy and can operate on or off of the electricity grid)
	• Incorporate low-power lighting systems into disaster relief programs, thereby promoting independence from fuel-based lighting and batteries (e.g. new light-emitting diode (LED) technologies make it possible to provide high-quality grid-independent light supplies that are far more rugged, efficient, safe and cost effective than versions currently in use)
	• Providing mechanical cooling (e.g. chilled beams and conventional air conditioning systems)
	• Implementing heat health alert plans
	  • Open designated cooling centres at public locations
	  • Provide information to the public through local media
	  • Provide bottled water
	  • Create a heat information line to answer heat-related questions
	  • Make emergency medical services with specially trained staff and medical equipment available

ENERGY AND INDUSTRIAL SECTOR	• Assure contingency planning, such as stockpiling • Change market conditions and financial mechanisms to increase resiliency • Encourage collaborations to support energy market development (e.g. joint development of natural gas pipelines, hydro power, and power transmission lines) • Distribute electricity generation to reduce risk of power disruption • Expand linkages with other regions
RECREATION SECTOR	• Change location and/or management of service provision • Increase use of artificial interventions to stabilize conditions • Encourage changes in recreational preferences
INDUSTRY, SERVICES AND TOURISM SECTORS	• Change storage and distribution systems in the wholesale and retail trades • Alter consumer goods and services offered in particular locations • Adapt to altered trade patterns by building robust ties with the globalising economy (e.g. ties could open up a wider range of possible alternatives for adaptation) • Capitalize on long-term trends in consumer behaviour and lifestyle (e.g. expand markets for cooling equipment, provide facilities and goods for outdoor recreation in temperate climates) • Employ artificial snow-making on ski hills • Groom ski slopes • Move ski areas to higher altitudes and glaciers • Invest in beach enhancement
INSURANCE SECTOR	• Communicate risk information to individual stakeholders (e.g. insurance pricing signals) to help inform appropriate adaptive behaviours • Reward actions taken to reduce risk (e.g. lower premiums) • Integrate insurance with other financial services • Improve tools to transfer risks out of the insurance market into the capital markets through catastrophe risk securitisations • Improve risk and capital auditing • Withdraw insurance coverage from locations at greatest risk

TABLE 5. EXAMPLES OF ADAPTATION ACTIONS THAT IF DESIGNED CAREFULLY COULD BE TURNED INTO SAM ACTIONS AND EXAMPLES OF MALADAPTATIONS

EXAMPLES OF MALADAPTATIONS	• Green space and trees offer a way to cope with hot weather, flooding, and air pollution but are themselves vulnerable to decreased water availability, rising temperatures, and changing patterns of disease and pests and can cause damage to the built environment through disruption or displacement of structures through direct damage as branches fall or through causing soil shrinkage • Narrow, tall streets can reduce heat risks during hot summers but can also aggravate winter gloom • Buildings designed to minimise energy use for winter heating may be susceptible to overheating problems in the summer • High densities that minimize travel distances and facilitate community energy schemes can also intensify urban heat island effects, reduce urban drainage capacities, and increase thermal discomfort and health risks • Flexible, timber-framed construction is effective in managing subsidence risk but may not cope as well with overheating and flood risks • More heat-tolerant livestock breeds often have lower levels of productivity • Engineering interactions to defend coastlines can change the connectivity of coastal ecosystems, facilitating the spread of non-native species and warm-temperatures species advancing polewards • Water savings achieved through the implementation of adaptation measures may not be set aside as buffers against future water supply shortages • Shepherd et al. (2005) found that water use savings and capacity expansions within water management projects in the Okanagan, BC were used by new residential developments. The region is now understood to be more at risk from water supply shortages than before the anticipatory adaptations were implemented.
CROSS-CUTTING ADAPTATION PATHWAYS	• Improve market signals related to climate variability and change • Strengthen mechanisms for sharing losses • Improve climate prediction and weather forecasting • Improve environmental monitoring • Improve emergency preparedness and response capacity • Improve information dissemination, outreach, and other forms of public education • Support research for “sustainability science” • Improve capacities to assess adaptation needs and responses

Sources: Adger et al. (2003); Adger et al. (2007); Agrawala (2005); Alig et al. (2002); Anonymous (2000); Association of British Insurers (2002); Auld et al. (2006); Austrian Federal Government (2006); Bandhari et al. (2007); Batima et al. (2005); Bulleri (2005); Burton and van Aalst (1999); Christie et al. (2005); Confalonieri et al. (2007); Daepp et al. (2001); Direction due Tourisme (2002); Dore and Burton (2001); Dowlatabadi (2007); Duraiappah et al. (2005); Easterling et al. (2007); El Raey (2004); European Environment Agency (2004); Fernandez (2002); Field et al. (2007); FireSmart (2005); FireWise (2005); Fischlin et al. (2007); Ford and Smit (2004); Government of the Netherlands (1997; 2005); Halsnæs and Verhagen (2007); Helmuth et al. (2006); Hewer (2006); Holden and Brereton (2002); Hunt (2005); Huq et al. (2003); Inkley et al. (2004); Jones et al. (2007); Lasco et al. (2006); Lee (2000); Mata and Budhooram (2007); McGee et al. (2000); McLeman and Smit (2006); Medhi (2006); Mieszkowska et al. (2006); Mills (2003); Mills (2004); Mills (2007); NCCMA (2003); Nicholls and Wong (2007); Pethick (2002); Ramsar Convention on Wetlands (2002); Ravindranath (2007); Robinson et al. (2005); Robledo et al. (2004); Rosenzweig and Tubiello (2007); Scholes et al. (2004); Shaw et al. (2007); Shepherd et al. (2005); Smit and Wall (2003); Smith (2002); Sohngen et al. (2001); Spittlehouse and Stewart (2003); Steemers (2003); Strachan et al. (2003); Swiss Confederation (2005); Sygna (2005); Tubiello et al. (2002); Waters et al. (2003); Wehbe et al. (2006); Weih (2004); West (2003); Wilbanks et al. (2007a); Wilbanks et al. (2007b); Worm et al. (2006).

APPENDIX

appendix 1: methods

The following methods can be used during climate change impacts and adaptation assessments at the local or regional scale[2].

Brainstorming

Brainstorming is a popular technique used to generate ideas in a group. The basic rules of brainstorming include a focus on generating many ideas without evaluating the merits of those ideas—critical judgment of ideas is reserved for a subsequent step in the process. Accordingly, unusual ideas are welcome, and there is an emphasis on building on and extending proposed ideas to come up with ever more creative possibilities (e.g. see What-if analyses)

The Pacific Northwest region in the United States faces critical challenges to a mainly hydroelectric energy supply as summer river flows decrease. In response to this problem, the University of Washington's Climate Impacts Group brought together utilities, government agencies and regional planning bodies for brainstorming sessions to develop ideas about possible ways to mitigate projected power shortages for the region (Harden and Eilperin 2006).

Case study

The case study is an approach to investigate complex social phenomena within a real-life context, and can be used to explore, describe or explain an observed situation. The use of case studies is commonly to answer "how" or "why" questions about contemporary events where an understanding of how the context relates to observed outcomes is desired (Yin 2004). For example, case studies exploring the experiences of other local governments with designing and implementing climate change adaptation strategies could provide valuable insight into opportunities and constraints for your context. This strategy can provide insight into how a real-life system may react to climate change impacts or variability and to adaptation policies.

Case studies are often included as part of developing novel policy areas that an organization may have limited experience with. A current project by the Canadian Institute of Planners and Natural Resources Canada is using a set of local case studies to find better ways of integrating scientific information into the policy and planning process, and to suggest best practices for use in climate change adaptation planning by municipalities in Canada (Canadian Institute of Planners 2008).

Assessment of the cost of adaptation

For our purposes, the cost of adaptation refers to the cost of planned policy initiatives designed to respond to climate change impacts, and does not include unplanned or individual adaptive actions. A combination of other methods discussed in this document can contribute to this assessment of the cost of adaptation to climate change, and this assessment begins by considering three questions: Adapt to what? Who or what adapts? And, how does adaptation occur? (Smit et al. 1999). To answer the first question one needs to have an idea of how conditions will change – for example, scenarios or storylines are needed to frame further analysis. In terms of who or what adapts, the system of interest needs to be defined. Are you interested in looking at the entire municipality? A particular sector or type of infrastructure? Finally, costs of adaptation depend critically on the strategies chosen and the net costs or benefits of those measures. These should be considered alongside the net costs or benefits of projected climate change impacts, and the degree to which adaptation measures will provide adequate responses to those impacts (see Assessments of the cost of inaction).

2 The information provided here draws primarily from the following sources:

McCarthy et al. (2001) and Carter et al. (2007): The "Impacts, Adaptation and Vulnerability" section of the Intergovernmental Panel on Climate Change (IPCC)'s third and fourth assessment reports, respectively.

Natural Resources Canada (2004): A Canadian perspective on climate change impacts and adaptation, with certain sections aimed specifically at the concerns of municipalities.

UNFCCC (2005): A compendium of methods for use in vulnerability and adaptation assessment.

Determining the costs of adaptation is thus a complex task, and methods for this are still developing. For the most part these methods draw heavily on economic valuation methods (e.g.: see Cost-benefit analyses and Cost-effectiveness analyses); however, other tools can also be used. A recent study of climate change adaptation options for water resources in the Okanagan also provided estimates of the cost of various adaptation measures (Cohen and Neale, 2006).

Assessments of the cost of inaction

There are costs associated with implementing adaptation measures and there are costs associated with choosing to not take proactive measures to adapt. The cost of inaction refers to the net costs that would be incurred due to climate change impacts in the absence of proactive adaptation measures. This is an important part of understanding and communicating with the public about the potential costs of maintaining the status quo: inaction is not neutral, rather it implies costs that will be borne sometime in the future (e.g. see Role of discounting).

Estimating the cost of inaction requires an understanding of the current situation and drivers, projecting changes in socioeconomic and climatic systems, interpreting those changes into expected impacts and then estimating economic values for those impacts. Estimates vary greatly depending on the approach and assumptions chosen for the analysis, particularly due to difficulties both in estimating physical impacts and in assigning an economic value to those impacts. A recent technical report by the European Environmental Agency provides an overview of the methodologies for cost of adaptation and cost of inaction, together with examples of estimates (European Environmental Agency, 2007).

Cost-benefit analyses

CBA is a quantitative approach that can be applied to determine the costs and benefits of a course of action in monetary terms. Three objectives may be evaluated: whether benefits outweigh the costs, whether net benefits are maximized, and which of multiple options presents the most net benefits. This is one of the more straightforward methods conceptually (although it is data-intensive) and is most appropriate for evaluating economic objectives or objectives that can be meaningfully assessed in monetary terms. For assets that are not traded through the market (and hence have no dollar value), techniques have been developed for assigning monetary values in some cases, for example by asking what people would be willing to pay for that asset (Rothman et al. 1999). Nonetheless, one of the significant drawbacks of CBA is that its application is problematic when non-monetary values such as social and environmental objectives are also being evaluated, as in climate change studies. There are also difficulties in valuing assets in the future versus their value in the present day (see Role of discounting).

CBA is one of the most widely applied decision support tools. The state of Maine in the United States used CBA to evaluate four potential options for adapting to sea-level rise at a specific study site, concluding in that case that it would be more cost-effective to retreat from the shoreline as sea level rises, as opposed to protecting development and maintaining the shoreline (USEPA 1995).

Cost-effectiveness analyses

This method is used to evaluate a single chosen objective so as to minimize the possible costs associated with its implementation. In contrast with CBA, this analysis treats benefits as fixed, and seeks only to find the least-cost strategy to achieve an objective. This method aims to provide a ranking of the cost of different options for achieving the given objective, and is most appropriate for evaluation of isolated projects. Similar to CBA, this method is limited when non-market values need to be accounted for (see Cost-benefit analyses).

In climate change studies it is suggested that this technique be used where a minimum level of a public good or service is required and the question is therefore how to achieve this objective at a minimal cost. Flood protection could be an example of such a service. In the United Kingdom, a cost-effectiveness analysis methodology was developed for determining whether options for achieving established water service standards could be carried out at a reasonable cost (Risk and Policy Analysts Ltd. 2004).

Decision analysis

Decision Analysis is a formalized method for approaching decision-making that employs a wide range of tools to structure and evaluate choices to see how well options satisfy objectives. This type of analysis begins with generating a comprehensive list of options that could potentially address the defined problem. Influence diagrams or decision trees are then used to identify points where decisions would have to be made, and where chance occurrences would influence the direction of events. The likelihood of chance events is then evaluated, and the utility of different outcomes is calculated. A final step uses specific criteria to determine which set of options has the greatest potential to achieve desired outcomes.

Decision analysis has been applied to evaluate intersecting issues of adaptation, mitigation and sustainable development in the context of BC's Gateway Programme. The method allows a complex and contentious set of issues and objectives to be structured in a way that can enhance understanding and communication to aid in the decision-making process (Wilson and McDaniels, 2007).

Role of discounting in assessments

Discounting is a method used in economic analyses to compare the value of costs and benefits occurring at different points in time. To calculate the value today, of something that will exist in the future, a "discount rate" is used. A discount rate expresses the degree to which consumption today is preferred over consumption a year from now—the higher the discount rate, the less value that is placed on that consumption (or good, service, cost, benefit, etc) in the future. Discounting is an important consideration because of our tendency to value a cost or benefit in the present more than that same cost or benefit in the future. However, application in the context of climate change and sustainable development also begs consideration of preserving options for future generations, which would imply quite a low discount rate.

A recent and controversial application of discounting was the United Kingdom's "Stern Review" that was charged with evaluating the cost of climate change adaptation in comparison to the cost of inaction, globally. Considerable debate developed around the report's conclusions, in part due to differing perspectives on whether the appropriate "social rate of time" discount rate had been applied. This type of discount compares the value of well-being today to well-being of future generations. Stern chose to use a very low discount rate that values well-being in the future as virtually equal to well-being today. While some defend this choice based on the imperatives of sustainable development, it is ultimately an ethical choice, not a technical choice. Hence, others begin from different ethical assumptions and conclude that a higher discount rate would produce more appropriate results (Varian, 2006).

Downscaling techniques

Downscaling is the process of deriving local or regional scale climate information from models or data at a larger scale. In effect, the larger climate is used as a predictor of the local climate. There are two main types of downscaling techniques: dynamical and statistical. Dynamical downscaling uses the inputs of Global Climate Models (GCMs) in order to develop Regional Climate Models (RCMs). Statistical downscaling combines large-scale climate variables with locally observed variables (often from a specific weather station) to produce a statistical model that is then used to project future changes at a local scale. An advantage of statistical downscaling is that it is less computationally demanding than dynamical downscaling, although it still requires a large amount of data to develop the model (Barrow et al, 2004; CCSN, 2007).

There are a variety of techniques that can be applied, as well as software that can assist in translating large-scale data to a local scale. The Canadian Climate Change Scenarios Network provides further information and software tools on their website (http://www.cccsn.ca). This method is increasingly being applied in order to develop smaller-scale scenarios that can aid in developing climate change adaptation policies at a local or regional scale.

Using expert judgments

Expert judgments are evaluations performed by people who have a particular expertise relating to the question at hand. The judgments can be of at least two types, and are commonly a bit of both: that is, they may be issues of factual judgment (something that can be proven right or wrong) or of value judgment (expressing an opinion) that derives from expert knowledge of the issue being evaluated. This is a routine part of creating policy-relevant evaluations.

Often expert judgment is done informally, although it is increasingly a formalized component of studies on climate change and associated uncertainty analyses. Two main ways that expert judgment can be applied formally are by pooling expert judgments to achieve one combined result or by presenting a range of distinct judgments made by individual experts. In the latter case a further process, such as consensus building, will be needed in order to incorporate these judgments into societally acceptable decisions. A related approach is the Delphi technique, where expert judgments are contributed in a structured process to come up with joint forecasts (Willows and Connell, 2003).

Expert judgment is used often in climate change studies where there is a lack of available data or where uncertainty is so great that other quantitative evaluations will not produce a meaningful result. For example, where predictions of technological, social or political change are required for climate change scenario development, formalized expert judgment may be the most reasonable way of estimating the necessary parameters. Another common use of expert judgment in climate change studies is to estimate uncertainty (Otwayl et al., 1992; Webster et al., 2003).

Facilitated workshops

Facilitated workshops are a participatory method that incorporates the ideas, concerns and preferences of all participants in a structured decision-making process. The technique draws on Decision analysis methods and requires participants to apply information to develop ideas and provide judgments on options. This often results in a ranking of policy options. It contributes to a learning process individually and collectively that simultaneously incorporates diverse beliefs and values to develop joint recommendations on preferred actions.

A series of facilitated workshops were used recently in the Okanagan as part of a participatory integrated assessment of water management. This method was used in order to enhance learning and understanding of the issue among participants, and to jointly develop a decision support model that is used to increase knowledge about the system and explore plausible future scenarios and adaptation options (Cohen and Neale, 2006).

Focus groups

Focus groups are a method that brings together around six to ten selected participants representing groups or individuals whose ideas and opinions are of particular interest for the discussion topic. This group is guided by a facilitator through an interactive discussion around specific questions in order to learn from participants' experience. The method is distinguished from other group methods by its intentional interaction between participants that can provide shared insight and a diversity of understandings, and can be an efficient way of gathering responses with limited resources or time. However, the very strength of this method—interaction—means that special consideration needs to be taken where sensitive topics are being discussed, or power dynamics between participants could constrain individual responses (Morgan, 1996).

Focus groups are used in a variety of settings for a range of purposes. For example, this technique is currently being used by Natural Resources Canada and professional planning associations in development of a national planning policy on climate change adaptation. Elsewhere, focus groups have been used in the prairies to understand agricultural producers' perceptions of risks, opportunities and capabilities due to climate change, as well as their ideas of what support will be required to manage risk (Stroh Consulting, 2005).

Multi-criteria analyses

Multi-Criteria Analysis (MCA) refers to any structured Decision analysis that evaluates preferred options for addressing a number of objectives simultaneously. This is done by identifying desired objectives and corresponding indicators that can include social, economic, biophysical or other types of components. These indicators are often evaluated quantitatively, for example through ranking or economic valuation; however, they will often not be in the same units and may also include qualitative measures. MCA includes techniques for comparing and evaluating outcomes while incorporating this range of types of indicators, and is particularly useful where a method such as cost-benefit analysis cannot be used due to the difficulties in assigning monetary values to social or environmental objectives.

This approach has wide application. In Canada, it has been used to evaluate conflictual policy areas such as sustainable forestry options in B.C. that address a range of public objectives (Sheppard and Meitner, 2005), and evaluating alternative energy supply futures for the country (Noble, 2004).

Policy exercise

This method brings together policy makers with academics to combine knowledge from multiple disciplines for use in developing policy to deal with complex management issues. Key components of the approach include proposing unconventional but plausible scenarios of the future, and then developing and testing different policy options that respond to the key challenges represented by the scenarios. This method requires a significant investment of time and capacity and incorporates a combination of mathematical or computer-based modeling and scenario analysis together with techniques such as facilitated workshops and brainstorming. The exercise is conducted in an organizational context that reflects real-world institutional issues of relevance to the problem being discussed.

This method can be used both to generate and evaluate adaptation options. The process does not necessarily result in new knowledge or an explicit set of policy recommendations. Rather, it can be used to identify priorities and gaps in knowledge, as well as institutional barriers or needed technological changes. In a case applying the policy exercise (PE) approach in southeast Asia, a combination of methods including data collection, modeling, impact assessments and background scenarios were used in preparation for the policy exercise workshops. This experience demonstrated the usefulness of PE for effectively structuring the issues involved in order to develop appropriate adaptation policy options (McCarthy et al., 2001).

Scenario development and analyses

Synthetic and analogue scenarios, in addition to Global Climate Model (GCM) scenarios, are methods for exploring possible changes in future climates (See Barrow et al., 2004, Section 6.4). Synthetic scenarios, also known as “arbitrary” or “incremental” scenarios, are the simplest climate change scenarios to construct and apply. This is done by using historical climate records and altering a climate variable by an arbitrary amount to see how it affects the system. Accordingly, its main use is in sensitivity analysis, to gain a better understanding of how changes to a certain variable may impact a system. It can also be used to identify thresholds and the tolerance of the system to changes in climate.

Analogue scenarios use existing climate information, either from the site being studied (“temporal” analogue) or from another location whose current climate is similar to that expected for the study site in the future (“spatial” analogue). A strength of temporal analogues is that, because the climate was experienced in the past, it is physically plausible that it could occur in the future. While the same is partly true for spatial analogues, the transferability of climate data from one location to another is limited due to geographical differences between locations (e.g: day length, proximity to water, etc). For both types of scenarios, a key limitation is that using analogues as a basis for future scenarios assumes that the climate will continue to respond the same way in the future as it has in the past. Global climate models (GCMs) are a more reliable approach for developing future scenarios for use in impact assessments.

The other side of scenario development concerns the socioeconomic context and drivers for climate impact assessment. This may be done by developing plausible “storylines” that describe social, economic, technological and political changes that will have a bearing on emissions, future conditions and adaptation possibilities. As it is impossible to predict trajectories for socioeconomic scenarios, these are often expressed as possible alternative futures. For the United Kingdom Climate Impacts Programme, four socioeconomic scenarios were developed alongside climate scenarios in order to produce an integrated climate impact assessment. Socioeconomic scenario development is also useful for promoting social learning about climate change impacts in the community (Berkhout et al., 2002).

Scenario analysis is a systematic evaluation using expert judgment and scientific methods to identify a range of possible outcomes that could occur, taking into account key drivers and the uncertainty surrounding them. This is the method used in the IPCC reports to develop future climate scenarios. In California, scenario analysis was used to explore possible energy futures, identify potential challenges and strategies, and make policy recommendations for the state (Ghanadan and Koomey, 2005).

Sensitivity analyses

Sensitivity analysis is a technique that looks at how sensitive a system is to climate variability or change. For example, how does the system respond to an increase of 2°C in average surface temperature? Synthetic scenarios are one example of a sensitivity analysis. Sensitivity analysis can also be used in estimating the uncertainty of outcomes (see Uncertainty analyses).

Sensitivity analysis was applied in a Canadian study to evaluate the impacts of climate change on drainage design methods and on different types of drainage systems. Using this method, they were able to investigate possible changes to variables, such as peak flow and runoff volume and how these changes would affect components of the drainage system, including required pipe size or the cost of different design methods (Kije Sipi Ltd., 2001).

Trade-off analyses

Trade-off analysis is a form of integrated assessment that incorporates stakeholders, experts and policy makers in a process designed to provide policy-relevant information. Through incorporation of relevant components of the social, economic, decision-making and biophysical systems, this approach highlights the interactions between different components of the system in order to describe tradeoffs associated with different adaptation options. Various qualitative and/or quantitative methods may be employed in the research process, including public consultations, focus groups, expert judgment, and mathematical models. Tradeoffs are identified between the components of interest. For example, these could be tradeoffs between different sectors of society, between environmental, social and economic objectives, or between adaptation and mitigation policies. These tradeoffs are then presented publicly in various forms, for example as tradeoff curves, maps or risk diagrams, to be used in decision-making (Stoorvogel et al., 2004).

This approach was applied in a case in the Philippines to evaluate tradeoffs in climate change adaptation options for a specific watershed. This study examined tradeoffs between key sectors of society in order to identify potential synergies and conflicts between different adaptation options. This provided insights into which policy options may have positive impacts on multiple sectors and which may have negative consequences. Thus allowing policy to be directed towards optimizing synergies and proactively mitigating negative effects of adaptation strategies. This approach also helped to identify early on some of the potential conflicts that could arise (Lasco et al., 2006).

Uncertainty analyses

Two main sources of uncertainty for climate change policy derive from limitations on our knowledge of how the global climate system works and our ability to model it, and the uncertainties present in predicting the course of human actions in the future (e.g. policy decisions, demographics, economics, technology, etc). While efforts are constantly being made to reduce uncertainties around climate change science and modeling, uncertainty will always be an important component informing climate change policy. Rather than becoming a source of indecision, this must be recognized and analyzed so as to best understand and communicate the areas of uncertainty that have a bearing on policy decisions.

Uncertainty analysis is therefore an integral part of any climate change assessment. This analysis can also be used to describe different types and degrees of uncertainty relating to policy options, or to assign relative likelihoods to various scenarios and present a selection of most likely scenarios. The purpose is to provide an informed basis for decision-makers and the public to begin consideration of appropriate policy options for adaptation and mitigation (Webster, 2003). For example, in the IPCC Fourth Assessment report uncertainty analysis is used to provide judgments of relative likelihoods that projected outcomes will occur, expressed in terms of the following confidence levels:

- Very High confidence (at least 9 out of 10 chance of being correct)
- High confidence (about 8 out of 10 chance)
- Medium confidence (about 5 out of 10 chance)
- Low confidence (about 2 out of 10 chance)
- Very low confidence (less than 1 out of 10 chance)

Vulnerability assessment

A starting point for planning for climate change adaptation is to conduct an assessment of the vulnerability of a community's human, natural and physical infrastructure to climate variability and severe weather. Such an understanding provides a basis for setting adaptation policy priorities by identifying areas that require new policies or partnerships, and areas of emerging opportunities. Vulnerability assessment at a local level proceeds in five steps. First, parties that would be affected by, and make decisions about, climate change for a certain sector are brought together. Second, current vulnerabilities to severe weather events are identified by participants for all affected sectors. Third, future conditions are estimated. Scenarios developed by experts on projected socio-economic and climate changes are provided to participants who consider what economic, social and environmental impacts may occur as a result. In step four, future vulnerabilities are estimated based on these scenarios, and potential adaptation strategies are identified. The final step is to evaluate options and their potential to reduce vulnerability, decide on preferred strategies and implement them. Implementation requires ongoing monitoring and review to ensure that adaptation approaches are responding to actual conditions and new information as it becomes available (Lemmen and Warren, 2004).

Vulnerability assessment has been utilized in BC to evaluate the vulnerability of forestry-based communities to climate change in places like Vanderhoof, BC (Natural Resources Canada, 2005).

What-if analyses

There are a variety of types of this analysis, which begins with the postulating of "What if?" questions in a structured brainstorming session. This is commonly used in risk management to anticipate potential problems and suggest response strategies and ways of mitigating the risk. In climate change studies, this technique can be used to initiate discussion about what impacts may occur under certain changes in climate, and generate ideas of appropriate responses. Example questions include, "What if available water supplies dropped by 20% during the summer? and What changes in water policy would be required for various uses, given this condition?" This technique could be used in a focus group or workshop setting that gathers together experts on the general subject area (e.g. agricultural or engineering experts) or the specific area of application (e.g. planners and engineers at the city).

appendix 2: understanding the consequences of climate change impacts

The important part of a climate change impact assessment should be not only obtaining information about changes in basic climatic variables such as temperature and precipitation, but also information on what these changes mean for the resources, infrastructure and vulnerability of areas relevant for the local government. This section outlines potential consequences of impacts that changes in climate variables could pose on the community. From the viewpoint of adaptation and vulnerability reduction, these consequences are very important for the design of adaptation actions since they relate changes in climate variables to socio-economic and ecological dimensions of local development. The list below helps to illuminate potential local consequences that are caused by the impacts of a changing climate and what potential vulnerability these consequences lead to at the local level.

<table>
<tr>
<td rowspan="2">If the impacts are changes in temperature, runoff and other climatic conditions; these will lead to significant changes in species ranges, ecosystem structure and function</td>
<td>The consequences could be issues such as:
Changes in climatic conditions will cause shifts in the geographic ranges of species. This is generally expected as a shift of species northward accompanied by a fundamental restructuring of ecosystems as conditions change.
The shift in habitable areas for species is expected to have serious consequences for overall biodiversity, given the natural (water bodies, mountains, etc.) and human (habitat fragmentation) barriers to species migration. Increased competition for available water supplies with human uses during the summer or periods of drought will additionally stress ecosystems.</td>
</tr>
<tr>
<td>These consequences could lead to potential vulnerability at the local level as follows:
Shifting ranges of species and a fundamental rearrangement of ecosystems in North America
Species ranges typically shifting northward and to higher elevations. Such changes in ecosystem composition can facilitate other disturbances, including invasive species or other infestations
Significant number of species extinctions are expected
Effects on phenology, migration, reproduction and dormancy of animals across North America
Surface and bottom water temperatures of lakes, reservoirs, rivers and estuaries in North America will likely increase (projection of 2 to 7^{o}C under doubling of CO_2)
Increased vegetation growth in certain areas, and an earlier onset of spring “greenness”
Forest growth will likely improve slightly in North America
Increased river scouring and turbulence due to changes in runoff timing could have negative effects on aquatic ecosystems</td>
</tr>
</table>

If the impacts are sea level rise, changing ocean temperatures, extreme weather events; these will have impacts on intertidal and marine ecosystems	**The consequences could be issues such as:** • When sea level rises at a moderate pace, intertidal ecosystems will naturally migrate inland. In the local context, however, flood protection and coastal development pose a barrier to this natural migratory process that will limit the ability of these ecosystems to adapt to changing sea level. Expected increases in extreme weather and storm surges will add to the stress on these ecosystems. • Increased ocean temperatures can also have serious implications for local ocean productivity, including phenomena such as red tides. Changes to ocean productivity and ecosystem function will have cascade effects on dependent species such as sea birds that depend on this food supply. Additionally, invasive species may fundamentally change coastal ecosystems.
	These consequences could lead to potential vulnerability at the local level as follows: • Rates of coastal wetland loss will increase due to sea level rise (high confidence); salt marshes may mitigate this effect or they themselves may decrease, depending on rate of sea level rise and storm impacts • Existing dykes may prevent the natural migration of intertidal ecosystems as sea level rises • Dikes and other mitigation/adaptation measures could have negative effects on ecosystems • Extreme weather will additionally stress ecological integrity in coastal areas • Warming is likely to extend and intensify summer thermal stratification, contributing to oxygen depletion • Estuarine communities and littoral biological productivity will change as sea level rises • Potentially negative impacts on ocean biodiversity and productivity, and resulting impacts for sea birds due to a decrease in food supply • Coastal habitats and dependent species will be increasingly threatened

If the impacts are changes to water quantity, temperature and salinity, this will stress fish, fisheries and the food chain	**The consequences could be issues such as:** • Climate change will contribute to profound changes in salmon health, migration patterns and spawning success. • Declines in salmon populations have cascading effects for terrestrial species and ecosystems that depend fundamentally on the salmon as a food and nutrient source. Changes in water temperatures and river flows will create opportunities for exotic species to invade.
	These consequences could lead to potential vulnerability at the local level as follows: • Salmon stocks in sharp decline throughout North America • Fisheries will be negatively affected by salinity and temperature changes in rivers • Profound changes to salmon health, migration and spawning success • Observed warming of the rivers is likely to have negative effects on salmon and cascade effects on predators, but positive effects on species tolerant of warmer water

If the impacts are changes to precipitation type, timing, intensity and frequency; together with temperature changes these will impact the availability and quality of the water supply	**The consequences could be issues such as:** • Water demand is increasing due to population growth and development. However, shrinking glaciers, earlier snowmelts and a decreasing snowpack will mean that less water is available in the summer and fall when there is high demand for hydroelectric power and local uses. Increased demand for surface water will in turn place pressure on limited groundwater supplies that are also at risk of salinization as sea level rises. As well, increasing water temperature, water-borne diseases, forest fires and landslides are a growing concern and can impact water quality.
	These consequences could lead to potential vulnerability at the local level as follows: • An increasing proportion of precipitation falls as rain rather than snow • Earlier melting and a significantly decreasing snowpack contribute to increases in winter and early spring flows while summer flows may decrease substantially • In the short term, melting glaciers may add to streamflow in spring; in the long term, this will probably mean less runoff, especially in summer • Increased water stress regionally and greater competition between agricultural, industrial and ecological uses across the continent • Ground water levels will rise as sea level rises, adding costs for water pumping and resulting in salt water intrusion into some wells and aquifers • More frequent landslides, forest fire contaminants as well as warmer temperatures could impact water quality • Surface and bottom water temperatures of lakes, reservoirs, rivers and estuaries in North America will likely increase (projection of 2 to 7°C under doubling of CO_2) • Water quality impacts could occur due to a longer erosion season and enhanced erosion in agricultural areas

If the impacts are changes in amount and timing of precipitation, sea level rise and extreme weather; these will stress water, storm and sewer infrastructure	**The consequences could be issues such as:** • The amount and timing of precipitation poses clear challenges for the capacity and functioning of stormwater infrastructure and the sewer system, particularly in urban contexts with low permeability (e.g. paved surfaces). At the same time, sea level rise could raise the water table and result in the floating of sewers and foundations if they are not designed to deal with this.
	These consequences could lead to potential vulnerability at the local level as follows: • Increases in heavy precipitation with expanding impervious surfaces (e.g. asphalt) could increase urban flood risk and pose design challenges and costs for stormwater management • Potential issues with reservoir capacity and operations, water supply, storm and sanitary sewer size, sewer flow during periods of summer drought and sewer outfall as sea level rises • There is no urgent need to upgrade infrastructure capacity; however, adding higher capacity by additional actions or upgrading the infrastructure as part of the regular maintenance cycle would be prudent • Rise in water table may also cause floating of sewers, foundations, etc that were not designed for those conditions • Continual upgrades of water and sewage systems will be necessary, and additional energy may be required for pumping

If the impacts are water supply shortages, temperature changes, changes in the number of growing days and in the frequency of natural disturbances; these will have both positive and negative implications for agriculture and food security	**The consequences could be issues such as:** • Projected changes in the local climate are generally expected to have positive impacts for agriculture in terms of the number of growing days, length of the growing season and potential to grow higher-value crops. This will be constrained, however, by soil suitability, moisture and erosion. Other threats include more frequent and severe pest infestations as their range extends northward, and the impacts of more frequent extreme weather events. **These consequences could lead to potential vulnerability at the local level as follows:** • Vulnerability of agriculture to climate change is complex: it is dependant upon direct and indirect climate effects, economic factors and technological and adaptation changes • The increase in number of growing days, decrease in frost-frequency in spring and fall, extension of the frost-free period and trend towards an earlier spring could have a positive impact on the agricultural growing season in Canada. Moderate climate change will likely increase yields of rain-fed agriculture in North America by 5 to 20% over the first decades of the century (high confidence). However, potentially positive impacts on agriculture are dependent on appropriate soil types, soil moisture, water availability and erosion. Potential for more spring flooding as well as summer drought conditions (lower soil moisture and streamflow) • Changes in temperature can improve or impair production of different crops; crops currently near thresholds will be negatively impacted (medium confidence) • Heavy rainfalls can impact agricultural crops • Possible introduction of new agricultural pests and diseases

If the impacts are a reduction in snowfall, this will pose challenges for winter sport industries, while beaches and natural parks will be faced with both challenges and opportunities in a changing climate	**The consequences could be issues such as:** • As winters become milder and less precipitation falls as snow, winter sport industries, notably the ski industry, will be negatively impacted. As sea level rises, more severe weather and storm surges become more frequent, beaches and waterfront areas could erode or become submerged. Warmer weather could attract more tourism for parks and beaches; however, ecosystem impacts of climate change discussed above could threaten these areas. **These consequences could lead to potential vulnerability at the local level as follows:** • Winter recreation could be negatively impacted, but snowmaking could offset some of the reduction to the ski season • Recreational beaches would change and some could become submerged • A longer warm weather tourist season could increase visits to Canada's natural parks, bringing economic benefits, but more pressure on ecological systems

If the impacts are sea level rise, climate variability and extremes, this will challenge energy production, transportation and associated infrastructure and economic activity	**The consequences could be issues such as:** • Changes in water availability could be positive in the winter as supply increases but negative in the summer when a reduced water supply coincides with increases in energy demand for residential cooling and other competing uses. On the other hand, demand for heating in the winter has decreased in Western Canada. • Transportation and associated infrastructure such as port facilities could be affected in many ways. Milder winter conditions could improve air and ground travel, but more frequent storms could have the opposite effect. Sea level rise is of particular importance for communities expanding along their coastlines, as a rising water table may reduce the bearing capacity of roads. Interruptions to energy and transportation services can have large associated costs for the economy, as witnessed during the 2003 power outage in northeastern North America.
	These consequences could lead to potential vulnerability at the local level as follows: • Hydropower production is sensitive to total runoff, the timing of runoff, and to reservoir levels • Under projected temperature increases, hydroelectric supply will improve in winter, but face challenges in summer due to conflict with instream flow targets and salmon restoration goals (e.g. under the Endangered Species Act) • In western Canada, there has been a significant decrease in the number of days requiring space heating and an increase in the number of days requiring space cooling, with resultant implications on total energy demand • Warmer and less snowy winters may reduce delays, improve ground and air transportation reliability and reduce road maintenance demands. However, more storms could increase risks • Declining fog trend in some parts of North America could be good for transportation. Higher potential flood levels and more frequent flooding at levels rarely experienced today is projected with very high confidence • More frequent flooding and landslides would impact transportation • Heat spells could cause increasing damage to railroad tracks and roads, with implications for future road design, construction and management • Sea level rise and an increase in extreme storm events has implications for ports, airports, railways, roads, highways, and inland navigation • Higher ground water levels in low lying areas may reduce bearing capacity or roads requiring rebuild or increased load restrictions

<table>
<tr>
<td rowspan="2">If the impacts are extreme heat and weather, pollution and shifting ranges of infectious diseases; these pose challenges for human health and safety</td>
<td>The consequences could be issues such as:
• Human health issues combined with a range of climate-induced pressures -- such as more intense and long-lasting heatwaves—would contribute to respiratory and cardiovascular illness, dehydration, heat stroke and mortality. Increases in hot and stagnant weather will exacerbate smog effects of air pollution and associated respiratory and cardiovascular disease, asthma attacks and mortality, especially among the elderly and very young.
• An increasing prevalence of infectious diseases as their host organisms (e.g.: mosquitoes carrying West Nile virus or ticks carrying Lyme disease) will migrate northward.</td>
</tr>
<tr>
<td>These consequences could lead to potential vulnerability at the local level as follows:
• Heat waves will intensify in magnitude and duration over areas where they already occur (high confidence).
• Water-borne disease and degraded water quality are likely;
• The range for vector-borne infectious diseases (especially Lyme and West Nile) will shift northward; there could be an increased risk of giardia, fleas and mites
• Respiratory illnesses due to pollen, ozone and other factors could increase; air quality impacts would be exacerbated by climate change
• Weather-related accidents could increase</td>
</tr>
</table>

If the impacts are the increasing concentration of population, infrastructure and economic activity in coastal zones, this will increase vulnerability to storm surges, sea level rise, extreme weather events and flooding.	**The consequences could be issues such as:** • Sea level rise combined with an increased risk of storm surges and extreme weather events pose new challenges for coastal settlements. Economic damage from severe weather has increased dramatically over the past several decades, largely due to the increasing value of infrastructure, property and economic activity at risk. Often upgrades will be required to prevent overtopping or breaching currently and in the future. Some have suggested that dike systems will need to be re-examined to consider whether they should be maintained, updated or even abandoned. The growing concentration of population and economic activity in vulnerable areas may increase vulnerability in the case of flooding or severe weather events. Emergency management planning will have to be continually updated to reflect these realities.
	These consequences could lead to potential vulnerability at the local level as follows: • Vulnerability of coastal populations increases with the concentration of wealth and people in exposed areas • A combination of El Nino conditions, storm surges and sea level rise increase risk of coastal flooding and storm impacts on the west coast of Canada • It is still unclear how El Nino and Pacific Decadal Oscillation systems may be impacted by climate change • Severe winter storms and coastal erosion have already been observed on the Pacific coast. Sea level rise and storm frequency or intensity will increase the risk of inundation, storm-surge flooding, shoreline erosion and other storm related impacts • Low-lying homes, docks and port facilities would be more frequently flooded at high tide and during severe storms • Munich Re, a leading insurance group internationally, recently stated that it expects climate change to be a major driver of losses in the future, and urged international action. Their most recent report showed an upward trend in the number of natural catastrophes and the value of losses due to those catastrophes annually • Communities' dikes system may require upgrades to prevent overtopping or breaching currently and in the future • Dike systems will need to be re-examined to decide whether to maintain, update, or abandon them; higher maintenance costs will be incurred for dikes, seawalls and channel works at the mouth of the Fraser River • Low lying areas that are not diked may be inundated, and pumping may be required at additional energy cost • Emergency preparedness measures will become obsolete unless knowledge of potential climate change impacts is incorporated into these plans.

appendix 3: provincial mechanisms to promote local sustainability

BRITISH COLUMBIA

Smart Planning for Communities Initiative: Smart Planning is a process for envisioning and planning for the long-term well-being of communities. The initiative provides a framework that helps communities develop the ability to engage in planning processes that incorporate sustainability principles and to apply integrated decision-making. The key capacity building components provided through the initiative include a website to link local and First Nations governments to sustainability planning resources, sustainability facilitators, and an information-sharing and resource network linking sustainability experts, resources, and communities.

http://www.cserv.gov.bc.ca/lgd/intergov_relations/smart_planning.htm

Local Government Act: The Act states that the minister may establish policy guidelines regarding the process of developing, and content of, official community plans and that the minister may only do so after consultation with representatives of the Union of British Columbia Municipalities. The minister may require a municipality to adopt an official community plan within a specified amount of time and, inversely, a local government may, by bylaw, adopt one or more official community plan

http://www.cserv.gov.bc.ca/lgd/gov_structure/community_charter/concordance/local_government_local_government.htm

Smart Growth BC: This non-governmental organization works with community groups, businesses, developers, planners, municipalities and the public to create more livable communities in British Columbia. It is focused on nurturing and mobilizing citizen movements regarding growth and sprawl issues around the province and on providing sound alternative policy solutions to these issues. The organization's website provides information on a number of its projects, which cover such diverse issues as agricultural land reserve protection, affordable housing, and voter education.

http://66.51.172.116/

ALBERTA

Municipal Sustainability Initiative: This initiative provides funding to municipalities to assist them in managing growth and enhancing long-term sustainability. Funding support can be used to support critical core and community infrastructure projects and to encourage collaboration and cooperation between neighbouring municipalities.

http://www.municipalaffairs.gov.ab.ca/wp_municipal_sustainability_initiative.cfm

Climate Change Action Plan: The plan supports local governments in finding ways to reduce emissions, including land-use planning. The government will conduct consultations and implement energy efficiency standards in building codes for homes and commercial buildings. Specific implementation plans to move ahead with these actions will be outlined.

http://www.environment.alberta.ca/1319.html

Land-use Framework: A framework that acts to manage the land, and all the activity on and below it, in a responsible way so that land-use resulting from resource development, agriculture, recreation, and community growth is conducted in a sustainable manner.

http://www.landuse.gov.ab.ca/

SASKATCHEWAN

The Planning and Development Act, 2007: The Act enables the Minister of Government Relations to authorize the adoption of official community plans and enables municipalities throughout Saskatchewan to address local land-use and development issues through the adoption of land-use bylaws, including official community plans.

http://www.testmach.govmail.gov.sk.ca/mun/new/mrd/publications/pdf/cpb/munlandusecontrol.pdf

Green Strategy: As part of the Sustainable Communities portion of the Green Initiatives Fund within the Green Strategy, the Province awarded funding to communities for climate change adaptation, water conservation and protection, green agriculture and sustainable development.

http://www.gov.sk.ca/news?newsId=6a744385-2f87-44ba-ac63-9cb18dcc9acd

MANITOBA

Neighbourhoods Alive!: This is a long-term, community-based, social and economic development strategy that supports community-driven revitalization efforts in designated neighbourhoods in Winnipeg, Brandon and Thompson. A Neighbourhood Planning Guide is available to help neighbourhoods assess their strengths, identify their vision of a vibrant community, and develop an action plan to achieve neighbourhood goals.

http://www.gov.mb.ca/ia/programs/neighbourhoods/index.html

Building Communities Initiative: Through this five year initiative, consultant teams were contracted to facilitate community consultation processes within each neighbourhood in Winnipeg to identify key needs and issues and to create prioritized lists of capital projects. These projects are now being implemented.

http://www.gov.mb.ca/ia/programs/bldgcomm/index.html

Sustainable Resource Management Branch: The Branch provides planning and policy assistance to local planning authorities.

http://www.gov.mb.ca/conservation/susresmb/

Sustainable Development Innovations Fund (SDIF): A fund that provides support for the development, implementation and promotion of environmental innovation and sustainable development projects. One of the priority areas, Sustainable Community Development focuses on encouraging eco-efficiency initiatives, environmental stewardship, capacity building mechanisms, and inner city revitalization.

http://www.gov.mb.ca/conservation/pollutionprevention/sdif/

Provincial Land Use Policies (PLUPs): These policies guide local authorities in preparing land-use plans and making sustainable land-use and development decisions. (Note: The term "Official Community Plan" does not appear to be used)

http://www.gov.mb.ca/ia/programs/land_use_dev/index.html

ONTARIO

Places to Grow: This provincial program aims to manage growth and development in ways that support economic prosperity, protect the environment, and help communities achieve a high quality of life. The program's website provides plans and technical studies, tools and resources (i.e. links to databases and case studies), and research on growth planning. Through Places to Grow, regional growth plans are developed in order to guide government investments.

http://www.pir.gov.on.ca/English/growth/index.html

Planning Act: Ontario's Planning Act provides communities with tools to influence and shape their growth to ensure development takes place in compact, integrated, and more sustainable ways. The Act requires that municipalities update their Official Community Plans every five years, thereby allowing citizens to become more involved in the planning process and the most current provincial and local priorities to be reflected in planning decisions.

http://www.mah.gov.on.ca/Page1456.aspx

Ontario Smart Growth Network: This network brings provincial and community leaders together to help design healthy and compact communities. Its mission is to promote a healthy environment, healthy communities, and sustainable local economies through smart land-use, transportation, and community design.

http://www.smartgrowth.on.ca/index.htm

QUÉBEC

Sustainable Development Act: An act developed with the objective of establishing a new management framework within the province of Québec to ensure that powers and responsibilities are exercised in the pursuit of sustainable development. The Act encourages integrated approaches to fostering sustainable development by provincial, regional, and local authorities.

http://www.canlii.org/qc/laws/sta/d-8.1.1/20060525/whole.html

Foundations for Success: Québec Infrastructures Plan: A provincial plan to ensure that both new and old public infrastructures, including municipal infrastructures, are sustainable. The plan works to ensure the safety and to improve the quality of life of the public.

http://www.tresor.gouv.qc.ca/en/publications/infrastructure/plan-infrastructure-en.pdf

NEW BRUNSWICK

Future of Local Governance: A comprehensive review of local governance within the Province of New Brunswick. The commissioner responsible for the review will create an action plan that outlines options and strategies aimed at ensuring the long-term viability of local governments and the communities they serve.

http://www.gnb.ca/cnb/Promos/lg/index-e.asp

Community Planning Act: This Act provides municipal and rural community councils with tools to plan and control development. It requires all communities to develop municipal plans containing policies and proposals that guide future development within the boundaries of each municipality.

http://www.gnb.ca/0370/0370/0003/pdf/0010-E.pdf

Conservation Design for Subdivisions (also known as Sustainable Community Design (SCD)): A concept for sustainable subdivision planning that encourages maximizing open-space conservation without reducing overall building density. endorsed by the Sustainable Planning Branch of the New Brunswick Department of Environment. SCD promotes economic gains while also facilitating social and environmental benefits.

http://www.elements.nb.ca/Theme/CertPlan/Daniel/daniel.htm

NOVA SCOTIA

Sustainable Communities Information: A project of the Nova Scotia Environment and Development Coalition that links issues of environment, economics, health, and culture through a democratic community process. The project's website provides tools, resources, and information on communities' successes with regards to sustainable livelihoods and green economies.

http://www.chebucto.ns.ca/environment/SCN/SCN_home.html

Rural Communities Impacting Policy: This project, funded by the Social Sciences and Humanities Research Council of Canada, aims to increase the ability of rural communities in Nova Scotia to access and use social science research to influence and develop policy that contributes to the health and sustainability of rural communities.

http://www.ruralnovascotia.ca/backgrounder.asp

Nova Scotia's 2020 Vision: A commitment adopted in the province's Environmental Goals and Sustainable Prosperity Act that sets out goals for the province with regards to ecosystem protection, air emissions, renewable energy, water quality, contaminated sites, solid waste, sustainable purchasing, and energy efficient buildings. The province will work with all levels of government to develop strategies and policies to advance the 2020 Vision.

http://www.gov.ns.ca/enla/pollutionprevention/docs/2020FactSheet.pdf

Ecotrust Municipal Program for Clean Air and Climate Change: This program provides funding to municipalities for projects that target reductions in greenhouse gases and other air pollutants.

http://www.gov.ns.ca/ecotrust/municipal/

PRINCE EDWARD ISLAND

Capacity Building Fund: A fund established by the Province of Prince Edward Island and the Government of Canada to assist communities and enhance their capacity to achieve and maintain long-term sustainability.

http://www.gov.pe.ca/cca/index.php3?number=1017455&lang=E

Provincial Planning Branch: This branch, which receives its mandate from the province's Planning Act, assists municipalities in achieving sustainable development.

http://www.gov.pe.ca/commcul/pais-info/index.php3

Community Development Program: A provincial program aimed at facilitating development of long-term community plans through community visioning processes that address the key areas of health, environment, education, and economic development. A Community Development Fund has been established to provide funding to projects initiated through the community development process.

http://www.gov.pe.ca/infopei/index.php3?number=20058&lang=E

NEWFOUNDLAND AND LABRADOR

Land Use Planning Section: A subgroup of the Engineering and Land Use Division of the Municipal Affairs Department that promotes growth of sustainable and attractive communities.

http://www.ma.gov.nl.ca/ma/landuse_planning.html

Community Services Council of Newfoundland and Labrador: An independent organization whose mission is to encourage citizen engagement, to promote the integration of social and economic development, and to provide leadership in shaping public policies.

http://www.envision.ca/templates/aboutcsc.asp?ID=61

YUKON TERRITORY

Association of Yukon Communities (AYC): This organization facilitates the establishment of responsible government at the community level and provides a united approach to addressing community ambitions. The AYC promotes development of Integrated Community Sustainability Plans (ICSP), defined as long-term plans that provide direction for communities to realize sustainability objectives related to the environmental, cultural, social, and economic dimensions.

http://www.ayc.yk.ca/

Community Development: This subgroup of the Community Services Department within the provincial government encourages, strengthens, enables, and supports local government in the Yukon.

http://www.community.gov.yk.ca/general/communitydevelopment.html

NORTHWEST TERRITORIES

Northwest Territories Association of Communities: A united voice for community governments that provides access to a wide variety of information on grants, policies, proposed legislation, new programs, and technical reports.

http://www.nwtac.com/

Community Planning Section: This section, a subgroup of the Lands Administration group within the Municipal and Community Affairs Department of the territory government, provides advice and assistance to community governments.

http://www.maca.gov.nt.ca/lands/community_planning/index.html

NUNAVUT

Nunavut Planning Commission: An organization responsible for developing land-use plans, policies, and objectives to guide resource use and development in Nunavut. The Commission aims to ensure the protection and promotion of both the existing and the future well-being of the residents and communities of the Nunavut Settlement Area.

http://npc.nunavut.ca/eng/index.html

Community Planning and Lands Section: A subcomponent of the Community Development Division of the Department of Community and Government Services, Government of Nunavut. This Section is responsible for providing advice and support on community planning and land management issues to municipalities in Nunavut.

http://cgs.gov.nu.ca/en/community-development/lands

appendix 4: climate change adaptation resources

DOCUMENTS

Canada's Fourth National Report on Climate Change. Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change. (2006). Government of Canada.
A national report that addresses the science, impacts, and adaptation issues facing Canada in the future.
http://www.ec.gc.ca/climate/4th_Report_on_CC_e.pdf

Collins, N., G. Smith, and J.B. Allen (2005). A Guide for Incorporating Adaptation to Climate Change into Land-Use Planning. Version 1.1. CEF Consultants Ltd and CBCL Limited.
A guide aimed at land use planners, engineers, administrators within municipal governments, and planning advisory committees that discusses mitigation and adaptation strategies, climate change impacts and plans, and land use planning.
www.cefconsultants.ns.ca/CCGuideLandUseNov05.pdf

Funding Your Community Energy and Climate Change Initiatives. A guide to funding and resources for British Columbia local governments. (2007). Community Energy Association.
A Canadian Energy Association report that provides information for BC local governments on funding sources and non-financial resources for climate change actions.
http://www.cbt.org/climatechange/pdfs/ CEA%20Funding%20Guide.2007-Sep.pdf

Girard, M. and M. Mortimer (2006). The Role of Standards in Adapting Canada's Infrastructure to the Impacts of Climate Change.
A Canadian Standards Association report that discusses the relationship of codes and standards to the design and operation of infrastructure works and the influence of codes and standards on climate change adaptation issues.
http://www.csa.ca/climatechange/downloads/pdf/ Impacts_of_Climate_Change_2006.pdf

Lemmen, D.S. and F.J. Warren (eds.). (2004). Climate Change Impacts and Adaptation: A Canadian Perspective. Climate Change Impacts and Adaptation Program.
A report produced by Natural Resources Canada that provides a summary of recent Canadian studies on climate change impacts and adaptation and a discussion of

adaptation within the sectors of water resources, agriculture, forestry, coastal zone, fisheries, transportation, and human health and well-being.
http://www.adaptation.nrcan.gc.ca/perspective/index_e.php

Mehdi, B. (ed.). 2006. Adapting to Climate Change: An introduction for Canadian municipalities. Canadian Climate Impacts and Adaptation Research Network.
A report produced by Natural Resources Canada for municipal decision-makers that outlines decision-making processes to adapt to climate change and provides examples of municipal adaptation measures applied across Canada.
http://www.c-ciarn.ca/adapting_e.html *(available in French and English)*

Research and Analysis Division, Infrastructure Canada (2006). Adapting Infrastructure to Climate Change in Canada's Cities and Communities. A Literature Review.
A report by Infrastructure Canada that discusses the challenges associated with, and processes used for, assessing adaptation responses. The report also reviews literature and research related to infrastructure and climate change adaptation in Canada.
http://www.infrastructure.gc.ca/research-recherche/alt_formats/pdf/rs14_e.pdf

Willows, R.I. and R.K. Connell (eds.). (2003). Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP: Oxford.
A report by the UK Climate Impacts Programme that describes eight stages of a decision-making framework to help planners, businesses, and government gauge risks associated with climate change and assess how best to respond. The report provides guidance on the use of the framework, recommends tools and techniques that may be applied at each stage, describes the concepts of risk and uncertainty, and supplies information on the key aspects of climate change risk assessment.
http://www.ukcip.org.uk/resources/publications/pub_dets.asp?ID=4

WEB RESOURCES

International

www.ipcc.ch
Intergovernmental Panel on Climate Change (IPCC) website provides information on the organization's meetings, reports, speeches, and presentation materials. Full Assessment reports, summary for policymakers, and technical summary of the Working Group II Report, "Impacts, Adaptation and Vulnerability," can be accessed from this site.

www.ukcip.org.uk
United Kingdom Climate Impacts Programme (UKCIP) website provides information about climate change scenarios for the UK. The Scenarios Gateway offers access to maps, datasets, and guidance documents relevant to the UKCIP climate change scenarios.

www.fao.org/clim/adaptation_en.htm
Food and Agriculture Organization (FAO) of the United Nations website that describes adaptation measures and provides links to information on win-win adaptation options, clean development mechanisms, food security, and risk management.

Canadian

www.hazards.ca
Canadian Atmospheric Hazards Network (CAHN) (Environment Canada) website provides links to background material on climate change, information on climatology, and data on extreme weather events for regions across Canada.

www.cccsn.ca
Canadian Climate Change Scenarios Network (CCCSN) (Environment Canada) website provides international and Canadian climate change scenarios, on-line instructions for using scenarios and downscaling tools, links to IPCC guidelines on scenario use and interpretation, bioclimate profiles for Canada, impact and adaptation research documents, and links to other tools used in impacts and adaptation research.

www.adaptation.gc.ca
Climate Change and Impacts and Adaptation Division (CCIAD); Natural Resources Canada website provides information on climate change impacts and adaptation research across Canada, including research on tools for adaptation and comprehensive case study research. The website also contains a project database of over 170 research projects supported by the CCIAD research program, as well as presentations from the CCIAD speaker series. There is also a section of additional links to climate change resources."

sustainablecommunities.fcm.ca
Centre for Sustainable Community Development (CSCD) (Federation of Canadian Municipalities) website provides information regarding financial support and capacity building resources for Canadian municipal governments to improve environmental performance, reduce greenhouse gas emissions, and further sustainable community development projects.

www.ec.gc.ca/climate/home-e.html
Environment Canada Climate Change website that provides links to reports and news releases related to Canadian climate change issues and initiatives.

pacificclimate.org (Note: Site is under development)
Pacific Climate Impacts Consortium (PCIC) website that provides climate change tools, including datasets, maps, and plots, and resources, including publications and presentations.

www.ouranos.ca
Consortium on Regional Climatology and Adaptation to Climate Change website provides access to the organization's publications, project reports, presentations, posters, and newsletters related to the issues and requirements for adaptation to climate change in North America. An Observed and Historical Data program with a climatic and hydrometric data search tool is available.

http://www.unsm.ca/sustainability/index.html
Union of Nova Scotia Municipalities (UNSM) Municipal Sustainability Office website that provides an overview of climate change and sustainability related approaches and resources for municipalities. In particular are links to interesting facts related to climate change adaptation and

impacts, examples of climate change adaptation projects, and an extensive list of resources relevant to municipal adaptation planning and research.

www.csa.ca/climatechange/services/adaptation/Default.asp?language=english

A section within the Canadian Standards (CS) Climate Change website that provides information about adaptation issues affecting the buildings and infrastructure sectors. Links to construction, engineering and risk management standards are provided.

www.ainc-inac.gc.ca/clc/adp/index_e.html

A section within the Clean Energy and Community Adaptation Program's (ICECAP) (Indian and Northern Affairs Canada) website that provides information about the process of adaptation communities may follow, summaries of adaptation projects, examples of adaptation strategies, tools and resources to assess vulnerability and adaptation strategies, as well as links to information on climate change impacts by region, modelling and research, and other climate related websites.

www.msc-smc.ec.gc.ca/saib/climate/climat_e.html

Meteorological Service of Canada's (MSC) (Environment Canada) Climate Change website provides information on the current state of Canadian and international climate science, trends in greenhouse gas concentrations, and research on climate change impacts, predictions and modelled projections on climate futures.

www.cccma.bc.ec.gc.ca/eng_index.shtml

Canadian Centre for Climate Modelling and Analysis (CCCma) is a division of the Climate Research Branch of the Meteorological Service of Canada, Environment Canada. Its website provides data for numerous climate models, such as: atmospheric climate modelling, sea-ice modelling, climate variability and predictability, the carbon cycle, and a number of other areas.

www.cbt.org/climatechange/action.asp

The Columbia Basin Trust's Climate Change website provides information on community climate change issues and resources for adaptation strategies.

appendix 5: glossary

Adaptability: The ability, competency or capacity of a system to adapt to (to alter to better suit) climatic stimuli

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects that moderates harm or exploits beneficial opportunities. (IPCC, 2001)

Adaptation Benefits: The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures. (IPCC, 2001)

Adaptation Costs: Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs. (IPCC, 2001)

Adaptation Measure: Policies and measures: usually addressed together, respond to the need for climate adaptation in distinct, but sometimes overlapping ways. Policies, generally speaking, refer to objectives, together with the means of implementation. In an adaptation context, a policy objective might be drawn from the overall policy goals of the country – for instance, the maintenance or strengthening of food security. Ways to achieve this objective might include, e.g., farmer advice and information services, seasonal climate forecasting and incentives for development of irrigation systems. Measures can be individual interventions or they consist of packages of related measures. Specific measures might include actions that promote the chosen policy direction, such as implementing as irrigation project, or setting up a farmer information, advice and early warning programme. Both of these measures would contribute to the national goal of food security. (UNDP, 2005)

Adaptation Policy Framework (APF): is a structural process for developing adaptation strategies, policies, and measures to enhance and ensure human development in the face of climate change, including climate variability. The APF is designed to link climate change adaptation to sustainable development and other global environmental issues. It consists of five basic Components: scoping and designing an adaptation project, assessing current vulnerability, characterizing future climate risks, developing an adaptation strategy, and continuing the adaptation process. (UNDP, 2005)

Adaptation Technology: A report by the UNFCCC Secretariat on a seminar on the development and transfer of technologies for adaptation to climate change states that defining adaptation technologies is difficult. It suggests that an operational definition might be used for "the application of technology in order to reduce the vulnerability, or enhance the resilience, of a natural or human system to the impacts of climate change". Technological approaches to adaptation include both "hard" technologies such as capital goods and hardware, as well as "soft" technologies such as knowledge of methods and techniques which enable "hard" technologies to be applied. (UNDP, 2005)

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. (IPCC, 2001)

Anticipatory Adaptation: Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

Autonomous Adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

Base-Line Scenario: Baseline scenarios depict a future state of society and/or environment in which no new environmental policies are implemented apart from those already in the pipeline today; or in which these policies do not have a discernable influence regarding the questions being analysed. (European Environment Agency, 2008)

Capacity: A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster. Capacity may include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management. Capacity may also be described as capability. (UN/ISDR, 2004)

Catastrophic Event: A climate-related event having sudden onset and widely distributed and large magnitude impacts on human or natural systems, such as historically rapid sea level rise or sudden shifts (over a decade or less) in atmospheric or oceanic circulation patterns. Such events have occurred in the past due to natural causes (UNDP, 2005)

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. The United Nations Framework Convention on Climate Change (UNFCCC), however, does make a distinction between "climate variability" attributable to natural causes and "climate change" attributable to human activities altering the atmospheric composition. In the UNFCCC's Article 1, "climate change" is defined as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." (IPCC, 2001)

Climate Feedback: The influence of a climate-related process on another that in turn influences the original process. For example, a positive climate feedback is an increase in temperature leading to a decrease in ice cover, which in turn leads to a decrease of reflected radiation (resulting in an increase in temperature). An example of a negative climate feedback is an increase in the Earth's surface temperature, which may locally increase cloud cover, which may reduce the temperature of the surface. (IPCC, 2001)

Climatic Hazards: include increasing frequency of extreme weather events (floods, hurricanes, tornados, droughts), increasing summer temperatures, lower level of precipitation during main growing seasons, changes in streamflow, changes in snowfall

Climate System: The system consisting of the atmosphere (gases), hydrosphere (water), lithosphere (solid rocky part of the Earth), and biosphere (living) that determine the Earth's climate. (NOAA, 2005)

Climate Variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forces (external variability). (IPCC, 2001)

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. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO). (IPCC, 2001)

Climatic Variable: Qualitative classification of a weather element (e.g. temperature, precipitation, wind, humidity, etc.) at a place over a period of time. (NOAA, 2005)

Coping Capacity: The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and human-induced hazards (UN/ISDR 2004). Capacity refers to the manner in which people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal, and adverse conditions of a disaster event or process. The strengthening of coping capacities usually builds resilience to withstand the effects of natural and other hazards. (European Spatial Planning Observation Network)

Critical Threshold: The point at which an activity faces an unacceptable level of harm, such as a change from profit to loss on a farm due to decreased water availability, or coastal flooding exceeding present planning limits. It occurs when a threshold q.v. is reached at which ecological or socioeconomic change is damaging and requires a policy response. (UNDP, 2005)

Development Pathway: An evolution based on an array of technological, economic, social, institutional, cultural and biophysical characteristics that determine the interactions between human and natural systems, including production and consumption patterns in all countries, over time at a particular scale. (IPCC, 2007)

Extreme Event: An extreme weather event refers to meteorological conditions that are rare for a particular place and/or time, such as an intense storm or heat wave. An extreme climate event is an unusual average over time of a number of weather events, for example heavy rainfall over a season.

Extreme Weather Event: 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). (IPCC, 2001)

Global Circulation Models (CGMs): Numerical representation of the atmosphere and its phenomena over the entire Earth, using the equations of motion and including radiation, photochemistry, and the transfer of heat, water vapour, and momentum. (NSIDC, n.d.)

Human System: Any system in which human organizations play a major role. Often, but not always, the term is synonymous with “society” or “social system” (e.g. agricultural system, political system, technological system, economic system). (IPCC, 2001)

Kyoto Protocol: The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol. Most Organization for Economic Cooperation and Development countries and countries with economies in transition agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005. (IPCC, 2007)

Mainstreaming: A definition of ‘mainstreaming’ does not yet exist, although the term is widely used. It seems that ‘mainstreaming’ is used interchangeably with ‘integration’. Mainstreaming refers to the integration of adaptation objectives, strategies, policies, measures or operations such that they become part of the national and regional development policies, processes and budgets at all levels and stages (UNDP, 2005).

Maladaptation: Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but instead increases it. (IPCC, 2007)

Mitigation: The promotion of policy, regulatory and project-based measures that contribute to the stabilization or reduction of greenhouse gases concentration in the atmosphere. Renewable energy programs, energy efficiency frameworks and substitution of fossil fuels are examples of climate change mitigation measures. (The World Bank, n.d.)

Mitigative Capacity: A country’s ability to reduce anthropogenic greenhouse gas emissions or enhance natural sinks. “Ability” refers to skills, competencies, fitness, and proficiencies that a country has attained which can contribute to greenhouse gas emissions mitigation. The main sets of factors influencing mitigative capacity are technological, economic, and institutional in character. The economic factors include income, abatement cost and opportunity cost while the technological factors include the ability to absorb existing climate-friendly technologies or to develop innovative ones. The institutional factors include the effectiveness of government regulation, clear market rules, a skilled work force and public awareness. (Winkler et al., 2007)

Non-Climatic Hazards: include globalization and growing competition, deepening wealth gap, changing demographics and population patterns, concerns about socio-political insecurity, rapid technological change, declining natural resources, ecosystem services, natural habitat and biodiversity, increasing level of pollutants in the natural environment also affecting health

No Regret Adaptation Options: Adaptation options (or measures) that would be justified under all plausible future scenarios, including the absence of man-made climate change. (Eales et al., 2006)

Planned Adaptation—Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

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

Reactive Adaptation: Adaptation that takes place after impacts of climate change have been observed.

Resilience: The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (UN/ISDR, 2004)

Risk (climate-related): is the result of interaction of physically defined hazards with the properties of the exposed systems – i.e., their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences – i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP 2005). Risk is the probability that a situation will produce harm under specified conditions. It is a combination of two factors: the probability that an adverse event will occur; and the consequences of the adverse event. Risk encompasses impacts on human and natural systems, and arises from exposure and hazard. Hazard is determined by whether a particular situation or event has the potential to cause harmful effects.

Risk Management: The implementation of strategies to avoid unacceptable consequences. In the context of climate change adaptation and mitigation are the two broad categories of action that might be taken to avoid unacceptable consequences. (UNDP, 2005)

Sensitivity: the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC, 2001)

Socio-Economic Vulnerability: is an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations (UNDP, 2005).

Stakeholder: A person or an organization that has a legitimate interest in a project or entity, or would be affected by a particular action or policy. (IPCC, 2007)

Threshold: Any level of a property of a natural or socioeconomic system beyond which a defined or marked change occurs. Gradual climate change may force a system beyond such a threshold. Biophysical thresholds represent a distinct change in conditions, such as the drying of a wetland, floods, breeding events. Climatic thresholds include frost, snow and monsoon onset. Ecological thresholds include breeding events, local to global extinction or the removal of specific conditions for survival. Socioeconomic thresholds are set by benchmarking a level of performance. Exceeding a socioeconomic threshold results in a change of legal, regulatory, economic or cultural behaviour. Examples of agricultural thresholds include the yield per unit area of a crop in weight, volume or gross income. (Marsden Jacobs Associates, 2004)

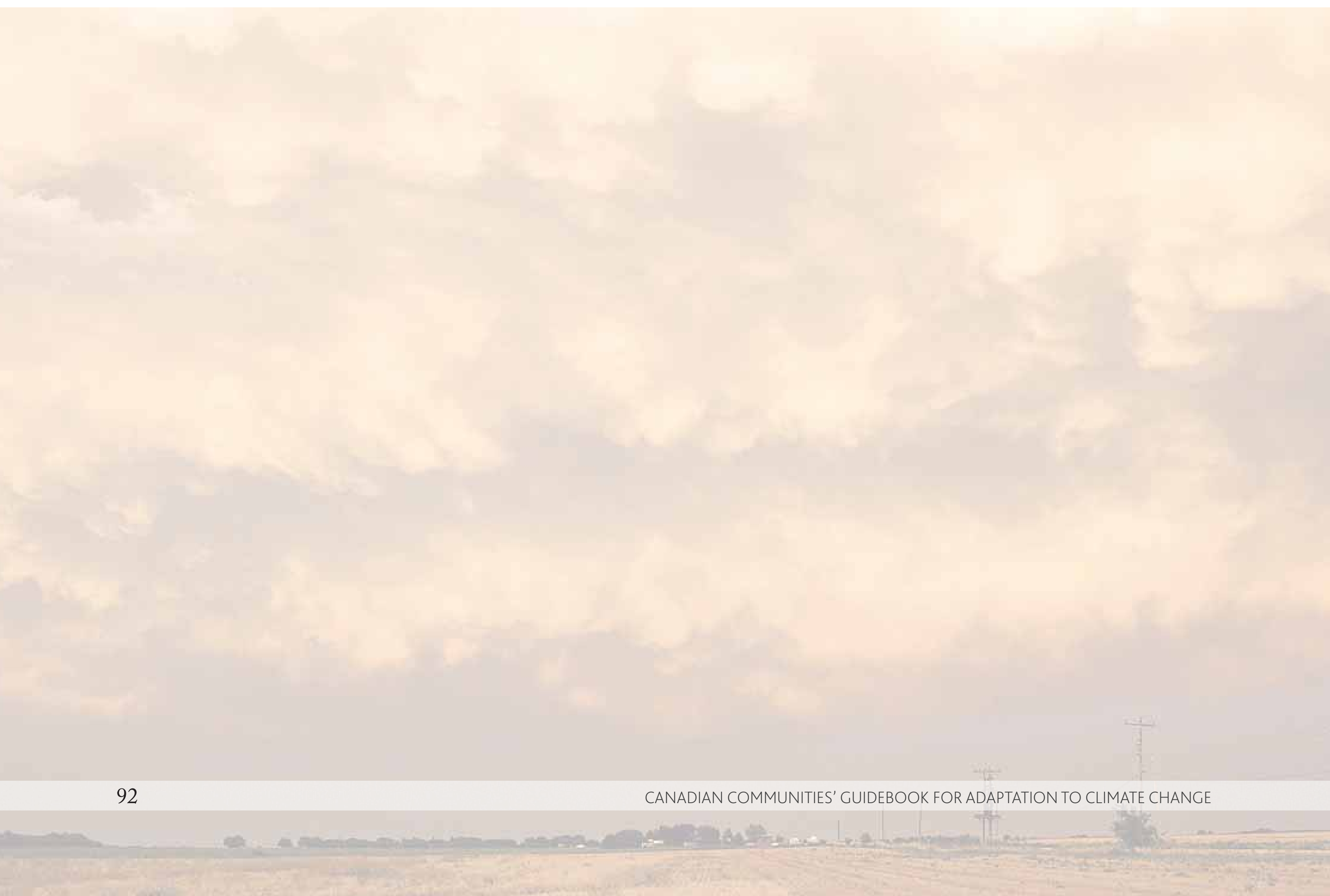
UNFCCC (United Nations Framework Convention on Climate Change): An international treaty adopted in 1992, and entered into force in 1994, that sets an overall framework for intergovernmental efforts to address challenges posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. Under the Convention, governments cooperate in preparing for adaptation to the impacts of climate change, launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, and gather and share information on greenhouse gas emissions, national policies and best practices. One hundred and ninety-two countries have ratified their membership with UNFCCC and the Kyoto Protocol is an addition to this treaty.

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. (IPCC, 2001)

Vulnerability assessment identifies who and what is exposed and sensitive to change. A vulnerability assessment starts by considering the factors that make people or the environment susceptible to harm, i.e. access to natural and financial resources; ability to self-protect; support networks and so on. (Tompkins et al., 2005)

Weather: The state of the atmosphere at a given time and place with regard to temperature, air pressure, humidity, wind, cloudiness, and precipitation. The term weather is used mostly for conditions over short periods of time. (Environment Canada, 2008)

Win-Win Options: Adaptation options that minimize harmful climate impacts and also have other social, environmental or economic benefits. (European Environment Agency, 2005) For example, no-till farming with residue mulching slows soil erosion and pollution runoff, acting to adapt agriculture operations to extreme weather while also benefiting aquatic ecosystems, improving agronomic productivity, contributing to food security, and reducing demand for fertilization and irrigation. (Lal et al., 2004)



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