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Climate Change Adaptation: Linkages with Social Policy

Research Paper

Canada

Climate Change Adaptation: Linkages with Social Policy

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A Report by the Adpatation to Climate Change Team (ACT), from the Simon Fraser University (SFU) for the Policy Research Initiative

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Executive Summary

Our Changing Climate

Our climate is changing and the impacts are already being felt across Canada. Impacts ranging from shifting precipitation patterns to extreme heat events threaten the well-being of Canadians and will continue to do so at an increasing rate, even as the international community begins, hopefully, to undertake the crucial work of reducing greenhouse gas emissions, or "mitigation." Climate projections indicate that all Canadians will experience the impacts of climate change, at least to some degree, and almost all sectors of our economy will be affected by climate change; indeed, some are already feeling the brunt of pressures that will only worsen as time goes by. Because of these wide-ranging impacts on Canadians, climate change will have implications for many areas of social policy; it is therefore crucial that we prepare the policy arena for the problems climate change will cause, with or without mitigation. This approach is known as "adaptation."

Social Policy in the Context of Climate Change

For the purposes of this report, we broadly define social policy as government actions that address hardships and income losses accruing to populations that are vulnerable to climate change. We provide many examples from Canada and around the world, of environmental programs that are in effect social programs. Some approaches we discuss are "ex-post accommodations" – after-the-event responses intended to minimize the impact of adverse climate events. Other approaches we discuss are "ex-ante adaptations" – actions that seek to reorient behaviour, prior to the onset of adverse events. The authors acknowledge that, while there is value in making the distinction between policies that are prior to the event (ex-ante adaptations), and those that are after the event (ex-post accommodations), both approaches can help to enhance adaptive capacity.

Social Policy that Enhances Adaptive Capacity

Because the effects of climate change on Canadians will be broad, there is a clear and urgent need for measures that assist Canadian communities and social structures to adapt to these new – and in many cases unprecedented – pressures. Building "adaptive capacity" – the ability of a system to respond successfully to climate variability – includes changes in mechanisms such as government transfers (whether in the form of cash or services), changes in financial incentives implicit in social and other fiscal policies, and changes in regulations (Intergovernmental Panel on Climate Change, 2007).

Access to economic wealth, modern technology, good infrastructure, information and skills, and quality of institutions all influence adaptive capacity. Increasingly, studies conclude that individuals' social capital (such as the quality of their social networks, access to and participation in decision-making processes) influences adaptive capacity. As demonstrated in this report, sectors and jurisdictions throughout the world have begun the process of building adaptive capacity through diverse technical, regulatory and social approaches.

Social Policy that Responds to Adverse Events

Once the adverse effects of climate change are experienced, there is a need to respond to those events in order to minimize the adverse impact on people, communities and industry. This report demonstrates various mechanisms used by government to respond to adverse events, including disaster assistance, safety-net programs and approaches to lower the negative impacts on stressed communities. Effective use and availability of such response mechanisms contribute to overall adaptive capacity.

NB: It is important to note that we identify measures being taken in a variety of jurisdictions that are assisting with enhancement of adaptive capacity and/or designed to respond to adverse events. We do not propose that all these measures be used by every jurisdiction as tools in the adaptation process; adaptation is by definition a regional exercise and it is incumbent on those designing strategy to establish the most appropriate measures for each region.

Report Mandate

This report, produced by the Adaptation to Climate Change Team (ACT) of Simon Fraser University (SFU) for the Policy Research Initiative (PRI), constitutes a general scan of current literature from around the world, including adaptation plans and actions in progress by all levels of government. The scan is intended to provide an overview of approaches, guidelines, tools, and policy options being employed to adapt to climate change to better understand the implications of climate changes for different areas of social policy, and the resulting linkages. Referencing studies on climate change impacts and adaptation in Canada, as well as those that address the linkages between social policy and climate change impacts internationally, we present an organized scan of which social policy areas could be affected by changes in the climate, and how this may occur. Examples, recommendations and gaps in policy specific to **health and safety** can be found in *Section Five*. *Section Six* of the report is a detailed scan of the social policy consequences of **heat events** in communities, identifying key issues limiting the adaptive capacity for vulnerable populations and suggestions for ways to improve the resilience of these populations to increasing extremes and variations in climate.

The authors recommend further targeted research into specific components of social policy to provide in-depth analysis, a detailed gap analysis, and recommendations for future policy development beyond the terms of reference for this paper. However, we have enhanced the report's original mandate by formulating preliminary identification of existing social policy gaps across the board in *Sections Four* and *Five*, and in doing so we make suggestions about further research and policy development that may be useful for Canadians as they refine their understanding of the increasing threats and expenses projected by current models.

Our Team

The senior researchers on this report are **Dr. Nancy Olewiler**, Director of SFU's Public Policy Program, and **Dr. John Richards**, Professor with SFU's Public Policy Program. Dr. Olewiler, a leading environmental economist, and Dr. Richards, one of Canada's leading social policy researchers, directed and advised research assistants **Christine VanDerwill**, MA, International Studies, SFU, and **Linsay Martens**, Master's Candidate, Public Policy Program, SFU. **Deborah Harford**, ACT's Executive Director, coordinated and co-wrote the report, and produced all final documents. This group has extensive experience in international research and in-depth

knowledge of the linkages between social and environmental policy, as well as in-depth knowledge of climate change adaptation issues and approaches around the world.

Methodology

In accordance with the approach used by the IPCC in its reports and current literature, this paper is grounded in vulnerability and adaptation theory and practice: It examines (i) the extent to which a system is unable to handle the adverse effects of climate change, and (ii) changes within the system, including changes in human behaviour, that are needed for that system to cope with or take advantage of the changing climate. Following the IPCC approach, the paper also reviews "the current scientific understanding of the impacts of climate change on human systems" in Canada and "the capacity of these systems to adapt and their vulnerability" (IPCC, 2007). To ensure transparency, we include key concepts and definitions as conceptualized by the IPCC (e.g. adaptation, adaptive capacity, vulnerability, resilience, etc.). We also refer to vulnerability assessments as conceptualized by the IPCC and to human dimensions of climate change literature. We emphasize second-generation vulnerability assessments that consider not only non-climatic drivers (e.g. demographic, sociopolitical, economic), but also factor in the ability of a system or population to adapt to climate change. We utilize internationally recognized literature to inform this comprehensive scan; the theoretical framework of the paper is also informed by literature from internationally recognized journals. Finally, we identify existing policy and potential gaps from the various contexts outlined above in order to provide policy makers with an understanding of current social-environmental policy interactions, and ways positive interactions can be strengthened and negative responses reduced. These conclusions highlight policies being used at home and abroad to build the resilience and awareness of vulnerable populations, increase adaptive capacity in communities, and develop and enhance Canada's institutional capacity to cope with climate change impacts.

Guide to the Report

The report establishes the context by outlining threats and opportunities posed by climate change (*Section One*). We next elaborate on our interpretation of social policy in the context of climate change adaptation (*Section Two*). We identify especially vulnerable populations for the purpose of defining where new policies are required (*Section Three*). We then document and provide a snapshot of the wide array of policy responses and intervention strategies in Canada and internationally, explore literature from Canada and around the world that illustrates the links between social policy and climate change impacts, and highlight specific Canadian policy gaps in this context (*Section Four*). *Section Five* summarizes the implications of climate change for policy and programs specifically related to health and safety, including recommendations and policy gaps. *Section Six* provides detailed information on the effects of extreme heat events on communities and vulnerable populations. This section posits issues that limit adaptive capacity, and adaptation policies currently in place; selected international responses; and preliminary recommendations for action as well as Canadian policy gaps.

We have also included an appendix of examples of adaptive capacity.

Section One: Threats and Opportunities Resulting from Climate Change

Our climate is changing and the impacts are already being felt across Canada. This section provides a brief overview of the current and projected climate change impacts that threaten the well-being of Canadians and a synopsis of threats and opportunities resulting from climate change. For the purposes of this report, we have synthesized these impacts into seven categories that have special relevance for social policy:

1. Increased severity and frequency of heat events
2. Severe storms, including extreme wind, rain, ice, and/or snowfall
3. Wildfires
4. Water shortages and drought
5. Changes in the cryosphere – melting permafrost, sea ice, lake ice, and snow
6. Shifting ranges and altered ecosystems, including disease, pest and invasive species migration
7. Sea level rise, storm surges, coastal and shoreline erosion

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change, issued in 2007, presents a thorough analysis of climate change based on the assessment of the world's leading climate scientists. Working Group I, whose analysis focused on physical scientific evidence, reports that global atmospheric concentration of carbon dioxide had increased to 379 parts per million (ppm) in 2005, higher than any value previously recorded (IPCC, 2007). By 2008, that value had risen to 385 ppm.

Current projections, as summarized in the Third Assessment Report of the Intergovernmental Panel on Climate Change, suggest that global average temperature could rise by 1.4°C to 5.8°C between 1990 and 2100 (Foland, Karl, Christy et al., 2001). Due to our northern latitude and large land mass, Canada is projected to experience greater rates of warming than many other regions of the world – by some estimates, more than double the global average (Lemmen and Warren, 2004).

Reductions in emissions, while crucial in reducing the likelihood of the planet becoming completely uninhabitable, will not alter many of the climate changes that have already been set in motion by CO_2 concentrations that already exist and will continue to increase even as we slow down our fossil fuel consumption (IPCC, 2007).

The greatest warming in Canada, on an annual basis, will occur in our Arctic regions. A mid-range estimate shows a possibility of global mean warming of 2.8°C by 2090-2099. Winter warming in Canada is projected to be 7°C or more in the high Arctic, 3°C to 4°C in Ontario and southern Quebec, and about 2.5°C along the B.C. coast. In the summer, the most warming is expected to occur over southern interior B.C. and the southwestern Prairies, up to 4°C. A summer warming of between 2.5°C and 3.5°C is expected over most of the rest of Canada, with the exception of the Arctic coast (1°C). This trend is a continuation of the observed warming, as summarized in Canada's National Assessment (Warren and Egginton, 2008).

Projected and current impacts of climate change include droughts, surface and ground water quality and supply issues, increases in the range of vector-borne disease, more frequent heat waves with high discomfort in urban centres, and exacerbated ocean storm surges. Resource-based communities will be vulnerable to economic and other difficulties caused by shifting ecosystems, and increasing weather extremes such as intense precipitation caused by shifts in the hydrological regime, high winds, or ice storms are among the greatest concerns for Canada's social structures and communities (Lemmen and Warren, 2004; Berry, McBean and Séguin, 2008). Heavy precipitation events are likely to become more frequent, with larger variations in intensity (Walther, Post, Convey et al., 2001), and seasonal changes expected to be more significant than changes in annual totals in terms of impact on human activities and ecosystems (Lemmen and Warren, 2004).

Increases in the frequency of extreme weather events, such as heat waves, droughts, floods, and storms, are one of the greatest concerns. As well, higher temperatures are projected to increase damage from disturbances such as forest fires and pests, and increase heat-related morbidity and mortality (Lemmen and Warren, 2004). In the North, changes in ice cover, permafrost stability and wildlife distribution are already hindering traditional ways of life (Berkes and Jolly, 2001). In other regions of Canada, changes in water flows, fish populations, tree distribution, forest fires, drought, and agricultural and forestry pests have all been associated with recent warming (Lemmen and Warren, 2004). In the past decade, losses from the 1998 ice storm, flooding in Manitoba and Quebec, drought and forest fires in western Canada, storm surges in Atlantic Canada, and numerous other events clearly demonstrate our vulnerability to climate extremes (Lemmen and Warren, 2004). The profound changes that are occurring or will occur as a result of the current and projected impacts of climate change are threatening, and will continue to threaten, the well-being of Canadians.

The main response to climate change so far has focused on mitigation through the reduction of greenhouse gas (GHG) emissions. Such a response is undoubtedly crucial to lessen the likelihood of the planet becoming uninhabitable, but it is far from adequate; damage caused by current and future emissions is already occurring and will continue to increase. Current CO_2 concentrations in the atmosphere are extensive enough to mean that our climate will continue to change regardless of our success at curtailing emissions and slowing down our fossil fuel consumption (IPCC, 2007). Therefore, our response to climate change must involve adaptation, or adjustments made to cope with or take advantage of the changing climate. The distinction between mitigation and adaptation is particularly apt in the area of social policy; while mitigation is vital to reducing the extent of future climate change, adaptation is essential to help reduce vulnerability of human systems in the face of current and expected climate-related impacts.

Continued climate change as projected by current climate models will impact all areas of the country and nearly every sector of the Canadian economy. Recent research indicates that no sector will be immune, whether it is directly affected by changing climate conditions or by mitigation measures taken to reduce greenhouse gas emissions (International Labour Organization (ILO), 2008). Primary sectors, such as agriculture, forestry and fisheries, may be the most severely affected, while changes in vacation destinations will impact the tourism industry, either negatively or positively, depending on the region (ILO, 2008).

Besides risks, climate change may also provide benefits, such as an extended growing season or warmer winter temperatures. While it is prudent – and necessary – to acknowledge Canada's vulnerabilities to climate change, we also recognize the opportunities for Canada that may arise

out of a changing climate. There is potential for adaptation planning and mitigation mechanisms to stimulate Canada's economy by taking advantage of emerging markets for new technologies and energy sources while also tapping into Canada's immense natural capital.

Furthermore, the expansion of non-farming and non-extractive activities in both the forestry and agricultural sectors could lead to new technologies and job growth. Depending on inputs, changing climate conditions could positively impact the agricultural sector, and growing conditions may improve in some regions or for some crops; however, the ability to expand agriculture will be constrained by soil suitability and water availability (International Labour Organization, 2008). Investments in adaptation could lead to employment and income opportunities through extending coastal defences, reinforcing buildings and infrastructure and water management; and green collar jobs could mitigate job losses associated with a transition to cleaner energy sources (International Labour Organization, 2008). Employment may also expand in the health sector as health needs rise from the increased risk of diseases and emergency management (International Labour Organization, 2008).

Section Two: Social Policy in the Context of Climate Change

For the purposes of this paper, we broadly define social policy as government actions that address hardships and income losses accruing to populations that are vulnerable to climate change. The list of hardships and losses addressed by social programs is long: physical handicaps (justifying disability payments), children with poor parents (justifying free kindergarten to grade 12 education), unanticipated loss of employment income (justifying unemployment insurance benefits), and so on.

Adverse environmental events due to climate change warrant an expansion of what is meant by hardship/loss relative to a social norm. In this policy scan we provided many examples, in Canada and elsewhere, of environmental programs that are in effect social programs.

Many who write about social policy resist defining it conceptually. Barr (1998), author of a highly respected text on the subject, insists: "The concept of the welfare state [i.e. social policy] … defies precise definition, and I make no serious attempt to offer one." Marshall (1965) shares that sentiment: "social policy is not a technical term with an exact meaning." Rather, the term "social policy" points to a set of public programs.

Social programs are often paternalistic in that they are intended to overcome what governments perceive as myopic or inefficient individual behaviour. For example, pay-as-you-go old age security obliges the working generation to provide some income to the old; hence, those who have been imprudent and undertaken no personal savings during their working lives are not destitute in old age. Universal health insurance obliges everyone to "buy" (via mandatory premiums and taxes) health insurance. Regulations governing the age at which one can leave school oblige parents to educate their children to the threshold school-leaving age. Some environmental programs are similar: for example, zoning to prevent residential construction in areas subject to wildfire or flooding substitutes government risk assessment for what would likely, if unregulated, be myopic individual behaviour.

Governments design social programs with – at least some – attention to the inefficiencies (moral hazard) created by their programs. For instance, some programs entail co-payments from the beneficiary: to minimize moral hazard, those who resign from a job must wait a specified number of weeks before becoming eligible for benefits. Social program design may use the price mechanism as incentive to minimize reliance on the program. An example is workers' compensation: assessments on firms vary according to claims made.

Moral hazard extends to social programs having an environmental dimension. Provision of sanitary water is a simple social program to avoid spread of water-borne disease. Climate change will increase severity of drought in some regions of Canada; in turn, drought will require municipal investment in more expensive infrastructure. Crop irrigation will exacerbate the problem of water scarcity, and pricing water use – both among urban users and farmers – is a potential policy to offset the moral hazard arising from zero or unduly cheap prices on use. Pricing water is not a social program per se, but a policy to deter the imprudent use of resources that may have serious adverse impacts on lives given probable climate change.

Some approaches we discuss are "ex-post accommodations" – after-the-event responses intended to minimize the impact of adverse climate events, including preventing severe distress or even

death (for example, programs to assist people faced with extreme urban heat events). Other approaches we discuss are "ex-ante adaptations" – actions that seek to reorient behaviour, prior to the onset of adverse events, in more efficient, adaptive ways (for example, more rigid zoning to prevent residential construction in areas prone to wildfires or flooding). Enhanced effectiveness of both approaches would improve the "adaptive capacity" of Canadians. The IPCC defines adaptive capacity (see Appendix A) as: "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).

Overall, social programs equalize incomes; often, they enhance economic efficiency; they frequently generate significant moral hazard. There inevitably arises debate over the appropriate degree of generosity and over the severity of unintended adverse effects – in the context of climate change as elsewhere. Since, for example, one impact of a changing climate will likely be increased drought in much of the Prairie region, to what extent should social policy sustain rural incomes in the region or provide incentives to relocate? Analogous debates will arise in the Atlantic region where some coastal towns may, in the course of this century, be flooded due to rising sea levels or lose their economic base as warming oceans decimate fish stocks.

In this paper, we provide a general scan of the potential linkages between what is known about current and anticipated changes in the climate and different social policies that either enhance adaptive capacity and/or accommodate adverse impacts. We also provide a detailed scan of the social policy consequences of heat events in communities.

Section Three: Most Vulnerable Populations

Climate change is an increasingly significant threat to the well-being of Canadians. All Canadians will experience the impacts of climate change and be adversely affected to some extent. However, the literature identifies specific groups that are particularly vulnerable to the impacts of climate change. These vulnerable groups act as indicators for the worst aspects of the climate change impacts, and of the effect on the population at large in varying degrees.

Threat	**Most vulnerable populations**	
1. Increased severity and frequency of heat waves	- Children (due to reliance on others and immature metabolisms) (Lemmen, Warren, Lacroix, 2008; Berry, McBean, Séguin, 2008). - Seniors (due to reduced thermoregulatory capacity, medications that exacerbate heat effects and financial constraints) (Séguin and Clarke, 2008; Berry et al., 2008).	- The chronically ill (Berry, McBean, Séguin, 2008). - Outside workers (Berry et al., 2008). - Those with inadequate shelter (Berry et al.,). - Those without access to cooling mechanisms (Berry). -Those living in areas with poor air quality (Berry).
2. Severe storms, including extreme wind, rain, ice and/or snowfall	- Those with inadequate shelter (Lemmen et al., 2008; Berry). - The chronically ill and seniors (mostly due to mobility constraints during and after storms) (Séguin and Clarke; Berry).	- Those living in low-lying coastal areas at risk of flooding (Séguin and Clarke; Berry). - Communities dependent on agriculture or forestry (Sauchyn and Kulshreshtha, 2008; Walker and Sydneysmith, 2008).
3. Wildfires	- Communities dependent on forestry, agriculture, resources, or tourism (Lemmen and Warren, 2004; Séguin and Clarke; Sauchyn; Walker).	- The chronically ill, seniors and children (due to respiratory concerns) (Séguin and Clarke; Berry).
4. Water shortages and drought	- Communities dependent on forestry, agriculture or resources (Lemmen, 2004; Séguin and Clarke; Sauchyn; Walker).	
5. Changes in the cryosphere – melting permafrost, sea ice, lake ice, and snow	- Resource-dependent communities (Furgal and Prowse, 2008). - Coastal communities (Furgal; Berry).	- Aboriginal communities, especially traditional hunters and trappers (Furgal).
6. Shifting ranges and	- Communities dependent on	- The chronically ill and

altered ecosystems, including disease, pest and invasive species migration	forestry, agriculture or resources (Lemmen, 2004; Séguin and Clarke; Sauchyn; Walker).	seniors (Berry).
7. Sea level rise, storm surges, coastal and shoreline erosion	- Those living along coasts or waterways (Berry).	- Fishing industry workers (Vasseur and Catto, 2008).

The IPCC defines vulnerability as "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, 2007). In this report, we use the vulnerable populations above to identify policy gaps that currently exist in Canada for responding to the top-of-mind climate change impacts, both in terms of adaptation to impacts, or "ex-post" policy measures; and those that will help build adaptive capacity, or "ex-ante" policy measures.

NB: The authors acknowledge that heightened efficiency of both approaches will contribute to adaptive capacity.

Section Four: Existing Social Policy and Climate Change

Section Four is an analysis of key illustrative examples of existing social policy in Canada and around the world as it relates to climate change. We have organized this section by two main areas: 1) **enhancing adaptive capacity**, which includes actions that seek to reorient behaviour in more efficient, adaptive ways before the impacts of climate change are fully felt; and 2) **responding to adverse events**, those responses to climate impacts that are intended to minimize adverse effects, including preventing severe distress or even death. This section includes key examples that illustrate a range of responses by organizations and nations that aim to protect and/or improve the well-being of people in the face of a changing climate.

Section Four also provides a concise synopsis of areas in which Canadian governments could enhance their preparation for climate change and focuses on policy areas that will come under increasing pressure as the effects of climate change intensify. We highlight gaps in Canadian policy and provide recommendations and international best practices that might inform Canadian policy.

4.1 Enhancing Adaptive Capacity

In section 4.1 we identify social policies – government actions aimed at protecting and improving the well-being of citizens – that enhance adaptive capacity and serve to reduce the vulnerability of human settlements and industry to the impacts of climate change *before* those impacts are fully felt.

4.1.1 Hazard and Vulnerability Assessments

Comprehensive hazard and vulnerability assessments provide policy makers with the information they need to identify options for reducing the risks and hazards associated with climate change. Hazard and vulnerability assessments are necessary in order to develop and implement effective strategies to protect and improve the well-being of Canadians and to enhance our collective adaptive capacity.

- **Mandated hazard assessments:** Some provincial governments have legislation in place that requires local governments to conduct hazard assessments as part of their emergency planning. Quebec's *Civil Protection Act*, which requires that citizens be made aware of potential risks and mandates communities to incorporate hazard assessments into their emergency plans, is an example of such legislation. Ontario's *Emergency Readiness Act* is another example. Ontario's legislation requires each municipality to create an emergency management program that includes hazard assessments, emergency plans, training, and exercises (McBean and Henstra, 2003).

- **Wildfire hazard assessments:** In response to specific threats, such as wildland-urban interface fire hazards, many communities have incorporated hazard-specific assessments into their practices. For example, the City of Calgary is utilizing Wildfire Hazard Assessments to ascertain the wildland-urban interface fire hazard associated with new development and to identify the need for mitigative actions. Such assessments are guided by the *FireSmart: Protecting Your Community* manual, developed by Partners in Protection, an Alberta-based coalition of professionals representing federal, provincial and

municipal agencies. There are two main components of the *FireSmart* assessment: the *Structure and Site Hazard Assessment Form*, which examines the building and the areas within 30 metres of the building, and the *Area Hazard Assessment Form*, which examines the environment farther than 30 metres from the building for factors that could lead to fire activity. Cumulative points are measured against a table provided by *FireSmart* to determine if the level of risk for both the development and the surrounding area is low, moderate, high, or extreme (Vicars, 2003; McFadden, 2005).

- **Participatory-integrated assessment processes:** A pilot project in the Okanagan Basin region of British Columbia utilized a participatory integrated assessment process to examine water management issues, including water-smart community plans and agricultural water use policies. The participatory integrated assessment was used "to expand the dialogue on implications of adaptation choices for water management to include domestic and agricultural uses and in-stream conservation flows" (Cohen and Neale, 2006).

- **Assessments of community infrastructure vulnerability:** The Environmental Health Research Division of the First Nations and Inuit Health Branch of Health Canada manages a community-based research program designed to enable Inuit and Northern First Nation communities to identify and assess key vulnerabilities and potential health impacts related to climate change.

- **Assessing the vulnerability of government services:** The United Kingdom's Department for Work and Pensions (DWP) has commissioned the Meteorological Office to review the impacts of climate change on its policies and operations. In collaboration with the Department for Environment, Food and Rural Affairs (DEFRA) and the Department of Health, DWP is actively studying the effects of climate change on vulnerable groups (e.g. low-income groups, children, disabled people, and pensioners) and how extreme weather events may influence the need for crisis loans. The DWP is also considering how climate change may impact its operations (e.g. ensuring services, such as Job Centre Plus, can continue to reach customers during an extreme weather event). DWP's priority areas include examining how past extreme weather events have affected the need for crisis loans, assessing the needs of the most vulnerable groups and exploring what services they will likely require, and ensuring that the DWP Contingency and Resilience Plan addresses short- and long-term risks associated with climate change, including ensuring that essential services will continue to reach clients (U.K. Department for Environment, Food and Rural Affairs, 2009a).

Hazard and vulnerability assessments give policy makers the information to identify mechanisms for reducing the risks and hazards associated with climate change. A scan of hazard and vulnerability assessments points to several gaps in Canadian policy.

- **Not all provinces require hazard assessments:** While Quebec and Ontario have legislation in place that requires local governments to conduct hazard assessments as part of their emergency planning, other provinces lack similar legislation.

- **Tools for conducting hazard assessments are scarce:** Through the Disaster Resilient Communities initiative, British Columbia's Provincial Emergency Program (PEP) produced a comprehensive on-line "Hazard, Risk and Vulnerability Analysis Toolkit" to

assist local communities in increasing their resilience (Government of British Columbia, 2002; McBean and Henstra, 2003). Tools for conducting hazard assessments are available; however, municipalities often lack the resources to carry out in-depth assessments. Increasing the accessibility of toolkits would help local communities to identify their particular risks and reduce their vulnerability to climate change impacts.

- **Conducting hazard assessments is a complex process:** While there are a few hazard-assessment tools that can be found on-line (e.g. the Federation of Canadian Municipalities offers a list), the practice of risk-assessment is a complex one, and requires appropriate training, human resources and collaborative efforts across and between organizations.

- **Assessments of vulnerable agencies, utilities and infrastructure are critical:** Another recommendation is facilitating assessments of vulnerable agencies, utilities and infrastructure along the lines of the U.K's Department for Work and Pensions (DWP) study, as outlined above. Ensuring that all vital utilities and agencies have plans to address the impacts of climate change on their operations could play an important role in protecting the well-being of Canadians.

- **Municipalities often lack information on best practices for heat alert systems:** Our scan found that municipalities often lack information on best practices for heat alert systems. A review for the National Collaborating Centre for Environmental Health recommends against a national warning system, and suggests that Canada might benefit instead from implementing a national "clearinghouse" with guidelines to help local communities: (a) define a heat wave, (b) set up a heat health warning system, (c) identify potential health interventions, and (d) develop a collaborative evaluation framework to improve local systems over time (Bassil, Cole, Smoyer-Tomic et al., 2007). While several cities in Canada have developed comprehensive hot weather response plans (see *Section Six*: Social Policy Linkages with Heat Events), the majority of municipalities in Canada do not have heat alert plans, and lack the resources and knowledge to efficiently develop such plans.

4.1.2 Information, Knowledge Transfer and Decision-Support Tools

Improving access to information and increasing the tools for knowledge transfer and decision support assists human settlements and industry to reduce vulnerability to the risks associated with a changing climate. Education has long been considered a social policy.

- **Information provision on specific threats:** Recognizing that urban sprawl into forested and natural areas will increase the risk of wildland-urban interface fires, Partners in Protection, an Alberta-based coalition of professionals representing federal, provincial and municipal agencies, developed the *FireSmart: Protecting Your Community* manual. The *FireSmart* manual is intended to serve as a community wildland-urban interface planner, and provides communities and individuals with the appropriate tools to plan for, and mitigate, the risk of fire in interface areas.

- **Helplines and guidebooks for the public:** Many provinces have established helplines for flooding and fire victims. The U.K.'s Environmental Agency has established a "floodline" for residents and, in collaboration with the U.K. Health Protection Agency, has

developed guides for residents whose homes have been flooded that provide general advice on protecting against infection, as well as specific advice about returning to a flooded home, food preparation and storage, and drinking water (U.K. Environment Agency, 2007).

Public information dissemination – or in other words, programs and tools to provide information to the general population about how to adequately protect oneself and others from the impacts of climate change, as well as targeted information to groups and sectors that are particularly vulnerable – represents an essential element of increasing the adaptive capacity of Canadians. Our scan found that communities and individuals frequently lack critical information about potential impacts, the level of risk associated with each impact, and appropriate steps that may help minimize those risks and increase resilience. The following are specific areas in which improvements and expansions in public information dissemination might prove beneficial in reducing the vulnerability of Canadians:

- **Web-based communication portals:** The International Polar Year (IPY) EALÁT project, *Studying How Indigenous People Adapt to Climate Change in the Arctic*, is developing a web-based portal for communication of relevant information related to circumpolar reindeer husbandry. Reindeer husbandry is practised by indigenous peoples all across Eurasia and Alaska, and the IPY EALÁT project is documenting indigenous knowledge about snow conditions as well as their perceptions about adapting to a changing climate. Web-based portals such as this can be an effective means to share information and support decision-making (International Polar Foundation, 2008).

- **Sector-specific manuals and guidance documents**: Alberta's *FireSmart: Protecting Your Community* manual, referenced above, targets community planners. The United Kingdom's Department of Health, Public Health Association (UKPHA), Faculty of Public Health, and the Chartered Institute of Environmental Health (CIEH) collaborated to produce a guidance document, *The health impact of climate change: promoting sustainable communities*, which contains advice for public health professionals on what can be done to mitigate and adapt to climate change and promote sustainable communities (U.K. Department of Health, 2008).

- **Demonstration projects:** The European Regional Development fund is supporting the Clim-ATIC (*Climate Change – Adapting to The Impacts, by Communities in Northern Peripheral Regions*) project to implement adaptation demonstration projects, and establish mechanisms to share and disseminate knowledge for community adaptation. With a focus on trans-national activities, the project involves community stakeholders working in partnership with public sector and academic institutions from five regions of northern Europe (Clim-ATIC, 2007).

- **Targeted interventions and decision-support tools:** Concern persists as to whether response plans are reaching the most vulnerable groups, particularly the elderly, socially isolated and homeless. Passive information approaches such as leaflets and brochures are proving insufficient, and several countries are developing and assessing more active approaches such as buddy systems, home visits and daily phone calls (Bassil et al., 2007).

- **Geospatial decision support systems:** A better understanding of the distribution of vulnerable locations, and those who are most vulnerable, could help health care workers

more effectively deliver targeted resources. A 2008 report (Mersereau and Penney) generated by the Clean Air Partnership (CAP) details the potential for utilizing a geospatial decision support system (GDSS) to help local government decision makers address heat issues in the Greater Toronto Area (GTA). The report suggests that a GDSS tool utilizing geographical information system (GIS) mapping technology could assist municipalities and city planners to:

- Assess vulnerability to heat of both populations and places in the GTA;
- Examine the relationship between "hotspots" (locations where temperatures are consistently hotter) and other variables; and
- Develop heat-related communication materials for a variety of audiences (Mersereau and Penney, 2008).

Accessibility to information and awareness-building can be enhanced through active means of communication and knowledge-sharing. Many countries are developing approaches to take stakeholder involvement to another level as well as promote cooperation at the local level.

- **Workshops and pilots** are especially effective tools to spread knowledge and engage stakeholders. Our scan found international best practices in these areas in several projects. The German Federal Ministry for Education and Research's pilot project, *Acting in the Framework of Climate Change – Stakeholder-Oriented Risk-Communication Based on Insecure Knowledge*, is partnering with social science researchers to engage stakeholders from agriculture and tourism as well as urban and regional planning. Instruments for adaptation strategies are presented in a workshop format while researchers explore risk communication methods. Results from the pilot will inform research on learning effects, and results are discussed with an inter-regional expert team with the on-line communication tool (Cologne Institute for Economic Research, 2007).

- The project Arctic TRANSFORM (Transatlantic Policy Options for Supporting Adaptations in the Marine Arctic), led by European Union (EU) and US experts, is organizing stakeholder-based workshops to assess the potential impacts and viability of different policy options. The project team brings extensive networks and expertise in Arctic natural sciences, international law, and marine and Arctic policy. It will present policy recommendations through an international conference in Brussels, Belgium, and through published reports, which will be disseminated via the project web site and to decision makers on both sides of the Atlantic (Institute for International and European Environmental Policy, 2007).

- **Establishment of interdisciplinary and inter-agency working groups:** Establishing interdisciplinary working groups to address the impacts of climate change is an important means of building resilience through increased knowledge sharing. One example of such a working group is Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). CSIRO has developed a working group called Adaptive Primary Industries, Enterprises and Communities to lead research and work with community, government and industry stakeholders to enable agriculture, fisheries, forestry, and other primary industries to prepare for and adapt to the effects of climate change and ongoing climate variability. These and other CSIRO scientists are identifying and publishing potential adaptation strategies that will help reduce the effects of climate change on the agricultural sector (CSIRO, 2009c).

- **Social networks and community-level cohesion:** Social networks are essential to maintain health and well-being, and minimize social isolation. A report from Stockholm recommended that officials enhance "social cohesion and community capacity" through the support of the Local Strategic Partnership, which "brings together voluntary and statutory agencies with the express purpose of strengthening local communities, contributing to social and economic development, and dealing with environmental problems including climate change" (Haq, Whitelegg, Kohler, 2008).

In January 2009, the United Kingdom's Department for Environment, Food and Rural Affairs (DEFRA) announced a new National Flood Forecasting Centre to improve response to flooding, which includes funding to local authorities to coordinate and lead flood management locally with the intent of facilitating better communication with residents, financial support for local homeowners to climate-proof their homes against floods, and funding for improved water rescue and trained personnel. Measures outlined by DEFRA include: 1) £15 million to help local authorities coordinate and lead flood management locally so that residents know who is in charge in the event of flooding; and 2) up to £1.25 million funding for Local Resilience Forums to prepare emergency plans in case of reservoir dam failure.

4.1.3 Risk Mitigation

Mitigating specific risks is essential in order to enhance the adaptive capacity of human settlements and industry. The examples we provide below substitute government risk assessment for what would likely be myopic individual behaviour were the government not to intervene.

- **Flood protection for homeowners**: After three extreme rainstorms in the summer of 2007 that resulted in severe flooding, the City of Saskatoon developed a Flood Protection Program, which provides up to $2,500 to homeowners to upgrade plumbing to the latest (January 2004) standard in affected homes. The aim is to decrease the risk of future flooding and the resulting damage. The Flood Protection Program does not involve an application process and homeowners who notified the City of sewer back-up as a result of the 2007 storms are eligible for the program (City of Saskatoon, 2007).

- **Flood management plans**: The community of Delta in Metropolitan Vancouver, located in the Fraser River delta, has a Climate Change Initiative that includes a Flood Management Plan, which focuses on reducing the risks associated with climate-induced flooding. Delta's Flood Management Plan includes berm construction, seawall/dyke inspections, developing a "made-for-Delta" storm surge model, and introducing a Floodplain bylaw to guide future development. Delta's Climate Change Initiative also includes an Infrastructure Improvement Plan, which focuses in part on using more permeable surfaces and infiltration swales (Corporation of Delta, 2008a).

- **Incorporating risk analysis into new development projects:** Municipalities applying for funding under the Canadian Strategic Infrastructure Fund are required to demonstrate how their projects address climate change impacts and adaptation, and most projects require an environmental assessment. For example, the Red River floodway expansion in Manitoba needed to demonstrate that it would not only provide the City of Winnipeg with one-in-700-year protection from spring floods, but that it would also address projected

increases in the intensity and frequency of storm events. Both the Confederation Bridge to Prince Edward Island and the Vancouver Convention Centre Expansion Project had to address the impact of rising sea levels during the environmental assessment of each project (Infrastructure Canada, 2006).

- **Comprehensive approach to increasing sectoral adaptive capacity**: Australia's government has identified challenges for its agri-food industries and developed a suite of measures to adapt to climate change under its Farming Future initiative. Measures include funding, which is directed at industry, farming and natural resource management groups, to boost training opportunities and programs to develop strategies to address climate change; a Climate Change Adjustment Program to provide assistance through targeted training on whole farm planning, business and risk management, and sustainable practices; and $46.2 million for Climate Change Research, to fund on-farm demonstration pilots that reduce greenhouse emissions, enhance soil management, and develop new adaptation technologies and techniques. The government is also providing drought relief assistance in the form of transitional income support to provide short-term support to farm families in financial difficulty (Australian Department of Climate Change, 2008).

Mitigating specific risks is essential in order to enhance the adaptive capacity of human settlements and industry. This is a vital area that requires an in-depth gap analysis. Our initial scan has indicated that not all jurisdictions have risk assessments and risk mitigation policies or programs for each of the hazards identified in *Sections One* and *Three*.

4.1.4 Land-Use Planning

Land-use planning is essential for both reducing the vulnerability and enhancing the adaptive capacity of human settlements and industry. Because of such factors as disability, income level and lack of knowledge and awareness, people do not always have the choice to protect themselves from the impacts of climate change (e.g. people being unaware that they reside in a floodplain or being unable to afford a home anywhere other than in a floodplain). Effective land-use planning is intended to protect and improve the well-being of Canadians.

- **Considering impacts of climate change in planning decisions**: The Canadian Institute of Planners has developed a climate change policy to ensure members consider the impacts of climate change in their planning decisions, minimize risks, protect natural resources, ensure no adverse public health effects, build resilience into communities, and utilize adaptation techniques (Canadian Institute of Planners, 2008). Manitoba has incorporated provisions for climate change adaptation in its Provincial Land-Use Planning Policies (Cunningham, 2008). Alberta's Land-use Framework takes a cumulative effects approach to managing the impacts of development on water, identifying the appropriate thresholds for each region and sub-region. Land-use planning and decision making must operate within the defined thresholds (Government of Alberta, 2009).

- **Restricting development in high-risk areas**: Communities like Langford, B.C., have put regulations in place to restrict development in high-risk areas. In Langford's case, development is restricted in high and extreme wildfire-hazard risk areas to minimize the risk associated with the wildland-urban interface. Langford has also put in place special

taxation rates for those living in areas that require extensive maintenance to reduce the risk of wildfire at the wildland-urban interface (City of Langford, 1996; McFadden, 2005).

- **Stringent requirements on new developments**: The Canmore, Alberta., Municipal Development Plan requires that all new development applications located within the wildland-urban interface submit both a Wildfire Risk Assessment Plan and a Wildfire Risk Management Plan. In Canmore, all new development plans in the wildland-urban interface area have their risk management plans approved by the fire chief (McFadden, 2005).

- **Coastal protection plans**: In an effort to limit exposure to the hazards related to sea level rise, New Brunswick's Coastal Areas Protection Policy provides a framework for coastal zone management and adaptation measures, including a setback limit on new development and construction.

- **Relocating coastal communities**: In Alaska, an Immediate Action Workgroup, with both state and federal representatives, was established in 2007 as part of Alaska's Climate Change Sub-Cabinet to identify short-term emergency steps to prevent loss of life and property due to climate change in the communities that must relocate, and to develop long-term strategies to support coastal Alaskan communities. The Workgroup issued recommendations that include erosion control, community evacuation plans and the creation of one state agency to lead the relocation effort and act as the coordinating agency with responsibility for maintaining federal, state and tribal partnerships. An immediate step that has been identified is the funding and coordination of the relocation of six coastal communities (Bronen, 2008).

Land-use planning is essential to reduce the vulnerability of Canadians and enhance the adaptive capacity of human settlements and industry. Our scan identified the following gaps in this area:

- Land-use planning guidelines that accommodate current and projected changes in climate, including:
    - **Coastal protection**: Prince Edward Island, Newfoundland and Labrador, and Nova Scotia currently have no coastal protection policies (with the exception of Nova Scotia's *Beaches Act*) (Hassol, 2004; Lemmen, Warren, Lacroix, 2008).
    - **Wildland-urban interface fires**: Most communities at risk of wildland-urban interface fires are less well prepared than Canmore, Alberta., which ensures that risk management plans are incorporated into development application processes, and that stringent analyses of those plans are carried out by fire experts (McFadden, 2005).

- **Comprehensive rollback programs:** In some areas, coastal erosion and permafrost melt are necessitating the relocation of human settlements and industries. In direct response to sea level rise and coastal erosion, communities like Tuktoyaktuk, N.W.T., have removed buildings that were located near the shoreline (Northwest Territories Environment and Natural Resources, 2008). A comprehensive rollback program, above and beyond rollback of infrastructure, is under development in the United Kingdom. In the past decade, Coastal Management Policy in England has been revised and is driven by two key programs, Foresight and Making Space for Water. An element of these programs is exploring retreat and restoration of coastal ecosystems in lieu of hardening shorelines through additional armouring or dyke construction (O'Riordan, Watkinson, Milligan, 2006; U.K. DEFRA,

2009c). In North America, Alaska's Immediate Action Workgroup provides an example of the challenges that policy makers face with this complex issue and possible response, such as funding and coordination of the relocation of coastal communities (Bronen, 2008).

4.1.5 Standards, Codes and Practices

Standards, codes and practices are important mechanisms for enhancing the adaptive capacity of human settlements and industry.

- **Reconceptualizing design standards:** The Northwest Territories recognizes that "there is a need for industry-standard design guidelines for buildings and foundations to allow for anticipated changes over the next 50 or more years. New standards will very likely increase construction cost; for example, higher performance foundation systems, suitable for less stable soils, could add $20,000 to the cost of a new home." The Northwest Territories Housing Corporation has repaired and replaced pile foundations affected by ground movement or water accumulation. As well, foundation systems that distribute weight and absorb the stress imposed by ground movement are now standard in new construction projects in the Northwest Territories. These foundation systems include piles of larger diameter and deeper installation, and the application of increased bond-breaking material to the portion of the pile within the permafrost layer to help prevent frozen soil from gripping the pile and pulling it upward (N.W.T. Environment and Natural Resources, 2008).

- **Building codes requiring water efficiency:** British Columbia's new building code has water efficiency requirements with the aim of reducing the environmental footprint of buildings. Specifically, the new code, effective September 5, 2008, requires that ultra low-flow toilets (six litres) and other water-efficient plumbing fixtures and fittings be used in all new construction and renovations. The new requirements apply to all building permit applications throughout the province (British Columbia Office of Housing and Construction Standards, 2007).

- **Bylaws requiring water efficiency:** Communities like Cochrane, Alberta., Lumby, B.C., Keremeos, B.C., Kelowna, B.C., and B.C.'s North Okanagan and Sunshine Coast Regional Districts have bylaws requiring new construction to use low-flow devices (Canadian Water and Wastewater Association, 2008).

- **Comprehensive design solutions:** The city of Chicago, Ill., is exploring "distributed solutions" and reducing "impervious areas" whenever possible through pilot projects, which complement Chicago's Green Urban Design (GUD) program. Distributed solutions include enhancing downspout disconnections, rain barrels, permeable paving solutions, required rear yard open space, allowing use of perforated plastic pipes for underground drainage, and developing green roof specifications (Parzen, 2008).

Design standards and building codes and practices are important mechanisms for enhancing the adaptive capacity and well-being of Canadians. Our scan identified many gaps in this area, in particular a lack of building codes and industry-standard design guidelines designed to accommodate current and projected changes in climate:

- **Design guidelines for melting permafrost:** Although new standards will likely increase construction costs, there is a need for industry-standard design guidelines for buildings and foundations to allow for anticipated changes over the next 50 or more years (N.W.T. Environment and Natural Resources, 2008).

- **Passive cooling standards and codes:** Cities such as Toronto have implemented codes, standards and innovative programs that include incentives to increase public uptake of passive cooling technologies, yet few other jurisdictions have policies of this kind that promote passive cooling (see *Section Six*).

- **Building codes:** While some municipalities have introduced energy and water conservation criteria into their building codes, most have not. Better-insulated buildings can reduce both heating and air-conditioning costs to less than half of prevailing norms (with the co-benefit of lowering GHG emissions). Even without air conditioning, such buildings provide some protection against extreme heat events. British Columbia's new building code is one example that could be followed to increase water efficiency in residential and office buildings. In many provinces, municipalities are restricted in their ability to regulate development. For example, in Alberta, municipalities can require that specific construction materials be used under their land-use bylaws; however, these municipalities are unable to ban the use of certain construction materials (e.g. wooden shake roofing – a risk in wildfires) as long as they meet the basic Alberta building safety codes (McFadden, 2005).

- **Water efficiency bylaws:** Municipal bylaws that require water-saving devices are a useful tool for addressing projected water scarcity issues driven by climate change, which may require us to question the tradition of "free water" and consider volumetric pricing, for instance – initially at low rates, but with expectation of escalation (Doberstein, 2007).

- **Water reuse and recycling:** Reusing and recycling water is an important strategy for addressing insufficient water supplies; however, this approach is not widely used in Canada due to a lack of regulations and guidelines. In fact, many local building codes currently discourage or prohibit grey water use (Thirlwell et al., 2007).

4.1.6 Training

Increased training for jobs that are less vulnerable to climate change is a critical component of enhancing adaptive capacity.

- **Training and jobs promotion:** Germany's Federal Ministry of Education and Research has launched a collaborative research program called High-Tech Strategy on Climate Protection to initiate the development of technologies and strategies for climate protection and adaptation. The program links climate protection with innovations that create jobs and ensure prosperity, and invites further investment and support from partners from business and industry (Climate Impact Research Coordination for a Larger Europe, 2008).

- **Training and green jobs promotion:** The US government has passed legislation providing funds for states to retrain dislocated workers in declining industries to prepare them to capitalize on the emerging green sector. The State of Washington has also passed a green collar jobs provision that specifically targets vulnerable populations for green workforce training. Target populations include low-income adults and youth in families under 200 percent of the federal poverty guidelines or a locally defined self-sufficiency standard; entry-level or incumbent workers in high-demand green industries who are in, or are preparing for, high-wage occupations; or dislocated workers in declining industries who can be retrained for high-wage occupations in high-demand green industries (Mijin Cha, 2006).

In terms of training, our scan identified the following gap:

- **Training strategies for jobs that are less susceptible to the impacts of climate change:** The promotion of industries and technologies that will sustain livelihoods in a changing climate is an important aspect of retraining. For instance, Germany's High-Tech Strategy on Climate Protection is a collaborative strategy on climate protection that explicitly addresses technologies for climate change adaptation, linking climate protection with innovations that create jobs and ensure prosperity, and invites investment from partners from business and industry. Canada would likely benefit from such an initiative.

4.1.7 Warning Systems

Speedy dissemination of essential information to those whose well-being is threatened by climate impacts helps to reduce the adverse effects of certain types of extreme events.

- **Public warning systems:** After the 1987 tornado in Edmonton that killed 27 people and injured hundreds, the Government of Alberta created a public warning system with the aim of providing critical public information and protecting life and personal safety. Alberta's Emergency Public Warning System allows local and provincial government officials to interrupt radio and television programming to broadcast warnings to citizens in the event of impending threats (including severe weather, flood, wildfire, hazardous material release, terrorist threat, and other threats to human life or safety) (Alberta

Emergency Management Agency, 2008; McBean and Henstra, 2003; Institute for Catastrophic Loss Reduction, 2009).

- **Increased surveillance and early warning systems:** Scientists have documented the damage from rain-on-snow (ROS) events on Arctic herds and permafrost temperatures. Research suggests that severe ROS events are increasing under climate change, and satellite imagery may provide much needed observational data on the actual frequency and spatial distribution of ROS events. Researchers from the University of Washington have used satellite imagery to analyze the particularly damaging 2003 ROS event on Banks Island in the Canadian Arctic archipelago that resulted in the death of approximately 20,000 musk oxen. The utilization of satellite imagery is emerging as a tool to help local inhabitants adapt and develop early warning systems in relation to critical food sources such as musk oxen and caribou (Grenfell and Putkonen, 2008).

- **Prediction tools and early warning systems:** The development of a "prediction tool" is being funded by the EU to assist planners in hazard analysis in low-lying and densely populated coastal regions that are vulnerable to impacts of sea level rise such as higher storm surges, flooding and erosion. The tool is a product of the CLASH research project. It monitors waves overtopping at coastal structures and provides data on "allowable overtopping discharges" to estimate the risk to people and infrastructure in the vicinity of coastal structures (Bouma, 2006).

Ensuring that essential information is effectively disseminated to those whose well-being is threatened is critical to protecting the health and safety of Canadians and reducing the adverse effects of the changing climate. Our scan identified the following gap in this area:

- **Public warning systems and long-term monitoring systems that integrate new threats arising out of climate change:** The changing climate highlights the need to integrate new threats into public warning systems. Some jurisdictions are developing alert systems that address the increasing threat of heat waves, air quality issues and infectious disease. For example, Quebec's Ministère de la Santé et des Services sociaux has begun developing a warning and monitoring system to deal with the rise of climate-driven infectious diseases that will result from extended ranges of many disease vectors (e.g. mosquitoes, ticks and rodents) and thus increase human exposure. Quebec's system is expected to be operational by 2013 Walker and Sydneysmith, 2008; Bourque and Simonet, 2008; Chiotti and Lavender, 2008; Développement durable, Environnement et Parcs Québec, 2008a). Initiatives of this kind will prove useful across Canada, especially in the south, as diseases travel north from warmer climates.

4.2 Responding to Adverse Events

In this section we highlight key examples of programs that respond to adverse events by accommodating the impact of climate change *after* they have already occurred – rather than acting as long-term adaptive strategies.

4.2.1 Disaster Assistance and Emergency Response

Climate change will increase the number of those who experience dramatic climate-induced losses. Once adverse impacts occur, disaster assistance and emergency services come into play.

- **Disaster financial assistance and emergency social services:** All provinces and territories – with the exception of Nunavut – provide disaster financial assistance to cope with the cost of repairs and recovery from uninsurable disaster-related property damage.

  Some provinces, such as Saskatchewan, provide essential social services to assist those affected by disasters. When the Saskatchewan Emergency Management Operations department declares an emergency under *The Emergency Planning Act*, the Ministry of Social Services is required to deliver essential social services, including transportation, clothing, food, lodging, and psycho-social support.

  Others, such as British Columbia, mandate municipalities to provide emergency social services to those affected by disasters. B.C. municipalities and regional districts are expected to "coordinate the provision of food, clothing, shelter, transportation, and medical services to victims of emergencies and disasters" (Government of British Columbia, 1995).

  Finally, provinces such as Ontario partner with agencies like the Red Cross and the Salvation Army to deliver emergency social services to those affected by disaster (B.C. Provincial Emergency Program, 2007; B.C. Emergency Social Services, 2007; Government of B.C., 1995; Alberta Emergency Management Agency, 2008; Saskatchewan Corrections, Public Safety and Policing, 2007; Saskatchewan Social Services, 2007; Manitoba Emergency Measures Organization, 2009; Manitoba Family Services and Housing, 2009; Ontario Municipal Affairs and Housing, 2008; Ontario Community and Social Services; 2008; Sécurité publique Québec, 2007; Newfoundland and Labrador Emergency Measures Organization, 2008; New Brunswick Emergency Measures Organization, 2009; Nova Scotia Emergency Management Office, 2008; Prince Edward Island Communities, Cultural Affairs and Labour, 2007; Nunavut Community and Government Services, 2008; Legislative Assembly of Nunavut, 2008; Northwest Territories Municipal and Community Affairs, 2008; Yukon Community Services, 2008).

- **Emergency response management systems:** The B.C. Emergency Response Management System provides the framework (e.g. standardizes processes for multi-jurisdictional/multi-agency response and guides emergency plan development) for a standardized emergency response in B.C. as well as financial claims support to communities, businesses and homeowners (Walker and Sydneysmith, 2008).

Once adverse impacts occur and affect Canadians, disaster assistance and emergency services are needed to protect and improve the well-being of Canadians. Our scan identified the following gaps in this area:

- **Expanded and improved emergency response management systems**: Jurisdictions throughout Canada have emergency response management systems, but many current systems are not adequate to address the increased frequency and intensity of extreme

weather events and natural hazards (e.g. wildfires, flooding, drought) predicted under climate change scenarios.

- **Increased severity and frequency of extreme weather events considered in disaster assistance**: All provinces and territories, with the exception of Nunavut, have disaster financial assistance to help those affected by disasters cope with the cost of repairs and recovery from uninsurable disaster-related property damage. No jurisdictions are yet taking into consideration the increased severity and frequency of extreme weather events that will likely result from climate change.

- **Enhanced emergency social services to ensure those adversely affected by climate impacts have their immediate needs met:** Extreme weather events can result in people being dislocated from their homes and communities. Those who are dislocated are often forced to temporarily reside in crowded shelters, which increase the risk of disease outbreak. The stress caused by such events can have a range of mental health effects, including depression.

  As stated above, some provinces, such as Saskatchewan, provide essential social services to assist those affected by disasters. Other provinces, such as B.C., mandate municipalities to provide emergency social services to those affected by disaster. Provinces such as Ontario partner work with agencies like the Red Cross and the Salvation Army to deliver emergency social services to those affected by disaster, but do not have their own comprehensive plan.

  Thus not all jurisdictions have coordinated emergency social services policies and procedures in the event of climate impacts (B.C. Provincial Emergency Program, 2007; B.C. Emergency Social Services, 2007; Government of B.C., 1995; Alta. Emergency Management Agency, 2008; Sask. Corrections, Public Safety and Policing, 2007; Sask. Social Services, 2007; Man. Emergency Measures Organization, 2009; Man. Family Services and Housing, 2009; Ont. Municipal Affairs and Housing, 2008; Ont. Community and Social Services, 2008; Sécurité publique Québec, 2007; Nfld. and Lbdr. Emergency Measures Organization, 2008; N.B. Emergency Measures Organization, 2009; N.S. Emergency Management Office, 2008; P.E.I. Communities, Cultural Affairs and Labour, 2007; Nunavut Community and Government Services, 2008; Legislative Assembly of Nunavut, 2008; N.W.T. Municipal and Community Affairs, 2008; Yukon Community Services, 2008).

4.2.2 Safety-Net Programs

Existing social programs can help to cushion losses caused by a changing climate.

- **Employment Insurance**: Canada's Employment Insurance provides temporary financial assistance to unemployed Canadians while they seek work or upgrade skills (Service Canada, 2008).

- **Drought-targeted safety-net programs**: Programs like crop insurance, the Rural Water Development Program, the National Water Supply Expansion Program, the Net Income Stabilization Account, the Canadian Agricultural Income Stabilization Program, the Canadian Farm Income Program, the Agricultural Income Disaster Assistance Program,

and the tax deferral program are all intended to offset negative socio-economic impacts of low agricultural incomes, whether arising from terms of trade effects, drought or other causes (Sauchyn and Kulshreshtha, 2008).

Some existing safety-net programs will help to cushion the blow of climate change impacts. However, to our knowledge, no Canadian programs have explicitly addressed the difference in impacts of climate change regionally, by occupation, by age, and so on. Some, such as Employment Insurance (EI), are *de facto* a social policy for short-term job losses resulting from climate change. EI can therefore be seen as a short-term safety net for job losses resulting from climate change; however, the long-term implications of climate changes are likely to create pressures that will require further consideration.

As referenced above, vulnerability assessments of agencies that provide a safety net through social assistance programs, such as the U.K.'s Department for Work and Pensions (DWP), are recommended. The U.K. DWP undertook an assessment of the potential environmental impacts on its operations. The DWP provides services for children, people of working age, current and future pensioners, disabled people and their careers, and disadvantaged and vulnerable members of society. The impacts identified in the DWP assessment were wide-ranging:

- Whether there is a need for the thresholds for cold weather payments to be re-examined and whether a cooling-related hot weather payment may need to be considered;
- The impact of extreme regional weather – and the potential increase in people failing to take out adequate insurance coverage – on the demand for crisis loans;
- The disproportionate impact of climate change on the vulnerable who make up a large part of the DWP's clients;
- The long-term impact on demographics that impacts the provision of support to tomorrow's pensioners;
- Possible disruption to office efficiency during heat or other extreme events;
- Whether local and national business continuity plans are sufficiently robust to accommodate the impact of more frequent extreme weather events; and
- Potential disruption to information technology (IT) and other office services as a result of energy suppliers not being able to meet peak demands for cooling (U.K. Dept. for Work and Pensions, 2008).

4.2.3 Retraining

Retraining can help to offset loss of employment occurring as a result of climate change. It is a crucial factor in facilitating smooth transitions between sectors during downturns that result from external shocks such as the impacts of climate change, and is an important element of social policy aimed at protecting and improving the well-being of Canadians.

- **Retraining and skills development:** Service Canada delivers Skills Development and Employment Benefits and Support Measures programs in Newfoundland and Labrador, Nova Scotia, Prince Edward Island, B.C., and Yukon. New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, the Northwest Territories, and Nunavut deliver similar employment programs. Specific examples include Ontario's Second Career program, which targets laid-off Ontarians, and B.C.'s Transitional Assistance Program, Tuition Assistance Program and Job Opportunities Program, all aimed at the forestry sector

(Human Resources and Skills Development Canada, 2008a; Ontario Ministry of Training, Colleges and Universities, 2008; B.C. Community Trust, 2007a; B.C. Community Trust, 2007b).

Retraining helps to mitigate the loss of employment as a result of the effects of climate change and is an important element of protecting and improving the well-being of Canadians. Our scan identified the following gap in this area:

- **Enhanced training and re-qualification programs at all stages of adjustment:** The existing programs in Canada (referenced above) are already providing training initiatives and could serve as a platform for additional, much-needed retraining programs that address job losses in industries impacted by climate change.

4.2.4 Lowering Impacts on Stressed Communities

In order to protect and improve the well-being of Canadians, some efforts are already being made to lower the impact on communities that are particularly stressed as a result of climate change.

- **Resource management to mitigate impacts:** Alberta and Saskatchewan have engaged in aggressive action against the pine beetle including aerial surveys, ground patrols and rapid-response teams to immediately cut and burn infected areas as well as up to 75 metres around infected areas (Hume, 2005).

  British Columbia's 2006-2011 Mountain Pine Beetle Action Plan aims to mitigate the impacts of the mountain pine beetle epidemic on communities and the economy, and ensure long-term sustainability. Some of the key objectives of the plan include supporting short- and long-term economic sustainability for communities; protecting workers; public health and safety; recovering value from dead timber; and conserving long-term forest values (Government of B.C., 2006).

  British Columbia's Forests for Tomorrow plan, managed by the Ministry of Forests and Range with input from the Ministry of Environment and the Ministry of Agriculture and Lands, is a reforestation program that seeks to improve the future timber supply and address risks to other forest values, including catastrophic wildfires and the pine beetle epidemic (B.C. Ministry of Forests and Range, 2007).

- **Transportation infrastructure adjustments:** The shortened winter road season disrupts the delivery of essential goods and services to remote regions of the Northwest Territories. As a result, agencies such as the Northwest Territories Housing Corporation have sped up the contract-awarding process to ensure that supply vendors have extra time to assemble materials, adjust load movement schedules and prepare for the possibility of reduced weight limits on roads. Additional responses include utilizing ice spray and radar technologies, and the Northwest Territories Department of Transportation is constructing bridges at stream crossings along the Mackenzie Valley Winter Road to reduce road-building times and reduce the negative impacts of early spring melt on stream crossings (Northwest Territories Environment and Natural Resources, 2008).

- **Prairie Farm Rehabilitation Administration:** The Prairie Farm Rehabilitation Administration (PFRA) was established in the 1930s to address the devastating impacts of

the Great Depression. The PFRA focuses on "developing and promoting [in Manitoba, Saskatchewan and Alberta] systems of farm practice, tree culture, water supply, land utilization, and land settlement that will afford greater economic security."
More recently, PFRA is utilizing new technologies such as the application of Geographic Information Systems (GIS), integrated resource planning and agro-climate information to respond to droughts (Agriculture and Agri-Food Canada, 2009).

To our knowledge, many communities and regions do not have comprehensive approaches to lower the impact of climate change on stressed communities or to embrace opportunities that may arise as a result of climate change. While the PFRA, B.C. Mountain Pine Beetle Action Plan and Forests for Tomorrow are examples of government action to lower the impact on stressed communities, a key gap we identified in this area is:

- **Positioning for long-term growth and competitive advantage:** New Zealand's Sustainable Land Management and Climate Change Plan of Action is based on three pillars: adaptation; reducing emissions and enhancing carbon sinks; and business opportunities. In consultation with industry, the government developed specific climate change policies to position the agricultural and forestry sectors for long-term economic growth and competitive advantage. An Emissions Trading Scheme (ETS) will cover all greenhouse gases by 2013, while a five-year Adaptation Programme will help the industry build up new skills and infrastructure to respond to climate change impacts (New Zealand Ministry of Agriculture and Forestry, 2007).

Section Five: Social Policy Linkages with Health and Safety

5.1 Health and Safety: Existing Policies and Programs

The impacts of climate change will directly affect the health and safety of individuals and communities. Below are examples of policies and programs to lessen these impacts and enhance the adaptive capacity of individuals and communities:

- **Building heat resilient individuals and communities:** In 2007, Health Canada initiated Building Heat Resilient Individuals and Communities in Canada, a multi-year collaborative project to reduce risks to the health of Canadians in specific vulnerable populations. Health Canada, along with provincial and municipal partners, is developing guidelines for heat and response systems on how to best anticipate and advise patients/clients, recognize/diagnose and treat symptoms occurring as a consequence of extreme heat events, as well as providing guidelines for health care workers regarding extreme weather events (see *Section Six* for more details) (Séguin, 2008).

- **Coordinating decision-making structures to facilitate planning and response activities:** Health Canada reports that "the creation of the Public Health Agency of Canada (PHAC), the National Framework for Health Emergency Management and the Voluntary Sector Framework for Health Emergencies has enhanced adaptive capacity by providing needed coordinating structures to facilitate emergency planning and response activities within and outside of government" (see *Section Six* for more details) (Séguin, 2008).

- **Developing hot weather action plans:** Toronto's Hot Weather Response Plan has been cited as an outstanding example of municipal adaptation to changing climate, and is considered one of the more developed and effective responses to extreme heat in the world. The plan involves more than 800 partner agencies and outlines strategic considerations, communications and notification procedures as well as the roles and responsibilities of supporting city services, agencies and organizations (see *Section Six* for more details) (Lemmen and Warren, 2004; Chiotti and Lavender, 2008).

- **Canada-wide standards for particulate matter and ozone:** In 2000, all federal, provincial and territorial governments,except Quebec, agreed on Canada-wide standards for particulate matter and ozone (see *Section Six* for more details) (Séguin, 2008).

- In 2007, the Government of Canada released *its Turning the Corner Action Plan to Reduce Greenhouse Gases and Air Pollution*, which committed to reduce greenhouse gas emissions by 20 percent by 2020 and 60 to 70 percent by 2050. To complement the plan, the government also invested $85.9 million in adaptation initiatives to enhance the scientific knowledge and tools needed to take further action against climate change and reduce the risks to Canadians.

- In 2007, Environment Canada and Health Canada began the implementation of the new Air Quality Health Index (AQHI) in various locations across Canada (Mersereau, 2007), which provides health messages directed at high-risk populations as well as the general population. The federal government has committed to outreach efforts, including working

with provincial partners to communicate the AQHI to the public through various media and by developing a toolkit for partners at all levels of government and non-government. The toolkit provides details on the health impacts of air pollution, information on how health professionals can interpret and explain the AQHI to patients, and actions that reduce exposure to air pollution (see *Section Six* for more details).

- **Occupational health and safety in the fishing industry:** Rising sea levels and increased storminess threaten the safety of fishers. Under the Fishing Industry Renewal Strategy, the Government of Newfoundland and Labrador has invested $750,000 over three years for Occupational Health and Safety Initiatives in the fishing industry, and is pursuing the establishment of the Fishing Industry Safety Council to engage in research, education and training (Government of Newfoundland and Labrador, 2007a).

- **Monitoring systems for climate-driven diseases:** Quebec's Ministère de la Santé et des Services sociaux has begun developing a warning and monitoring system to deal with the rise of climate-driven infectious diseases. The system is expected to be operational by 2013 (Développment durable, Environnement et Parcs Québec, 2008).

- **Monitoring systems for climate-driven diseases:** The EU project, Emerging Diseases in a Changing European Environment (EDEN), is mapping ecosystems and environmental conditions that influence the spatial and temporal distribution and dynamics of human pathogenic agents, and coordinating the development of monitoring tools, predictive models, and early warning systems. These tools and skills are intended to inform health policies and support decision makers undertaking risk assessment and intervention activities (European Commission, 2007b).

- **New disease surveillance technologies:** Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is developing new early warning surveillance technologies to deliver real-time alerts and information to health care workers. Early warning health surveillance tools and technologies use sophisticated statistical modelling, forecasting techniques, data mining, modelling, and control charting techniques to analyze complex health data in close to real-time speed (CSIRO, 2009b).

- **Surveillance, monitoring and communication for vulnerable groups:**
    - In Italy, the Department of Epidemiology Health Authority and local health authorities identify vulnerable population subgroups by using surveillance systems that consider risk factors such as socio-demographic characteristics and medical conditions (Matthies et al., 2007);
    - France has set up a system for real-time surveillance of health data, city-scale censuses of the isolated and vulnerable, visits when necessary, air conditioning for hospitals and retirement homes, and the drawing up of emergency plans for retirement homes (Tan, 2008);
    - In Catalonia, Spain, town officials are using a software program to prepare a census of groups at risk during a heat wave, and record cooling centres and means of transport for at-risk people to these centres (Matthies et al., 2007);
    - England's National Heat Wave plan is complemented by information targeted at health care and childcare professionals. It includes a guide that offers advice on caring for people most at risk during a heat wave and on organizing those who

provide care, including social workers and home-care providers (U.K. Department of Health, 2008). Another document provides advice for teachers, school nurses, parents, assistants, and others looking after children in schools, nurseries and childcare centres. England's recently updated contingency plan for heat waves also calls for residential and nursing homes to create "cool rooms" able to maintain temperatures below 26°C (U.K. Department of Health, 2008).

- Philadelphia's comprehensive heat response plan involves over 6,000 groups and individual volunteers who are identified prior to the summer and provided with information regarding the warning signs of heat stress, identifying the most vulnerable persons, and treatment recommendations according to level of severity (see *Section Six* for more details) (Sheridan, 2006).

- **Satellite sensors to predict disease outbreaks:** Scholars from the US National Oceanic and Atmospheric Administration (NOAA) Oceans and Human Health Initiative (OHHI) are pioneering the use of satellite sensors to predict cholera outbreaks. Utilizing ocean observation sensors to measure chlorophyll, sea surface temperature, rainfall, and ground temperature, scientists are able to predict when and where cholera is likely to occur and develop responses to reduce the spread of cholera (US NOAA, 2009).

5.2 Recommendations and Canadian Policy Gaps

Our scan identified the following gaps in health and safety policy:

- **Occupational health and safety (OHS) rules that adequately ensure worker safety in the face of increasing extreme heat events:** As a result of climate change, Canada is expected to experience a steady increase in the number of +30°C days, and the frequency and intensity of heat waves is projected to increase as warming continues. Although most provinces include some measures to protect workers from extreme heat related to specific jobs, such as welding or mining, they do not all have measures to protect workers during extreme heat waves. Only B.C., Saskatchewan, Quebec, New Brunswick, and P.E.I. include measures in their OHS regulations that protect workers from heat stress based on the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (Séguin, 2008; Government of B.C., 2009b; Government of N.B., 1991; Government of P.E.I., 1987; Government of Sask., 1996).

- **OHS rules in relevant jurisdictions that address the safety of those working in the fishing industry in the face of rising sea levels and increased storminess and storm surges:** Increased storms, storm surges and sea level rise present exacerbated OHS concerns for fisheries. Fishing vessels will also need to travel farther from the coast to find suitable resources due to species displacement. These factors combine to place crews and ships at greater risk in the event of storm activity and increase the demand for search-and-rescue operations, as do federal regulations, which require vessels to be a specified length with no specific measurements for beam and height, resulting in top-heavy vessels susceptible to rollover in more extreme storms. In response to emerging climate impacts, Newfoundland and Labrador has taken steps in this regard by establishing the Fishing Industry Safety Council as part of its Fishing Industry Renewal Strategy (Vasseur and Catto, 2008; Government of Newfoundland and Labrador, 2007).

- **Revised risk factors associated with various professions:** As a result of climate change, Canada will experience increased windstorms, forest fires, storm surges, landslides, snowstorms, hail, and floods. These events will threaten the safety of workers in a broad range of sectors including power/energy utilities, transportation, forestry, emergency services, health care, tourism and recreation, which will require extensive revisions of historical understanding, assessment of and response to professional risk factors (Walker and Sydneysmith, 2008).

- **Emergency management plans that incorporate worker care:** The *London Climate Change Adaptation Strategy Draft Report* recognizes that extreme weather may affect those working in health and social services at a time when demand for such services is high. For instance, workers may be physically affected by an event or while responding to an event; workers may be required to stay at home to manage domestic issues; workers may be unable to get to work where transport systems are affected; and working conditions may be compromised (Government of B.C., 2002; Greater London Authority, 2008).

In 2008, Prince George, B.C., experienced significant flooding. During the course of the flooding, municipal workers monitored the river, ice flows, water surge, and flooding levels 24 hours a day in sub-zero temperatures. In response to the impacts of this event on emergency and municipal workers, the community of Prince George is now incorporating worker care into its Emergency Response Plan, an approach believed to be the first of its kind in terms of overall comprehensiveness.

- **Enhanced childcare regulations that include heat-stress provisions:** Infants and children are at particularly high risk during heat events due to specific metabolic factors, low perception of danger and the lack of capacity or resources to reduce their own exposure to heat. Children from low-income families are at further elevated risk during heat events if their housing lacks air conditioning or other means of reducing the impact of extreme heat (e.g. pools, sprinklers). Health Canada also reports that children suffer more psychological trauma as a result of natural hazards because they have lower coping capabilities; resulting effects can include loss of recently developed skills, eating and sleeping disorders, and behavioural issues.

  No province has specific requirements within their childcare regulations that protect children from enduring heat stress while in the childcare facility by ensuring utilization of measures such as air conditioning or other means of cooling. Only B.C. has provisions within their *Child Care Licensing Regulations* that require facilities to maintain sufficient, comfortable temperatures (Séguin, 2008; Government of Saskatchewan, 2001; Government of Alberta, 2008a; 2000; Government of Manitoba, 1999; 1986; Government of Quebec, 2006; Government of Newfoundland and Labrador, 2005, Government of Nova Scotia, 2007; Government of New Brunswick, 1983; Government of P.E.I., 2004; Government of B.C., 2001).

- **Enhanced long-term care facility regulations that include heat-stress provisions:** Seniors and the elderly tend to be less physically, financially and emotionally resilient to the effects of a changing climate. Medications commonly used by seniors may exacerbate the effects of extreme heat (Haq, Whitelegg, Kohler, 2008; Séguin, 2008), and medical expenses resulting from heat events can also have a significant economic impact on

uninsured, low-income seniors (Séguin, 2008). Health care facilities provide residency and health services to many seniors across Canada. However, legislation and regulations that govern such facilities – including Alberta's *Social Care Facilities Licensing Act*, Saskatchewan's *Health Facilities Licensing Regulations*, and Manitoba's *Residential Care Facilities Licensing Regulations* – do not include provisions to protect seniors from the effects of extreme heat by mandating temperature thresholds or cooling requirements in such facilities. England's recently updated contingency plan for heat waves calls for residential and nursing homes to create "cool rooms" that can maintain temperatures below 26°C (Séguin, 2008; Haq et al., 2008; Government of Alberta, 2008c; Government of Saskatchewan, 2008; Government of Manitoba, 1988; U.K. Department of Health, 2008).

- **Enhanced public health surveillance and preparedness that addresses the impacts of climate change, particularly on the most vulnerable, such as Aboriginal communities, and rural and remote communities:** The World Health Organization (WHO) states that "the restoration and improvement of general public health infrastructure will reduce population vulnerability to the health impacts of climate change" (WHO, 2009). Likewise, a study in B.C. recommends that "public health surveillance, emergency preparedness and research functions must be bolstered in order to take on a stronger leadership role in climate change and health adaptation policy development and implementation" (Ostroy, Ogborn, Takaro et al., 2008). The same study noted that climate change will aggravate existing health disparities and that public health's response to the impacts of climate change must be focused on rural and remote resource-dependent communities. Aboriginal communities in both rural areas and vulnerable urban neighbourhoods have the worst socio-economic and health profiles, and it would therefore be ideal if public health planning in this regard had a particular focus on these communities (WHO, 2009; Ostroy et al., 2008).

Section Six: Social Policy Linkages with Heat Events

This section provides a detailed scan of the literature on extreme heat events and responses related to social well-being in Canada and around the world.

We begin in Section 6.1 by outlining key threats of heat events and populations that are most vulnerable to these. In Section 6.2, we look at specific sectoral challenges driven by extreme heat. Section 6.3 outlines Canadian responses to these challenges to date. Section 6.4 illustrates actions and policies being developed by the international community. Finally, in Section 6.5, we include a brief summary of both Canadian and international recommendations for further research needed, and note policy areas that would benefit from further consideration.

6.1 Heat Events: Key Issues Limiting Adaptive Capacity

As a result of climate change, Canada is expected to experience a steady increase in the number of +30°C days, and the intensity of heat waves is projected to increase (Séguin and Clarke, 2008). For instance, research estimates that the number of days in south-central Canada with 3 p.m. temperatures of 30°C could more than double by 2050 and triple or quadruple by 2080; even larger increases have been estimated for other cities across the country by 2050 (Séguin, 2008). Heat waves are defined as periods of abnormally and uncomfortably hot temperatures lasting from several days to several weeks (Séguin and Clarke, 2008); however, research suggests that even short or moderate heat episodes can adversely affect human health (Koppe, Kovats, Jendritzky, et. al., 2003; Smoyer-Tomic, Kuhn and Hudson, 2003).

Heat events can lead to increases in:

- Illness and death;
- Pressure on health and emergency services;
- Demand for energy-intensive cooling (e.g. air conditioning) and increased risk of power system failures;
- Social inequality for those living in poorly designed and/or overcrowded buildings and who have limited resources to reduce or escape the heat;
- Demand for limited water resources, leading to increased shortages and stress on local ecosystems; and
- Damage to temperature-sensitive infrastructure (Greater London Authority, 2008).

A summary of key vulnerabilities follows:

Urban settlements: Heat events are associated with a diverse range of impacts on human settlements, in particular in large urban centres with high population densities that create the urban heat island (UHI) effect. Broadly defined, UHI describes the increased temperature of urban areas compared with the temperature of the surrounding non-urban areas (Koppe et al., 2003). Literature points to “anthropogenic heat production, airflow and the built form” as the main contributing factors to the UHI and indicates that, in general, the larger a city and the greater the population, the more pronounced the urban heat island (Koppe et al., 2003). Moreover, qualities associated with conventional construction and pavement materials contribute to a higher radiated heat absorption factor, leading to higher summer night

temperatures, thereby limiting night-time recuperation from day-time high temperatures (Smoyer-Tomic, 2002). When discussing the UHI, it should also be noted that cities are marked by a variety of microclimates, and in some instances the thermal differences within the various urban microclimates may be greater than the difference between urban and rural climates (Koppe et al., 2003).

In addition to the UHI effect experienced by all urban dwellers, a high urban population density, large numbers of high-risk inhabitants, and people living in older high-density housing without air conditioning aggravate the problems.

Health impacts: People are particularly vulnerable during heat events occurring early in the season, as they are un-acclimatized to heat stress, as are populations living in traditionally cooler climates (Séguin, 2008). For instance, a temperature of 30°C in Vancouver might be considered anomalous, resulting in negative impacts to health, whereas the same temperature in Winnipeg may have less health impact as summer conditions with high temperatures are more common (Smoyer-Tomic, 2002). High ozone and smog concentrations are important co-factors during heat events. Their principal effects on human health include acute and/or chronic damage to the respiratory system and negative impacts on the cardiovascular system (Séguin, 2008). The World Health Organization (WHO) has cited evidence for an interactive effect on mortality from high temperatures and ozone concentrations, an effect more severe than a simple addition of expected impact of each taken separately (Matthies, Bickler, Cardenosa, et al., 2007). Age, health status, socio-economic conditions, and nature of work (outdoor vs. indoor and so on) all affect the ability of people to cope during heat events (Séguin, 2008). (NB: The Health Canada Assessment found no such evidence.)

Key vulnerable population groups:

- Seniors;
- Children;
- Chronic disease sufferers, including:
    - Cardiovascular and respiratory illnesses
    - Renal disease
    - Diabetes
    - Obesity
    - Those taking certain medications
    - People in long-term care, especially those immune compromised
- People who are of low socio-economic status, especially those in densely populated urban areas; and
- People in certain working conditions and occupations, such as the health sector, or those required to work outdoors for extended periods (e.g. construction workers, forest workers, power-line technicians, traffic police) (Matthies, Bickler, Cardenosa et al., 2007; Séguin, 2008).

An expanded definition of vulnerability outlined in International Journal of Epidemiology literature attributes vulnerability to heat events to a combination of factors: “People’s vulnerability to heat depends on climatic factors and individual risk factors, including medical, behavioural and environmental factors, for example, age, gender, pre-existing disease, use of certain medications, level of hydration, living alone, housing condition (building type or living on a higher floor), and the presence and use of air conditioning in the home or residential institution. It also can be said that the vulnerability to heat wave is a function of sensitivity, the

exposure to heat wave, and the adaptation measures and actions in place to reduce the loss of life" (Tan, 2008).

6.1.1 Seniors

Seniors tend to be less physically, financially, and emotionally resilient than those younger. Medications commonly used by seniors may exacerbate the effects of extreme heat (Haq, Whitelegg, Kohler, 2008; Berry, McBean, Séguin, 2008), and medical expenses resulting from heat events can also have a significant economic impact on low-income seniors (Berry, McBean, Séguin, 2008). Among the frail elderly (aged 75+), women are at higher risk of being affected during a heat event partly because they are more likely to live alone than men (Haq, Whitelegg, Kohler, 2008). A high rate of social isolation puts seniors at greater risk during heat events (Berry et al.,2008). When living alone, seniors may not receive care during a heat event and seniors are less likely to call for medical attention (Tan, 2008).

A 2008 report of the *US Climate Change Science Program and the Subcommittee on Global Change Research* acknowledges that social networks play an important role in coping with extreme weather events, and indicates that socially isolated individuals are at a greater risk of dying from extreme heat, as are people living in neighbourhoods without public gathering places and an active street life (Ebi, Sussman and Wilbanks, 2008).

6.1.2 Children

Infants and children are at high risk due to specific metabolic factors, low perception of danger and the lack of capacity or resources to reduce their own exposure to heat. Children from low-income families are at higher risk if their housing lacks air conditioning. Health Canada also reports that children suffer more from the psychological trauma of natural hazards because they have lower coping capabilities; resulting effects can include loss of recently developed skills, eating and sleeping disorders, and behavioural issues (Berry, McBean and Séguin, 2008).

6.1.3 Chronic Disease Sufferers

Almost all chronic diseases pose a higher risk of death/illness in the context of heat events. Psychiatric disorders, depression, diabetes, pulmonary, cardiovascular, and cerebro-vascular conditions constitute relevant examples (Matthies, Bickler, Cardenosa, et al., 2007). Persons on specific medications or those addicted to drugs are less capable of thermoregulation during heat waves (Berry et al., 2008), and any condition that limits mobility and reduces the ability for self-care increases the risk for death or heat-related illness (Matthies et al., 2007). Hospitals and clinics may become overwhelmed with admissions during heat waves, and the resulting compromise of care may place chronically ill patients at further risk (Berry et al., 2008). Renal morbidity (e.g. stress on the kidneys and compromised function of the renal system) resulting from dehydration and hyperthermia may increase in susceptible individuals, in particular the elderly (Hansen, Bi, Ryan, et al., 2008).

6.1.4 Low Socio-Economic Status

Climate change is likely to exacerbate health inequalities due to low socio-economic status and low education (Greater London Authority, 2008; Berry et al., 2008). In general, people with higher income and education levels have superior access to the information and resources necessary to cope with an extreme weather event (Berry et al., 2008). The homeless are vulnerable to extremes in temperature because they are exposed (Berry et al.,2008). In addition, many homeless people are socially isolated and lack access to a TV, radio or telephone, and may therefore remain unaware of emergency announcements. A 2008 report of the *US Climate Change Science Program and the Subcommittee on Global Change Research* acknowledges that social networks can play an important role in coping and recovery from extreme weather events. It points to studies that indicate that individuals who were socially isolated were found to be at greater risk of dying from extreme heat, as well as people living in neighbourhoods without public gathering places and an active street life (Ebi, Sussman and Wilbanks, 2008).

6.1.5 Densely Populated Neighbourhoods and Crime

Factors associated with overcrowding can diminish peoples' coping capacity. These include fear of going outside due to higher crime rates and bad interior air quality. Such factors are compounded by infrastructural deficits (such as badly maintained roads, housing, water, and wastewater infrastructure). Crime levels increase as the opportunity for crime increases in hot weather – people spending more time outside the home increase their risk of being victimized, and the long periods of absence from property leave them more vulnerable to burglary; leaving windows open for ventilation and cooling also increases the opportunity for crime (Greater London Authority, 2008).

6.1.6 Working Conditions and Productivity

Even amongst healthy adults, excessive exertion can result in dehydration, heat exhaustion, kidney failure, liver damage, heat stroke, or death (Séguin, 2008). Heat events may exacerbate health inequalities in work environments, in particular for outside workers; for those engaged in heavy manual labour or physical activity; and for people working in buildings not well ventilated or thermally regulated. Protective clothing, often an occupational requirement, may even become a dangerous hazard (Matthies et al., 2007; California Department of Industrial Relations, 2008). Evidence shows that people who work in poor-quality environments tend to be from lower socio-economic groups (Greater London Authority, 2008). The California Division of Occupational Safety and Health reported that 84 percent of all heat illnesses in 2008 occurred during the July heat wave that year (California Department of Industrial Relations, 2008).

In addition to health risks, an increased frequency and severity of heat events may directly impact labour productivity. In a study estimating labour productivity for 21 world regions, Kjellstrom et al., predict the "slowing down of work; whether it occurs through self-pacing (which reduces output) or occupational health management interventions (which increases costs), the end result is lower labour productivity (which is defined as the value of output over labour costs) in most regions" (Kjellstrom, Kovats, Lloyd, et al., 2008). The study highlights the need for more comprehensive research that evaluates current and potential adaptation measures (e.g. climate-proofing industrial and commercial buildings, training programs, work-rest cycles,

changes to hours and practices, and technological advances such as cooled suits) in the context of labour productivity (Kjellstrom et al., 2008).

6.2 Key Sectors Affected by Extreme Heat

6.2.1 Health

Most health care facilities have not been designed with heat events in mind, and changes to climate may make these buildings uncomfortable for both staff and patients. A recent report from Australia cites hospital computers overheating and failing during a 1997 heat event in Adelaide. Other concerns included hospitals becoming overcrowded as citizens sought an air-conditioned environment, and the overloading of hospital electrical systems from excessive use of fans and electrical equipment, posing the risk of both electrical failure and fire hazard (Carthey and Chandra, 2007). Hospital vulnerability to heat events may thus compromise patient care at times when demand for care may be high. (NB: This may not currently be a top-of-mind issue for Canada, but serves to illustrate heat issues that areas of the country may encounter under future climate changes.)

The *London Climate Change Adaptation Strategy Draft Report* recognizes that extreme weather may affect those working in health and social care services at a time when demand for such services are high, for instance:

- Staff being physically affected by the event or in responding to an event;
- Staff being required to stay at home to manage domestic issues;
- Staff being unable to get to work where transport systems are affected;
- Compromised working conditions (Greater London Authority, 2008).

6.2.2 Electric Power Sector

Heat events of increasing intensity and frequency will increase peak electricity demand for air conditioning in much of Canada (Lemmen, Warren, Lacroix, 2008). Electricity demand decreases as mean daily temperatures rise until roughly 18°C, the threshold at which electricity demand begins to climb (Chiotti and Lavender, 2008). The effects of peak demand can be serious and wide-ranging, and may contribute to brownouts and blackouts (Bourque and Simonet, 2008; Chiotti and Lavender, 2008). High temperatures may reduce the efficiency of transmission lines (e.g. reducing transducers' ability to dissipate heat and causing metal power lines to expand, resulting in sagging lines) (Smoyer-Tomic, 2002). Moreover, when fossil-fuel-derived electricity demands increase during heat spells, greenhouse gas emissions increase, which further exacerbates the climate problem.

6.2.3 Transportation

Heat can adversely affect transportation infrastructure such as roads, railways, and bridges. For instance, in the Australian heat wave of January 2009, buckled rails forced cancellation of commuter trains (BBC News, 2009). Hotter summers and heat waves may also make travel on public transportation more uncomfortable and dangerous for vulnerable populations; low-income persons are more likely to use public transport and are further exposed to potential overheating on public transport systems and interrupted service (Greater London Authority, 2008).

6.2.4 Agriculture and Livestock

Increased temperatures associated with heat events often coincide with dry spells or drought conditions in rural areas impacting crops and livestock (Smoyer-Tomic, 2002). Un-acclimatized plants exposed to extreme temperatures (above 40°C) may experience wilting or death, and unfavourable soil conditions could result from extreme warming and drying, as occurred in Canada in the summer of 1999 (Smoyer-Tomic, 2002). A recently published report, *Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat*, cites decreases in food production resulting from crop failure during the 2003 heat wave in Europe, and states that "despite the general perception that agriculture in temperate latitudes will benefit from increased seasonal heat and supply food to deficit areas, even mid-latitude crops will likely suffer at very high temperatures in the absence of adaptation" (Battisti and Naylor, 2009). As stated in the report, "record high daytime and nighttime temperatures over most of the summer growing season reduced leaf and grain-filling development of key crops such as maize, fruit trees, and vineyards; accelerated crop ripening and maturity by 10 to 20 days; caused livestock to be stressed; and resulted in reduced soil moisture and increased water consumption in agriculture" (Battisti and Naylor, 2009). Extreme heat impacts on livestock include reproduction, feeding and milk production issues, and death in some instances (Smoyer-Tomic, 2002).

6.3 Canadian Adaptation to Extreme Heat Events: Key Policies/Responses to Date

Some policies have been proposed or implemented in Canada to address extreme heat events.

6.3.1 Federal and Provincial Policy and Programs

In 2007, Health Canada initiated Building Heat Resilient Individuals and Communities in Canada, a multi-year collaborative project to reduce risks to the health of Canadians in specific vulnerable populations. Health Canada, along with provincial and municipal partners, is developing guidelines for heat response systems, on how best to anticipate and advise patients/clients; recognize/diagnose and treat as a consequence of extreme heat events, extreme precipitation, and increased warming trends; and develop guidelines for health care workers regarding extreme weather events (Séguin, 2008).

A federal National Climate Change Adaptation Framework proposes areas of potential collaboration among jurisdictions to increase Canada's capacity to adapt to climate change impacts, to recognize and reduce risks, and to identify and pursue opportunities (Séguin, 2008).

Health Canada reports that "the creation of the Public Health Agency of Canada (PHAC), the National Framework for Health Emergency Management and the Voluntary Sector Framework for Health Emergencies has enhanced adaptive capacity by providing needed coordinating structures to facilitate emergency planning and response activities within and outside of government" (Séguin, 2008).

Several provinces and territories are developing climate action plans that include adaptation measures for extreme heat events, while several provinces, territories and cities have published adaptation-specific plans and strategies:

- Quebec's plan includes setting up an alert system for intense heat and for monitoring, in real time, related health problems in all regions of Quebec likely to be affected; supporting health management in the analysis of the ventilation/air-conditioning/dehumidification needs of care institutions, taking into account climate change; and financial support for the creation of cool areas in urban communities and cooling for strategic infrastructures (Séguin).

- British Columbia has provisions within its childcare licensing regulations that require facilities to maintain comfortable temperatures. To our knowledge, no other provinces have such provisions (Government of B.C., 2001; Séguin, 2008; Government of Saskatchewan, 2001; Government of Alberta, 2008a; 2000; Government of Manitoba, 1999; 1986; Government of Quebec, 2006; Government of Newfoundland and Labrador, 2005; Government of Nova Scotia, 2007; Government of New Brunswick, 1983; Government of Prince Edward Island, 2004).

- Though most provinces do include some measures to protect workers from extreme heat related to specific jobs such as welding or mining, they do not all have measures to protect vulnerable workers during extreme heat waves. B.C., Saskatchewan, Quebec, New Brunswick, and P.E.I. include measures in their occupational health and safety regulations that protect workers from heat stress, according to the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (Séguin, 2008; Government of B.C., 2009b; Government of N.B, 1991; Government of P.E.I., 1987; Government of Saskatchewan, 1996).

6.3.2 Research

Since 2002, the Clean Air Partnership (CAP) has maintained an ongoing urban heat island (UHI) research program, including the Cool Toronto initiative (Berry, McBean and Séguin, 2008). CAP has also partnered with the Canadian Centre for Remote Sensing on a multi-year research project (Mersereau and Penney, 2008) to assess the microclimate associated with various land uses and building types (Berry et al., 2008). The Environmental Prediction in Canadian Cities (EPiCC) network is undertaking research programs on the UHI effect specific to Vancouver and Montréal (Berry et al., 2008). In addition, Ouranos, a research consortium on regional climatology and adaptation to climate change, is conducting research projects on heat waves and urban heat islands. Recognized as a leader in Canada for its research on climate change, its ongoing projects include the identification of sectors vulnerable to intense heat in Canadian metropolitan areas (Séguin, 2008).

The National Collaborating Centre for Environmental Health (NCCEH), located at the B.C. Centre for Disease Control (BCCDC) in Vancouver, was established by the Public Health Agency of Canada and conducts ongoing research, including studies on health and heat episodes. For example, the NCCEH Health Heat Episode Public Health Intervention Review Team produced the *What is the Evidence on Applicability and Effectiveness of Public Health Interventions in Reducing Morbidity and Mortality during Heat Episodes?* report (Bassil, Cole, Smoyer-Tomic et al., 2007; Battisti and Naylor, 2009). The Toronto-based Wellesley Institute also conducts research into this topic, and has produced several policy recommendations (e.g. *Killer Heat, Killer Smog: Six recommendations to build on the report from the Medical Officer of Health on short, medium and long-term strategies to deal with urban heat and smog* report) (Shapcott, 2006). The Climate and Health Research Program (CHRP), housed in the Department of Earth and Atmospheric Sciences at the University of Alberta, is a research initiative that investigates the relationship between climate and human health. CHRP-affiliated projects have included an analysis of weather-related mortality in the Toronto-Windsor Corridor and an inter-urban analysis of housing and population risk factors in heat-related mortality in cities of the US Eastern seaboard (Smoyer-Tomic, 2002). Researchers from the R. Samuel McLaughlin Centre for Population Health Risk Assessment at the University of Ottawa, University of Toronto's Department of Public Health Sciences, and University of Toronto's Centre for Environment are also leading projects and collaborating with public health units to investigate the impacts of heat events (Centre for Environment, 2007; R. Samuel McLaughlin Centre for Population Health Risk Assessment, 2008).

6.3.3 Heat Alert Systems and Hot Weather Response Plans

Heat alert systems anticipate weather conditions likely to impact human health, and are often utilized in conjunction with hot weather response plans that include intervention strategies targeted at vulnerable populations (Mersereau and Penney, 2008). The following section provides a snapshot of heat alert systems and hot weather response plans in Canada. More detailed reports and analysis specific to heat alert systems (e.g. Humidex index, WBGT, synoptic systems) in Canada can be found in CAP and Health Canada literature.

Several Canadian cities and municipalities, largely limited to Ontario and Quebec, have implemented heat alert systems and developed response plans with interventions to protect vulnerable populations from health risks associated with extreme heat (Séguin and Clarke, 2008). The implementation of response systems in Canada has been influenced by heat-related deaths in the US and Europe, as well as recent evidence indicating that heat alert systems combined with intervention strategies can save lives and prevent heat-related illness. Awareness of the issues is increasing among public health officials within Canada as they examine temperature-related mortality in specific jurisdictions and identify vulnerable populations in light of future climate projections (Séguin, 2008).

Heat Alert Systems: Heat alert systems, also known as heat/health watch warning systems, set thresholds for taking action on heat events (Mersereau and Penney, 2008). Montréal (and France) has a system that takes into consideration regional characteristics, triggering alerts when maximum and minimum temperature thresholds are predicted (Mersereau and Penney). Heat alert systems have been prepared for nine Quebec cities with more than 100,000 inhabitants (Séguin, 2008). Toronto utilizes the "spatial synoptic classification system," as do a growing number of cities and municipalities worldwide (Mersereau and Penney). CAP literature describes

spatial synoptic systems as measurement systems customized for individual urban areas. They are based on the specific meteorology (e.g. air mass type, dew point, cloud cover, wind speed, and direction), urban structure and demographics, while also taking into account the negative impact of several consecutive days of oppressive weather, as well as the fact that heat events earlier in the year are more dangerous that those in late summer (Mersereau and Penney). Heat alert plans based on the Toronto system are being developed for the Peel Region while Waterloo, Halton, Kingston, and Ottawa have introduced advisory systems based on the commonly used Humidex index advisory; the latter two municipalities also incorporate air quality conditions into their heat advisories (Chiotti and Lavender, 2008).

While spatial synoptic classification systems are more difficult to implement in smaller municipalities, the Humidex index considers only temperature and humidity, and is based on relative human discomfort levels, with the result that the heat thresholds are not targeted to specific populations. The Humidex index assumes that temperature affects all people equally, regardless of the time of year, geographic location, or duration of the heat event (Mersereau, 2007). This system is not ideal. Temperature and humidity alone do not account for other factors (such as air velocity and radiant load from the sun) necessary to properly measure heat.

An alternative threshold warning is the Wet Bulb Globe Temperature (WBGT) index, which has conventionally been used in Canada to measure occupational heat exposure (Canadian Centre for Occupational Health and Safety, 2008).

Hot weather response plans: A detailed scan by CAP found that response plans typically consist of one or more of the following components:

- Procedures for alerting municipal staff, community agencies and the public to the occurrence of extreme heat;
- Procedures to communicate to the public and organizations working with at-risk groups about the health risks associated with extreme heat and heat-safety information; and
- Procedures for rolling out public health intervention activities typically including, but not limited to, opening cooling centres and extending the operating hours of municipal facilities (Mersereau, 2007).

Toronto: Toronto's Hot Weather Response Plan has been cited as one of the more effective responses to extreme heat in the world. The plan involves over 800 partner agencies and outlines strategic considerations, communications and notification procedures, as well as the roles and responsibilities of supporting city services, agencies and organizations (Chiotti and Lavender, 2008). The City of Toronto has also created brochures (*How to Beat the Heat; Hot Weather Plan for Landlords; Child and Car Safety in Hot Weather; Fan Facts; Heat, Drugs, and Alcohol; Help Pets Beat the Heat; Medications and Heat–Related Illness; and Outdoor Exercise During Heat and Smog Alerts)* directed at the general populace as well as for targeted populations (Mersereau, 2007). Toronto regularly assesses and updates this plan, and has enacted targeted interventions designed to help vulnerable populations cope . For example, public health inspectors are sent to boarding homes and rooming houses to monitor indoor temperatures and encourage property managers to provide cool communal areas (Mersereau and Penney, 2008). Recognizing that many vulnerable groups do not have access to TV, radio or telephone, and are consequently likely to be unaware of heat alert announcements, Toronto Public Health embarked on a targeted, city-wide education campaign of landlords and tenants regarding the health risks of heat stress, especially for persons taking psychiatric drugs and other medications (Chiotti and Lavender, 2008). Recent literature also indicates that "Toronto Public Health is moving towards

ward-based community cooling centres in the hope of better serving at-risk populations, and the health unit is also considering the use of two mobile drinking water vehicles to target at-risk areas of the City during heat and extreme heat alerts" (Mersereau and Penney, 2008).

Air quality standards, alerts and the Air Quality Health Index: In 2000, all federal, provincial and territorial governments, except Quebec, agreed on Canada-wide standards for particulate matter and ozone (Séguin, 2008). In the Waterloo region of Ontario, when hot weather and poor air quality coincide, the public health unit issues a combined alert to the community. In Middlesex-London,Ontario, public health messaging always includes information about smog, heat and high levels of the UV index (Mersereau and Penney, 2008). Ontario has passed legislation on a Clean Air Plan and has implemented initiatives to reduce levels of air pollution (Séguin, 2008).

In 2007, Environment Canada and Health Canada began the implementation of the new Air Quality Health Index (AQHI) in various locations across Canada (Mersereau, 2007), which provides health messages directed at high-risk populations as well as the general population. The federal government has committed to outreach efforts, including working with provincial partners, to communicate the AQHI to the public through various media and developing a toolkit for partners at all levels of government and non-government. The toolkit details the health impacts of air pollution, information on how health professionals can interpret and explain the AQHI to patients, and actions to reduce exposure to air pollution. Provinces across Canada are working in partnership with the federal government to implement the AQHI and develop outreach programs directed at both medical professionals and the general public to accompany the data generated and published by the federal government.

BC Transit, the B.C. Ministry of Environment and Environment Canada partnered to form the BC Clean Air Day Committee, which has developed an on-line *Clean Air Toolkit* to help local governments develop emissions reduction programs. The *Clean Air Toolkit* includes tips on obtaining funding for air quality programs, resources on "transit-friendly planning," and examples of local initiatives and bylaws directed at reducing emissions (BC Transit, 2009).

Passive cooling: Several measures initially introduced to reduce energy use and mitigate other extreme climate change events (such as flooding) have been found to reduce the UHI effect and offer cool shelters during extreme heat events (Séguin, 2008). Examples include the following: planting shade trees, installing reflective roofs, optimum planning of roadways and buildings, and urban reforestation (Séguin). Other adaptations being developed in many Canadian cities include building green roof systems and high-albedo roofs that lower the absorption of solar energy, as well as the increased use and availability of public transportation.

Quebec has a province-wide standardization of fines for cutting down trees, and several municipalities (e.g. Québec, Gatineau, Montréal, Laval, Saint-Eustache) are increasing tree planting along streets, improving tree maintenance and making tree replacement mandatory (Séguin). In 2006, Toronto's City Council adopted a green roof strategy that includes a pilot program and incentives to property owners for installation of green roofs; more recently, the city has created an "Eco-Roof" incentive program for institutional, commercial and industrial (ICI) buildings. The ICI program will provide subsidies of $50 per square metre for green roof projects, and subsidies of $2 to $5 per square metre for cool roofs (roofs that reflect the sun's thermal energy) (City of Toronto, 2008). Green roof policies complement Toronto's Green Development Standard, a set of performance targets that encourages sustainable site and building

development, and contains targets and strategies for reduction of urban heat such as urban forest enhancement, increasing permeable surfaces and energy efficiency (Mersereau and Penney, 2008).

Other mid- and long-term actions: Volunteer and charitable organizations play an important role in building awareness and responding to heat events. As outlined by Health Canada, "a national collaboration among the Canadian Red Cross, the Salvation Army, St. John Ambulance and other key organizations developed a voluntary sector framework for health emergencies and a model for developing and sustaining episodic volunteers" (Séguin, 2008). Another example is resources developed by the Canadian Institute of Child Health (CICH). CICH has published brochures for parents and caregivers (e.g. *Changing Habits, Changing Climate: A Foundation Analysis* and *Climate Change and Your Child's Health*), which provide information on the effects of climate change specific to children's health and ways to protect children from climate change impacts (CICH, 2008).

6.4 Selected Examples of International Responses

A scan of responses to extreme events reveals that cities, municipalities and nations worldwide are developing short-term and long-term strategies for adaptation to more frequent and extreme heat events. The following section provides a snapshot of short-term and long-term adaptation measures that have been enacted or are being considered throughout the world, with an emphasis on measures targeted to vulnerable populations and sectors.

6.4.1 Heat Alert Systems and Hot Weather Response Plans

Numerous countries around the world have developed heat alert systems with corresponding hot weather response plans (also referred to as "heat-health action plans" or "heat-wave response plans"). Australia is in the process of developing a national plan and many European countries – Belgium, Denmark, England, France, Italy, the Netherlands, Portugal, Spain, and Switzerland – developed national plans following the devastating 2003 heat events (European Commission, 2007b; Research Institute for Climate Change & Sustainability, 2009). In London, England, the Mayor has integrated heat response policies into the London Climate Change Adaptation Strategy; in Australia, the state of Queensland is addressing heat waves through an adaptation plan and the Queensland Ambulance Service (QAS) response plan (Greater London Authority, 2008; State of Queensland, 2007). Many response plans (e.g. France, Spain and England) also include alert systems that implement a "maximum mobilization level" or "emergency level" if the impacts of a heat event (e.g. power cuts, drought, management problems in the funeral centres, and heavy air pollution) overwhelm the health field (Greater London Authority, 2008; Fouillet, Rey, Wagner, et al., 2007; Matthies, Bickler, Cardenosa, et al., 2007). The German Weather Service has developed an on-line decision-support tool that provides critical medium-term forecasting of heat and complements national heat alert systems. The Service may enable health services to gather weather data up to 10 days prior to a heat event, enabling them to better plan and respond (European Commission, 2007b).

In the US, Philadelphia's synoptic heat warning system has served as a motivating example to many cities around the world, including Toronto and Shanghai (Sheridan, 2006). The US Environmental Protection Agency (EPA) has developed an *Excessive Heat Events Guidebook* in

collaboration with NOAA, US Centers for Disease Control and Prevention (CDCP), and the US Department of Homeland Security (DHS), to provide information for municipal officials (US EPA, 2009).

6.4.2 Targeted Interventions and Decision Support Tools

While research indicates that heat response plans save lives, concern persists as to whether response plans are reaching the most vulnerable groups, particularly the elderly, socially isolated and homeless. Passive information approaches such as leaflets and brochures are proving generally insufficient, and countries are developing and assessing more active approaches, such as buddy systems, home visits and daily phone calls (Bassil, Cole, Smoyer-Tomic et al., 2007). A project named "Assessment and prevention of acute health effects of weather conditions in Europe" (PHEWE)[1] investigated the relationship between temperature and mortality in 16 European cities and presented results through conferences and journal articles in the *International Journal of Epidemiology*. Utilizing research generated out of an EU initiative named Project EuroHEAT[2], the WHO has identified several response plans that include innovative interventions and decision-support tools targeted at vulnerable populations. We outline some of the more active approaches generated out of the WHO, PHEWE and EuroHEAT projects along with grey literature (e.g. adaptation plans and health departments' web sites) below:

- In Italy, the Department of Epidemiology Health Authority and local health authorities identify vulnerable population subgroups by using surveillance systems that consider risk factors such as socio-demographic characteristics and medical conditions (Matthies et al., 2007).

- France has set up a system for real-time surveillance of health data, city-scale censuses of the isolated and vulnerable, visits when necessary, air conditioning for hospitals and retirement homes, and the drawing up of emergency plans for retirement homes (Tan, 2008).

- In Catalonia, Spain, town officials are using a software program to prepare a census of groups at risk during a heat wave, record cooling centres and means of transport for at-risk people to these centres (Matthies et al., 2007).

- England's National Heat Wave plan is complemented by information targeted at health care and childcare professionals. It includes a guide that offers advice on caring for people most at risk during a heat wave, and on organizing those who provide care, including social workers and home care providers (U.K. Department of Health, n.d.). Another document provides advice for teachers, school nurses, parents, assistants, and others looking after children in schools, nurseries and childcare centres (U.K. Department of Health, 2008).
    - England's recently updated contingency plan for heat waves also calls for residential and nursing homes to create "cool rooms" able to maintain temperatures below 26°C (U.K. Department of Health, 2008).

- Philadelphia's comprehensive heat response plan involves over 6,000 groups and individual volunteers who are identified prior to the summer and provided with

information regarding the warning signs of heat stress, identifying the most vulnerable persons and treatment recommendations according to level of severity (Sheridan, 2006).

- One such group is the Philadelphia Corporation for Aging that helps promote heat awareness through staff training and information sessions at senior centres (Sheridan, 2006). In the event of a heat wave, additional measures include direct notification to nursing homes, continuity of services (e.g. utilities), outreach to the homeless, increasing emergency medical service staff, keeping senior centres open, making health department staff available for media interviews, activating a publicized hotline (operated by the Philadelphia Corporation for the Aging), paying home visits in extreme situations, and opening air-conditioned shelters for those whom the Department of Public Health feels it necessary to move (Sheridan, 2006).

The integration of high-quality evaluations into heat response plans is recognized as a critical element to determine what works to reduce mortality, for whom, and in what context (Matthies et al., 2007). In 2006, the U.K. Department of Health asked the Health Protection Agency to undertake an evaluation of England's National Heat Wave plan, in order to provide a rapid overview of mortality and morbidity in the period when the heat wave plan was in operation (a 2006 heat event that triggered an alert), and to assess the following:

- The level of implementation of the plan across health and social care organizations in England;
- The effectiveness of the heat wave plan; and
- Surveillance and information resources, and possible needs (Matthies et al., 2007).

The evaluation had three parts: epidemiological study, including general practitioner data; evaluation surveys; and a multi-agency seminar for organizations involved with the heat wave plan and key experts. It led to the development of a report that included a number of recommendations, such as the need for further epidemiological studies on heat waves and associated effects, and research to determine the most appropriate ways to evaluate interventions (Matthies et al., 2007).

Spain updates its response plan every year with new data obtained from ongoing evaluations that include epidemiological studies (mortality and morbidity data), analysis of distribution of informative material, assessment of actions developed in primary health care centres and in collaboration with social health care centres, analysis of actions developed by Sanitation Response (heat phoneline), and assessment of actions developed by the Department of Social and Civic Action (Matthies et al., 2007).

In California, adaptive measures for outdoor workers are being enacted to prevent illness and fatalities associated with heat events. The Heat Illness Prevention Standard (*Title 8*, *California Code of Regulations*, *Section 3395*), adopted in 2005, requires all employers with outdoor worksites to take steps to prevent heat illness (e.g. training all employees and supervisors about heat illness prevention; providing specific amounts of fresh water; providing access to shade for at least five minutes of rest when an employee believes he or she needs a preventive recovery period; and developing and writing procedures to ensure compliance with standards) (Division of Occupational Safety & Health, 2008). The standard was created in response to an increase in the number of possible heat-related incidents reported to the Division of Occupational Safety & Health starting in July 2005, and in recognition that that no existing US occupational federal standard specifically and comprehensively addressed the prevention of heat illness (California

Department of Industrial Relations, 2008). The California Division of Occupational Safety & Health also offers educational brochures (e.g. Heat Hazards in Agriculture – A guide for employers to carry out tailgate training for workers), heat illness prevention training seminars, and an online "Heat Illness Prevention e-Tool," which provides information on the basics of preventing and responding to heat illness, and detailed information on effective best practices (Division of Occupational Safety & Health, 2008; California Department of Industrial Relations, 2008).

Geospatial decision support systems: A better understanding of the distribution of vulnerable locations and populations could help health care workers more effectively deliver targeted resources. A 2008 report generated by the Clean Air Partnership details the potential for utilizing a geospatial decision support system (GDSS) to help local government decision makers address heat issues in the Greater Toronto Area (GTA), suggesting that a GDSS tool utilizing geographical information system (GIS) mapping technology could assist municipalities and city planners to:

- Assess vulnerability to heat of both populations and places in the GTA;
- Examine the relationship between "hotspots" (locations where temperatures are consistently hotter) and other variables; and
- Develop heat-related communication materials for a variety of audiences (Mersereau and Penney, 2008).

Jurisdictions such as Phoenix, Arizona, Montréal (Canada), and London (England) are using GIS technology to formulate vulnerability assessments to heat events. In 2007, the US Environmental Protection Agency funded a GIS pilot project in Philadelphia to determine vulnerability to heat on a neighbourhood scale by overlaying US census data with satellite imagery, mortality rates and emergency dispatch call data (Mersereau and Penney, 2008).

Germany's Potsdam Institute for Climate Impact Research (PIK) is using GIS technology to develop studies on the impacts of heat events on agricultural yields. A 2007 report, titled *Correlation Analysis of Climate Variables and Wheat Yield Data on Various Aggregation Levels in Germany and the EU-15 Using GIS and Statistical Methods, with a Focus on Heat Wave Years*, looks at how annual wheat yield variability is affected by weather, in particular with respect to human-induced climate change and increasingly intense and frequent heat events in Europe. The study applies geo-statistical methods and GIS to analyze spatial and temporal variability of wheat yield in Europe (Potsdam Institute for Climate Impact Research, 2008).

6.4.3 Passive Cooling, Building Codes and Built Environment Policies

Many countries and cities are adopting long-term responses to heat events, such as building regulations and urban planning to address building design and energy use, that not only help cities adapt but also have synergistic mitigative functions. For instance, in an effort to reduce the UHI effect, many European and Japanese cities have enacted green roof policies. Examples of specific legislation include a Swiss requirement that buildings of more than four storeys provide a rooftop garden; a municipal bylaw in Stuttgart, Germany, that requires the installation of a grass roof on all flat-roofed industrial buildings; and a bylaw in Mannheim, Germany, that requires developers to install green roofs on most new and renovated building development in the downtown core (Johnson, 2002). In Japan, the Tokyo Metropolitan Government (TMG) requires that all new construction projects over a certain size green their rooftops and wall surfaces (Green Roofs for Healthy Cities, 2009). California has enacted legislation that requires building owners to use white or cool-coloured materials in construction of roofs; a recent report by the Lawrence Berkeley National Laboratory Heat Island Group estimates that retrofitting 100 square metres of roof with white materials can provide additional mitigative benefits by offsetting 10 tonnes of CO_2 emission (Lawrence Berkeley National Laboratory, 2008).

England's Heatwave Plan advocates that government departments, local authorities and public health authorities promote the greening of the built environment, and shading and insulating buildings, with priority given to hospital estates, care homes and areas of social deprivation where green spaces are limited or non-existent (Greater London Authority, 2008). The Forestry Commission's London Region has developed a Tree and Woodland Spatial Framework that includes an on-line tool for directing resources, tree planting and improved woodland management in London areas where these will most benefit disadvantaged communities (England Forestry Commission, 2008). As part of its "10-Year Project for Green Tokyo", that city is implementing programs such as the "Umi-no-Mori," or sea forest, comprising approximately 480,000 trees planted on landfill (Hasegawa, 2008). In addition, Tokyo is introducing solar heat-blocking, water-retaining pavement in the city centre as a measure to reduce the UHI phenomenon (Hasegawa). Lawrence Berkeley National Laboratory Heat Island Group also advocates the use of cool pavement technologies such as materials for roadways that reflect more sunlight and last longer because they are not as stressed by excessive heat (Lawrence Berkeley National Laboratory, 2008).

Other passive cooling technologies include reflective surfaces; control of solar radiation by vegetation and trees; eaves and blinds; earth tubes; thermally massive construction; and the formation of air paths for natural ventilation (Shimoda, 2003). The European Committee for Standardization (CEN) has drafted building standards to help the member countries implement the European Energy Performance of Buildings Directive (EPBD). Design standards not only help meet requirements regarding the energy consumption of buildings, but also provide criteria and design values for the indoor environment including thermal, indoor air quality, light and noise (European Commission, 2008). Literature describing what is referred to as "climate integrated design," including tropical vernacular architecture, provides information on design principles (e.g. employing light-weight construction, cross ventilation and shaded outdoor living spaces) that could offer "spatial adaptive potential" to maintain comfort in extreme heat and inform building codes (Steemers, 2003; Anselm, 2006).

Germany is developing innovative ways to adapt within its warmest city, Freiburg, with a project that examines the thermal comfort of people in urban settings and creates draft modules suitable for urban planning (Mayer, Holst, Dostal, et al., 2008). One of the main objectives is the creation of guidelines for urban planning in Central Europe, oriented to the challenges of city dwellers (Mayer et al., 2008). Air conditioning is increasingly used as an adaptation measure; however, this response creates a trade-off: it reduces risks to populations from extreme heat events, but potentially increases GHG emissions (if the electricity is generated thermally); it also potentially impedes acclimatization. In a project called "Simulation-Supported Automation for Sustainable Air-Conditioning of Buildings in Summer," Germany is researching energy-optimized control technology procedures for air-conditioning systems and building operations (Cologne Institute for Economic Research, 2007).

In a report recently published by the Stockholm Environmental Institute, the authors advocate integrated and preventive health and social care that helps improve the health of older people and thus enables them to be more resilient (Haq, Whitelegg, Kohler, 2008). Specific measures include climate proofing the homes of persons of retirement age (e.g. retrofitting to ensure energy efficiency), creating highly accessible local systems that do not require vehicles or high transport cost, and urban and rural planning that encourages walking and cycling (Haq et al., 2008).

6.4.4 Enhancing Social Networks and Community

The Stockholm report emphasizes the role of social networks and community in maintaining health while minimizing social isolation, recommending that officials enhance "social cohesion and community capacity" through the support of a Local Strategic Partnership (LSP) that "brings together voluntary and statutory agencies with the express purpose of strengthening local communities, contributing to social and economic development and dealing with environmental problems including climate change" (Haq, Whitelegg, Kohler). A Portland, Oregon, pilot project intended to retrofit the urban environment to reduce the UHI effect had the additional beneficial effect of enhancing social capital in the local community. Outcomes included installation of green roofs, increased vegetation, planting of trees in parking and abandoned lots, as well as development of a sense of ownership and community amongst the participants (Ebi and Semenza, 2008).

6.5 Recommendations and Canadian Policy Gaps

6.5.1 Canada-Specific Recommendations

National clearinghouse rather than national warning system: "A national warning or intervention system is probably not appropriate for Canada because of its diverse climates (even within the heat wave zone) and decentralized, provincially-run public health and social services. Rather than a national system, which may be effective in countries with limited climatological variation and highly centralized administrative traditions (such as France), Canada might benefit from a national clearinghouse with guidelines for defining a heat wave or episode, setting up local heat-health warning systems (HHWS), and suggestions for potential health interventions and a collaborative evaluation capacity to improve local systems over time. A systematic heat

wave intervention process, with clearly defined criteria that are able to measure a variety of benchmarks, is needed to reduce inefficiency in developing systems and improve effectiveness in existing heat episode warning systems" (Bassil, Cole, Smoyer-Tomic et al., 2007).

Possible adaptation measures to heat suggested by Health Canada: Possible adaptation measures to manage health risks related to climate change include the following:

- Registries of vulnerable individuals (e.g. seniors) who require assistance;
- Hot weather response plans and early warning systems;
- Provision of information about the health risks of heat stress and short-term actions to protect health during extreme heat events;
- Provision of information about medium-term measures to reduce temperatures in and around homes (e.g. planting bushes and trees);
- New building guidelines that make buildings more heat resistant;
- Requirements for smart urban planning to reduce UHI;
- Provision of accessible air-conditioned public facilities and shelters for extended hours and accessible drinking fountains in outdoor public places;
- Improved urban design to reduce heat island effect (e.g. planting trees, increasing green spaces, shading conditions along streets and parking lots, pattern of subdivisions, and shape, size and orientation of building lots);
- Intervention activities (e.g. "heatline") to provide information to vulnerable populations;
- A "buddy system" to check on neighbours; and
- Provincial health ministries to include climate change projections in planning (Séguin, 2008).

6.5.2 International Recommendations

Key recommendations from EuroHEAT Conference:

- Establish multi-purpose collaborative mechanisms between bodies and institutions, and a lead body to coordinate responses;
- Develop heat-health warning systems (HHWS) in collaboration with meteorological services. There is no best HHWS: an effective HHWS must be targeted to local needs;
- Implement measures to reduce exposure, such as: individual behavioural measures, short-, medium- and long-term housing measures, and long-term improved urban planning, building design, transport, and energy policies;
- Identify groups at high risk before summer, and plan and target interventions accordingly. Community organizations, medical practitioners and care providers play an important role in identifying persons at risk, in advising individuals at high risk from heat-related illness and following up persons at particular risk;
- Provision of health care, social services and infrastructure should include summer health workforce planning, health service provision, and training of health personnel and other interest groups. Emergency departments of hospitals could be alerted to heat waves to better manage an increase in patient admissions;
- Develop heat-related health information in advance of heat events and include targeted information to particular groups such as health care institutions and care givers;
- Incorporate real-time health surveillance into planning processes; this is important to detect early impacts of hot weather, to potentially modify interventions and to inform about abnormal outbreaks or clusters of health impacts; and

- Monitor and evaluate how existing heat-health action plans have worked. Monitoring health outcomes over time in relation to heat events is another important component of the plan (European Commission, 2007a).

Recommendations from U.K. government specific to ageing population: As outlined in the report *Growing Old in a Changing Climate: Meeting the challenges of an ageing population and climate change*, there currently is no overarching, explicit policy response that addresses the interface between climate change and older people who are particularly vulnerable to extreme weather events. While directed towards U.K. policy makers, policy recommendations from the report are valuable and include:

- Leadership should come from government, which should establish an Older People and Climate Change Group working with older people's organizations, key stakeholders, the voluntary sector, government agencies, and academia. The group should develop a vigorous national policy framework that combines cross-sectoral approaches to link climate change interventions and policies to improve the quality of life of older people.
- Climate change proofing the homes of older people through a major program of investment, to be funded by national government, so that every dwelling in England is retrofitted to the highest possible standard of energy efficiency. There should be investment in the third sector (i.e. voluntary and community organizations, charities, social enterprises, cooperatives, and mutuals) to work at the grassroots of communities to identify properties and older people who could benefit from such a scheme.
- Embark on a program of local accessibility enrichment and modal shift, taking into account best practice on walking, cycling, public transport, and land use while utilizing Strategic Health Authorities and local authorities that have a key role to play in developing integrated and preventive measures to ensure older people enjoy healthy and active ageing.
- By 2015, standards of modal share and public transport efficiency, reliability, interchange potential, safety, and security should be equal to best practice in the European Union. Community transport will be vital for those older people who are unable to use public transport. Older people have suffered from the trend toward out-of-town shopping centres that are accessible only by car, and from the withdrawal of so many bus services across the country (Haq, Whitelegg, Kohler, 2008).

6.5.3 Policy Areas for Further Research

The following suggestions are gleaned from the literature and noted as potential policy areas that the Policy Research Initiative could explore:

Information on best practices: a national clearinghouse, and decision-support tools and surveillance systems: As noted in Section 6.5.1, Canada might benefit from implementing a national clearinghouse with guidelines to help local communities develop hot weather response plans. These guidelines could include decision-support tools and surveillance systems derived from those used in larger Canadian cities and European municipalities to develop targeted interventions directed at vulnerable populations. A compendium of these techniques could be collated by the PRI and provided to municipalities.

Incentives to increase use of passive cooling technologies: Some cities, such as Toronto (Mersereau, 2007), have implemented codes and standards along with innovative programs that

include incentives to increase the uptake of passive cooling technologies, yet regulations and incentives to promote passive cooling are absent in many jurisdictions.

Best practices on addressing needs of vulnerable populations: An accessible, comprehensive guide to best practices (e.g. registries, cooling rooms in homes) for protecting vulnerable populations during heat events could be shared across jurisdictions and further developed. As outlined in the report, *Growing Old in a Changing Climate: Meeting the challenges of an ageing population and climate change* (Haq et al., 2008), there currently is no overarching, explicit policy response that addresses the interface between climate change and older people who are particularly vulnerable to extreme weather events. Other recommendations in the report include establishing a working group to develop policies specific to elderly populations, retrofitting the homes of elderly and developing built environments that are conducive to the well-being of elderly populations.

Financial assistance measures: The United Kingdom's Department for Work and Pensions (DWP) commissioned the Meteorological Office to review the impacts of climate change on its policies and operations, and is actively studying the effects of climate change on vulnerable groups that the DWP serves (e.g. low-income groups, children, disabled people, and pensioners) (Haq et al., 2008). The study is also examining how heat events may influence the need for cooling-related hot weather payments (e.g. payments to help poorer households pay increased summer energy bills for increased use of air conditioners and fans) and how climate change may impact DWP operations (e.g. possible disruption to office efficiency during a heat event and potential disruption to IT and other office services as a result of energy suppliers not being able to meet the peak demands for cooling). The PRI could examine the feasibility of a similar study in Canada.

Occupational health and safety (OHS) rules: The number of +30˚C days and the frequency and intensity of heat waves is projected to increase as warming continues. Although most provinces include some measures to protect workers from extreme heat related to specific jobs, such as welding or mining, they do not all have measures to protect workers during extreme heat waves. Only B.C., Saskatchewan, Quebec, New Brunswick, and P.E.I. include measures in their OHS regulations that protect workers from heat stress based on the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (e.g. WGBT Index) (Government of B.C., 2009b; Government of Quebec, 2005; Government of N.B., 1991; Government of P.E.I. 1987; Government of Sask., 1996). The policies in these provinces can serve as a guide for the provinces who have yet to adopt similar measures.

Protection of vulnerable populations: Children and the elderly are at greater physical risk from heat events than other age groups, especially those who reside in low-income households (Berry, McBean and Séguin, 2008). The PRI could undertake a study of what sort of policy initiatives might address the risks faced by low-income families generally, with particular focus on seniors and families with small children. Policies could include, for example, provision of information targeted to these groups, and guidelines and/or regulations for childcare and long-term care facilities for cooling requirements in heat events.

Stronger engagement with professional groups: Policy makers would be well served to also explore the opportunity to engage with professional groups such as urban planners, engineers and educators to find novel means of addressing and responding to social challenges associated with climate change.

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Appendix A: Adaptive Capacity

Adaptive capacity, as defined in broad terms by the Intergovernmental Panel on Climate Change (IPCC), is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and resources/technologies (IPCC, 2007). Economic wealth, access to technology, infrastructure, information and skills, and institutions all influence adaptive capacity. Increasingly, studies argue that it is also determined by levels of human and social capital, such as education and social networks, and good governance (for instance, access to and participation in decision-making processes). Sectors and jurisdictions throughout the world have begun the process of building adaptive capacity through diverse technical, legislative and social approaches.

Recent adaptation literature, such as the national reports from Natural Resources Canada and Health Canada, promotes the concept of enhancing adaptive capacity as a "no-regrets" approach that reduces vulnerabilities and delivers benefits, regardless of climate changes. National and provincial legislation, and formalized adaptation plans such as Germany's *klimazwei* (climate change and adaptation) program (see Section 6.4.3) and Australia's Farming Future initiative (see Section 4.1.3), are driving many of the local initiatives cited in this report, while others originated at the municipal or community level. Key adaptive capacity approaches include:

Introducing legislation, market-based instruments, codes and standards

- Rewarding and discouraging behaviour through incentives and penalties.
- Updating land-use planning regulation, codes and standards for buildings and infrastructure.

Creating partnerships and collaborations

- Cross-sectoral task forces/working groups comprising local and provincial agencies, stakeholders, researchers, academics, developers, planners, health care workers, etc.

Building and sharing knowledge

- Ongoing updates of relevant climate science and observational data and trends.
- Transfer of ongoing updated knowledge to decision makers and the general public.
- Demonstration projects and pilots.
- Review and assessment of existing policies and programs to assess vulnerability to impacts.

Developing planning and decision-support tools

- Tools (e.g. databases, guides, web portals, checklists, satellite images) to provide key information needs and guidelines for complex management decisions.
- Visual tools to raise awareness about the potential impacts of climate change.

Developing ecosystem-based approaches

- Establishment of amended boundaries or protected areas to maintain ecosystem representation as ecosystems shift over time.
- Increased ecosystem resilience to ensure the continued provision of ecosystem goods and services (e.g. fresh water, soil stability).

Providing transitional assistance

- Assistance in the form of training programs.
- Assistance in the form of transitional income support.

Many of the selected practices and initiatives in this report are illustrative of one or more of these approaches. Selected international and Canadian examples are provided in the chart below:

Selected examples of initiatives and key elements to building adaptive capacity
Legend: √ indicates that element is included in initiative

Selected initiative	Introducing legislation, market-based instruments, codes and standards	Creating partnerships and collaborations	Building and sharing knowledge	Developing planning and decision-support tools	Developing ecosystem-based approaches	Providing transitional assistance
International Polar Year EALÁT project						
Emerging Diseases in a changing European Environment (EDEN) project						
Germany's Adaptation Strategies for Sustainable Forest Management under Climate Change – Decision Support System "Forest and Climate Change"						
England's Making Space						

for Water program						
Management of Alaskan fisheries through North Pacific Fishery Management Council						
Australia's Farming Future Initiative and Climate Change Adjustment Program						
Participatory Integrated Assessment of Water Management and Climate Change in the Okanagan Basin project						

Notes

[1] The project "Assessment and prevention of acute health effects of weather conditions in Europe" (PHEWE) was a three-year pan-European collaboration between epidemiologists, meteorologists and experts in public health. It investigated the relationship between temperature and mortality in 16 European cities, representing a wide range of climatic, socio-demographic and cultural characteristics. The use of a standardized methodology allowed for direct comparison between cities (Michelozzi et al., 2007).

[2] EuroHEAT is a project coordinated by the Global Change and Health Programme of the WHO Regional Office for Europe that quantified the health effects of heat in European cities and identified options for improving the preparedness and response of health systems to protect health from heat waves. Its activities contributed to the implementation of the Declaration of the Fourth WHO Ministerial Conference on Environment and Health, and of the EC Environment and Health Action Plan (European Commission web site, n.d.).