SYNTHESIS

Synthesis

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SUMMARY

Adaptation involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, in order to moderate harm or take advantage of new opportunities. It is a necessary complement to the reduction of greenhouse gas emissions in addressing climate change. Adaptation in Canada will be informed by knowledge of current and projected impacts of, and vulnerability to, changing climate, as well as lessons learned from practical adaptation experiences. The following bullets represent key conclusions arising from this national-scale assessment of climate change impacts and adaptation, and are discussed in the subsequent sections of this synthesis.

- The impacts of changing climate are already evident in every region of Canada.
- Climate change will exacerbate many current climate risks, and present new risks and opportunities, with significant implications for communities, infrastructure and ecosystems.
- Climate change impacts elsewhere in the world, and adaptation measures taken to address these, will affect Canadian consumers, the competitiveness of some Canadian industries, and Canadian activities related to international development, aid and peace keeping.
- Impacts of recent extreme weather events highlight the vulnerability of Canadian communities and critical infrastructure to climate change.
- Adaptive capacity in Canada is generally high, but is unevenly distributed between and within regions and populations.
- Resource-dependent and Aboriginal communities are particularly vulnerable to climate changes. This vulnerability is magnified in the Arctic.
- Some adaptation is occurring in Canada, both in response to, and in anticipation of, climate change impacts.
- Integrating climate change into existing planning processes, often using risk management methods, is an effective approach to adaptation.
- Barriers to adaptation action need to be addressed, including limitations in awareness and availability of information and decision-support tools.
- Although further research will help to address specific knowledge gaps and adaptation planning needs, we have the knowledge necessary to start undertaking adaptation activities in most situations now.

INTRODUCTION

The impacts of changing climate are already evident in Canada and globally. Climate change will continue for many decades, and even centuries, regardless of the success of global initiatives to reduce greenhouse gas emissions (mitigation). Adaptation is a necessary complement to mitigation in addressing climate change (Figure SR-1). Adaptation involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, with the goals of moderating harm and taking advantage of new opportunities (Box SR-1). The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC AR4) states that, while neither adaptation nor mitigation actions alone can prevent significant climate change impacts, taken together they can significantly reduce risks. It highlights that there is no optimal mix between adaptation and mitigation, and that climate change policy is not about making choices between the two. Mitigation is necessary to reduce the rate and magnitude of climate change, while adaptation is essential to reduce the damages from climate change that cannot be avoided (Intergovernmental Panel on Climate Change, 2007; Klein et al., 2007).

In this report the term 'climate change' refers to any change in climate over time, whether it is the product of natural factors, human activity or both. This usage is the same as that of the Intergovernmental Panel on Climate Change, but it differs from the usage in the United Nations Framework Convention on Climate Change, which restricts the term to climate changes that can be directly or indirectly related to human activity and are additional to natural climate variability. The term 'changing climate' is used sometimes in this report to highlight that these changes are ongoing.

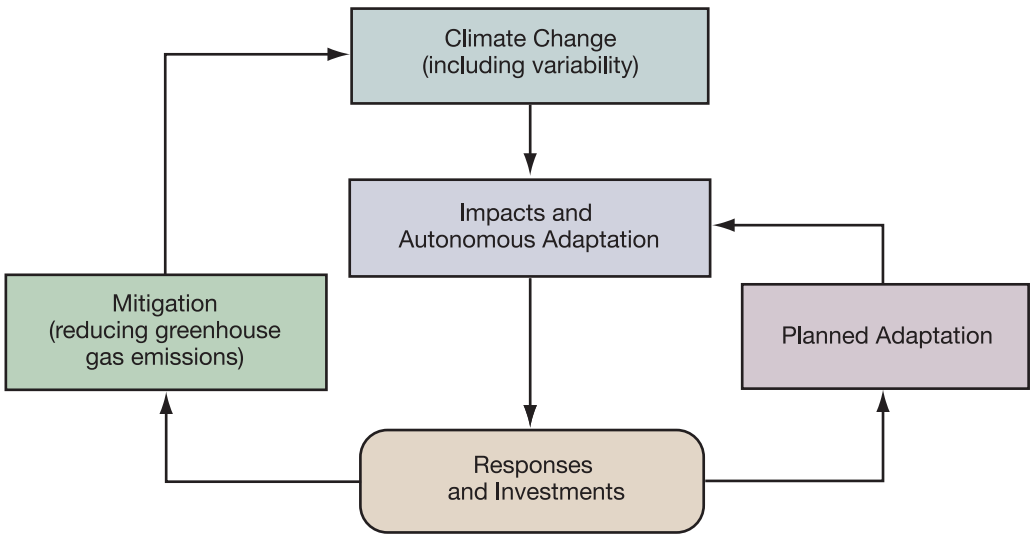


FIGURE SR-1: Adaptation and mitigation in the context of climate change (*modified from* Smit et al., 1999).

This synthesis of *From Impacts to Adaptation: Canada in a Changing Climate 2007* presents conclusions regarding current and future impacts of, and vulnerabilities to, climate change in Canada. It also discusses adaptation actions being taken now to reduce risks and take advantage of opportunities associated with changing climate, and those that could be undertaken in future. Although the identification of specific priority issues for policy and program action requires analyses beyond the scope of this scientific assessment, the conclusions of this assessment do provide input into that detailed analysis. The synthesis is based on information contained within the individual chapters of the report — particularly Chapters 3 through 8, which present regional analyses for Northern Canada, Atlantic Canada, Quebec, Ontario, the Prairies and British Columbia, and Chapter 9, which examines the implications for Canada of climate change impacts and adaptation elsewhere in the world. The key findings of these chapters are summarized in Box SR-2. The remainder of the synthesis provides an integrative analysis of that information at the national scale. As appropriate, the conclusions are linked to findings of the IPCC AR4, demonstrating that the challenges that climate change adaptation presents to Canada are shared with other countries and regions, and that there is a great deal to be learned through the sharing of adaptation experiences.

Information on recent and projected changes in climate is provided in Chapter 2 of the assessment, as well as in the six regional chapters, which discuss current climate, recent climate trends and future projections as input to analyses of sensitivity and vulnerability to climate change.

BOX SR-1

What is adaptation to climate change?

Adaptation to climate change is any activity that reduces the negative impacts of climate change and/or takes advantage of new opportunities that may be presented. Adaptation includes activities that are taken before impacts are observed (anticipatory) and after impacts have been felt (reactive; Table SR-1). Both anticipatory and reactive adaptation can be planned (i.e. the result of deliberate policy decisions), and reactive adaptation can also occur spontaneously. In most circumstances, anticipatory planned adaptations will incur lower long-term costs and be more effective than reactive adaptations.

Table SR-1: Different types of adaptation (*modified from* Smit et al., 1999).

ADAPTATION			
Based on	Type of adaptation		
Intent	Spontaneous	Planned	
Timing (relative to climate impact)	Reactive	Concurrent	Anticipatory
Temporal scope	Short term	Long term	
Spatial scope	Localized	Widespread	

Adaptation will usually not take place in response to climate change alone, but in consideration of a range of factors with the potential for both synergies and conflicts. Successful adaptation does not mean that negative impacts will not occur, only that they will be less severe than would be experienced had no adaptation occurred. In deciding what adaptation option is most appropriate for a particular situation, attention must be paid to feasibility, likelihood and mechanisms for uptake.

BOX SR-2

SUMMARY OF CHAPTER KEY FINDINGS

NORTHERN CANADA (Chapter 3)

- Current levels of exposure and sensitivity to climate-related changes, as well as limitations in adaptive capacity, make some northern systems and populations particularly vulnerable to the impacts of climate change.
- Climate-induced changes in permafrost, sea ice, lake ice and snow cover have large implications for infrastructure maintenance and design.
- Climate changes will result in shifts in species availability, accessibility and quality, with consequences for biodiversity and human populations that rely on these resources.
- Increased navigability of Arctic marine waters and expansion of land-based transportation networks will bring both opportunities for growth in a range of economic sectors and challenges associated with culture, security and the environment.
- Maintaining and protecting aspects of traditional and subsistence ways of life in many Arctic Aboriginal communities will become more difficult in a changing climate.

ATLANTIC CANADA (Chapter 4)

- Changing climate will result in more storm events, increasing storm intensity, rising sea level, higher storm surges, and more coastal erosion and flooding, affecting coastal communities and their infrastructure and industries.
- Water resources will come under increasing pressure as conditions shift and demands change in response to both climatic and non-climatic factors.
- Impacts on marine fisheries will extend beyond fish species to include numerous aspects of fishery operations, such as transportation, marketing, occupational health and safety, and community health and well-being.
- Although higher temperatures and longer growing seasons could benefit agriculture and forestry, associated increases in disturbances and moisture stress pose concerns.
- Vulnerability of Atlantic communities can be reduced through careful planning, especially in coastal regions and through adaptation focused on limiting exposure to sea-level rise.

QUEBEC (Chapter 5)

- The largest changes in climate in this region are anticipated to occur in Northern Quebec, exacerbating existing problems relating to natural disasters and critical infrastructure, and challenges in maintaining traditional ways of life.
- Climate change impacts on the natural environment will adversely affect ecosystem health, and have especially significant consequences where natural resources are a key component of the economy. Some impacts could be beneficial for certain economic sectors, including hydroelectricity and forestry.
- In the maritime region, there will likely be increased shoreline erosion along the Gulf of St. Lawrence and the St. Lawrence River estuary, where most of the region's social and economic activity is concentrated.
- In southern Quebec, an increase in the frequency, intensity or duration of extreme weather conditions would increase risks for the aging built environment, vulnerable populations and communities in areas exposed to natural hazards.
- Adaptation offers many possible solutions for reducing adverse impacts. Quebec's increasingly diversified knowledge economy provides a high degree of adaptive capacity. Little is generally known about the costs and limitations of adaptation, particularly in the long term.

ONTARIO (Chapter 6)

- Climate-related disruptions to critical infrastructure, including water treatment and distribution systems, energy generation and transmission, and transportation have occurred throughout the province and are likely to become increasingly frequent in the future.
- Water shortages have been documented in southern regions of the province, and are projected to become more frequent as summer temperatures and evaporation rates increase.
- Climate-related events, such as extreme weather, heat waves, smog episodes and ecological changes that support the spread of vector-borne diseases, all present risks to the health of Ontario residents.
- Remote and resource-based communities have been severely affected by climate-related events

that have caused repeated evacuations, disrupted vital transportation links and stressed forest-based economies. The impacts are expected to increase in the future.

- Ontario's ecosystems are currently stressed by the combined influence of changing climate, human activities and natural disturbances.
- Ontario has a strong capacity to adapt to climate change; however, this capacity is not uniform across the region and between sectors.

PRAIRIES (Chapter 7)

- Increases in water scarcity represent the most serious climate risk in the Prairie provinces.
- Ecosystems will be impacted by shifts in bioclimate, changes in fire and insect disturbances, stressed aquatic habitats and the introduction of non-native species, with implications for livelihoods and economies dependent on ecological services.
- The Prairies are losing some advantages of a cold winter. Cold winters limit pests and diseases, facilitate winter operations in the forestry and energy sectors, and provide access to remote communities through the use of winter roads.
- Communities dependent on agriculture and forestry are highly sensitive to climate variability and extremes. Drought, which can have associated economic impacts of billions of dollars, wildfire and severe floods are projected to occur more frequently in the future.
- Adaptive capacity, though high, is unevenly distributed, resulting in differing levels of vulnerability within the region.
- Although adaptation processes are not well understood, institutions and civil society will play a key role in mobilizing adaptive capacity by building on several recent initiatives that enhance resilience.

BRITISH COLUMBIA (Chapter 8)

- Many regions and sectors of British Columbia will experience increasing water shortages and increasing competition among water uses (for example, hydroelectricity, irrigation, communities, recreation and in-stream flow needs), with implications for transborder agreements.
- Extreme weather and related natural hazards have impacted, and will continue to impact, critical infrastructure, affecting communities, industries and the environment.
- British Columbia's forests, forest industry and forest-dependent communities are particularly vulnerable to climate-related risks, including pest infestations and fire.
- Climate change will continue to exacerbate existing stresses on British Columbia's fisheries. The vulnerability of Pacific salmon fisheries is heightened by the unique social, economic and ecological significance of these species.
- British Columbia's agricultural sector is facing both positive and negative impacts from climate change, with more frequent and sustained drought being the greatest risk.
- Integrating climate change adaptation into decision-making is an opportunity to enhance resilience and reduce the long-term costs and impacts of climate change.

CANADA IN AN INTERNATIONAL CONTEXT (Chapter 9)

- Climate change is already affecting the residents, economies and environments of all regions of the world. These impacts, which are primarily related to extreme climate events and changes in water resources, are mostly adverse and are expected to continue and intensify in the future.
- Diseases currently prevalent in warmer climates will become greater threats in Canada as a result of greater incidence of disease and vectors in countries that are involved in trade and travel with Canada.
- The impacts of climate change and the adaptation measures that other countries take to respond to them can affect Canada in a number of ways, with potentially significant implications for competitiveness, health, tourism, disaster relief, development aid and peace-keeping.
- As a developed country, Canada will face increasing demands to support disaster relief efforts and to help developing countries adapt to climate change.

IMPACTS

The impacts of changing climate are already evident in every region of Canada.

Impacts of changing climate on many physical and biological systems, such as ice and snow cover, river, lake and sea levels, and plant and animal distributions, are unequivocal (Table SR-2) and have been documented in other recent climate change assessments (Intergovernmental Panel on Climate Change 2001, 2007; Arctic Climate Impact Assessment, 2005). In addition, increases in the occurrence of heat waves, forest fires, storm-surge flooding, coastal erosion and other climate-related hazards are consistent with observed climate trends. Many of these impacts directly influence human systems. For example, decreases in the thickness and duration of lake and river ice have significantly impacted the viability of many winter road networks that provide access to remote communities and mine sites in northern Canada (including the northern parts of many provinces; Chapters 3, 5, 6 and 7), while coastal erosion has impacted buildings and critical infrastructure, and threatened cultural sites on all of Canada's marine coasts (Chapters 3, 4, 5 and 8).

There is also strong evidence that climate change has been a contributing factor to a number of other environmental, social and economic issues. These include the unprecedented outbreak of mountain pine beetle in British Columbia, which encompassed over 9.2 million ha of forest in 2006, and is now spreading eastward into Alberta. Although fire suppression and other historical factors have contributed to this outbreak, the recent predominance of hot summers that favour beetle reproduction, and mild winters that allow their offspring to survive, have been critical factors (Figure SR-2; Chapter 8). Since 1990 in parts of Atlantic Canada, sea lettuce has been spreading, rendering estuaries less suitable for shellfish or finfish and less attractive to residents and tourists. This spread has been related, in part, to climate-driven reductions in freshwater inflow during summer (Chapter 4).

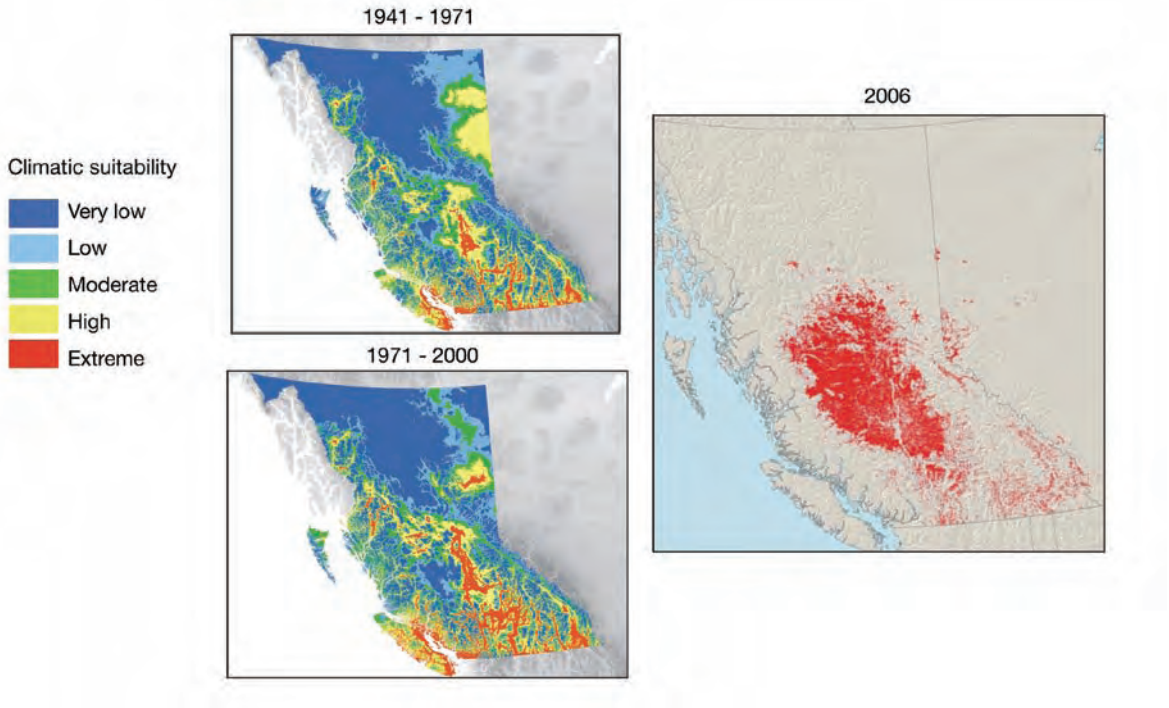


FIGURE SR-2: *Left:* Historical distributions of climatically suitable habitats for the mountain pine beetle (MPB) in British Columbia (*adapted from* Carroll et al., 2004). Areas with 'very low' suitability are unsuitable for MPB, whereas 'extreme' areas are those considered climatically optimal. ***Right:*** Total area affected by mountain pine beetle in British Columbia in 2006 (Natural Resources Canada, 2007).

TABLE SR-2: Some observed impacts of changing climate on physical and biological systems in Canada.

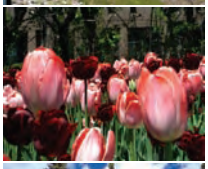
	System and nature of impact	Examples	Relevant chapters
	**Glacier cover** – mass and area; widespread reductions with local variability	• widespread retreat since late 1800s in western Canada, since 1920s in Arctic • glaciers in BC are currently retreating at rates unprecedented in the last 8000 years • estimated loss of ice mass in Canadian Arctic of 25 km^3/a for period 1995–2000	3, 7, 8 and 9
	**Snow cover** – reduced annual extent and duration	• 10% decrease in extent in Northern Hemisphere for period 1972–2003 • decrease of 20 days in duration of snow cover in Arctic since 1950	2, 3 and 5
	**Sea-, lake- and river-ice cover** – reduced extent and duration	• 3% per decade decrease in annual average area of sea ice in Northern Hemisphere for period 1978–2003 • reduction of ice cover season on Great Lakes by 1–2 months during past 150 years	2, 3, 4, 5 and 6
	**Permafrost conditions** – warming and deepening of annual thaw layer	• most significant warming in western Arctic • at least 1°C increase in surface permafrost temperature since 1990 in northern Quebec • increase in summer thaw penetration in the 1990s	2, 3, 5 and 7
	**River and lake levels** – changes in water levels and timing of peak flow events	• decline in summer and fall runoff in Prairies, leading to lower lake and river levels at those times • trend towards earlier spring runoff	2, 5, 6, 7, 8 and 9
	**Plant phenology** – events occurring earlier	• 26-day shift to earlier onset of spring over the past century in Alberta • 5–6 day advance since approximately 1959 in the onset of phenological spring in eastern North America	2, 4, 5, 6 and 7
	**Plant productivity** – lengthening growing seasons and increased productivity	• greater productivity rates of spruce and poplar in Quebec • lengthening of growing season for crop production	5
	**Distribution of some animal species** – northward or upslope shifts in terrestrial ecosystems, shifts towards warmer thermal regimes in freshwater ecosystems	• increasing abundances of cool and warm water fish species relative to cold water species	3 and 6
	**Coastal erosion** – enhanced as a result of decreased ice cover, sea-level rise, increased storminess and non-climatic factors	• accelerated erosion and degradation of the dunes and coastline throughout the Gulf of St. Lawrence, northeastern Prince Edward Island and southwestern, western and eastern Newfoundland	3, 4, 5 and 8

Photo credits: All images are from Natural Resources Canada, except: Glacier cover from Ben W. Bell, Sea-, lake- and river-ice cover from Environment Canada, and Distribution of some animal species from Government of Yukon.

Climate change will exacerbate many current climate risks and present new risks and opportunities, with significant implications for communities, industry, infrastructure and ecosystems.

Climate change is evidenced by changes in average conditions as well as by changes in climate variability and extreme climate events. Many of the most severe and costly impacts will be associated with projected increases in the frequency and magnitude of extreme climate events and associated natural disasters, including flooding due to high-intensity rainfall and storm surges, ice and wind storms, heat waves and drought (Chapters 2–9). An understanding of future climate extremes is particularly important for the design and maintenance of infrastructure, emergency management, and community health and safety (Chapters 5 and 6).

Gradual changes in average temperature, precipitation and sea level also affect community and ecosystem sustainability. Some of the most significant and pervasive impacts in Canada will be related to water resources. Water-stressed areas will expand due to decreased runoff in many areas resulting from changes in precipitation and increased evapotranspiration (Chapter 2), while reduced water quality and quantity will be experienced on a seasonal basis in every region of Canada (Chapters 3–8). Increasing demands on water resources for agriculture, energy production, communities and recreation will have to be managed in consideration of ecosystem needs (Chapters 4–8). In addition to increasing the impacts already observed, changing climate will bring new risks to some areas, such as the introduction of vector-borne diseases into areas where climate conditions presently inhibit survival of the vector host (Chapters 5, 6 and 9). Climate-related impacts on ecosystems will present new challenges to the management of protected areas (Chapters 6, 7, 8).

Climate change will also bring opportunities, including longer and warmer growing seasons, which could increase productivity and allow cultivation of new and potentially more profitable crops and tree species (Chapters 4–8). Agriculture and forestry in Canada are susceptible to changes in disturbance regimes and more frequent drought, demonstrating the need for timely and effective adaptation (Chapters 7 and 8). Decreased sea-, river- and lake-ice cover permit longer shipping seasons, although lower lake and river levels could have negative impacts on transportation (Chapters 3, 4 and 6). Increased marine transport in the Arctic would provide opportunities for economic growth, along with environmental and security risks (Chapter 3).

Impacts will be cumulative and frequently synergistic (Figure SR-3). For example, increased frequency and magnitude of heat waves will result in increased peak electricity demand for air conditioning, while decreased runoff from mountain glaciers in western Canada and lower water levels on the Great Lakes are likely to reduce potential for hydroelectricity generation in these areas. Combined with anticipated increases in demand for electricity related to population and economic growth, changing climate could result in increased numbers of black-out and brown-out events (Chapters 6 and 8). The cumulative nature of impacts, and associated cascading uncertainties, makes it likely that climate change will produce 'surprises' — impacts related to the crossing of critical thresholds that have not been anticipated. As is the case for all human and managed natural systems, the magnitude of impacts can be reduced through adaptation.

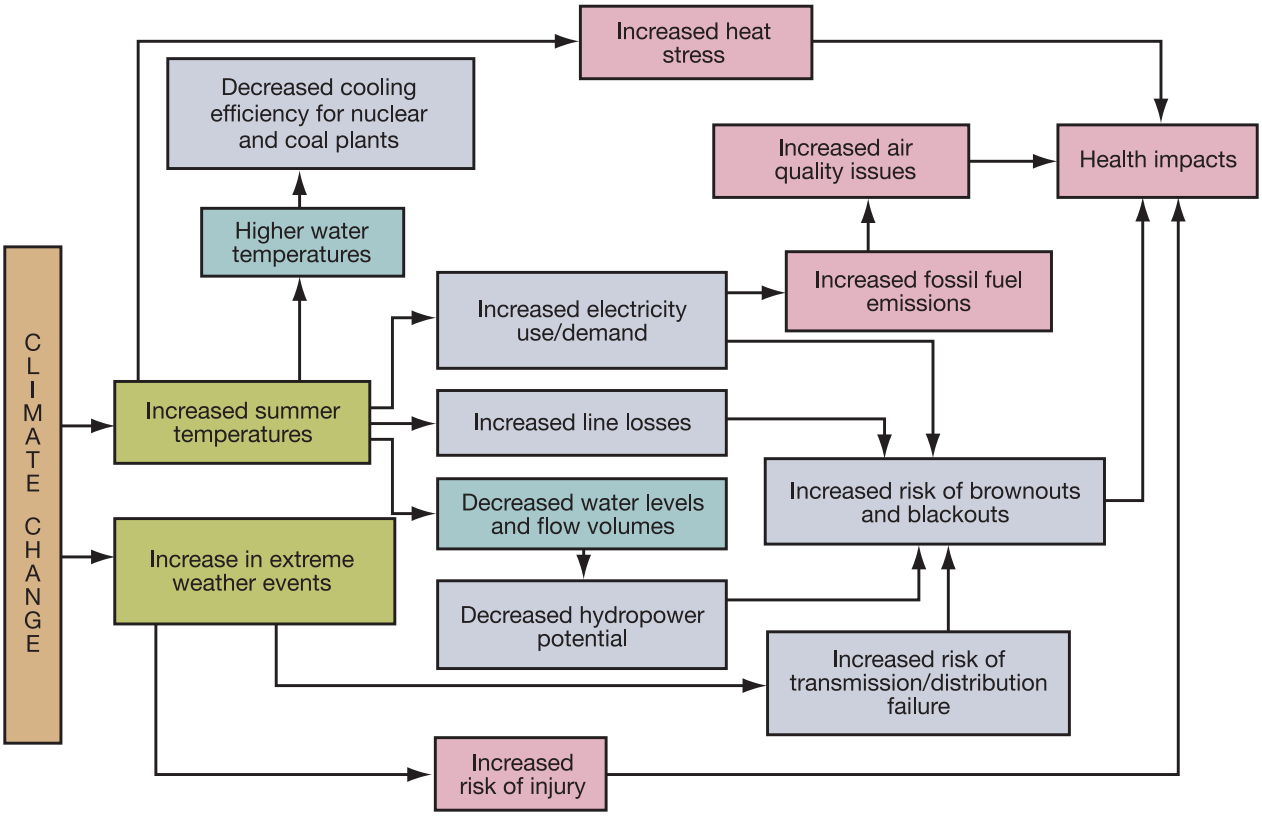


FIGURE SR-3: Illustration of the potential cumulative and synergistic impacts of climate change, using example of how impacts on the energy sector can amplify the direct impacts of climate change on human health.

Climate change impacts elsewhere in the world, and adaptation measures taken to address these will affect Canadian consumers, the competitiveness of some Canadian industries, and Canadian activities related to international development, aid and peace keeping.

Climate change impacts elsewhere in the world will affect supply-demand dynamics and the competitive advantage of some Canadian industries. This will influence the net economic costs of climate change in Canada. For example, although forest productivity may increase in Canada, greater productivity increases in other countries could result in lower forestry-product prices on the global market and a reduced share of the market for Canadian producers (Chapter 9). For tourism, climate change may reduce the attractiveness of some Canadian natural areas (Chapters 3, 4, 5, 7 and 8). When examined in a global context, however, tourism in Canada is expected to be positively impacted by climate change, as warmer temperatures would make Canada a more attractive destination for foreign tourists and encourage more Canadians to forgo vacations to tropical locations due to less severe winters in Canada (Chapter 9).

Climate changes elsewhere in the world will also influence Canadian humanitarian and development activities. In addition to commitments to assist developing countries in their efforts to adapt to climate change, changing climate will increase the need for disaster relief. Observed trends toward increases in the frequency of disasters related to extreme climate events (Figure SR-4) are expected to continue in the future. Extreme events are also expected to become more intense. Environmental stress and scarcity issues (primarily related to food and water) caused by climate changes can exacerbate political, social, economic, ethnic, religious or territorial conflicts, leading to increased political instability and displacement of populations (Chapter 9).

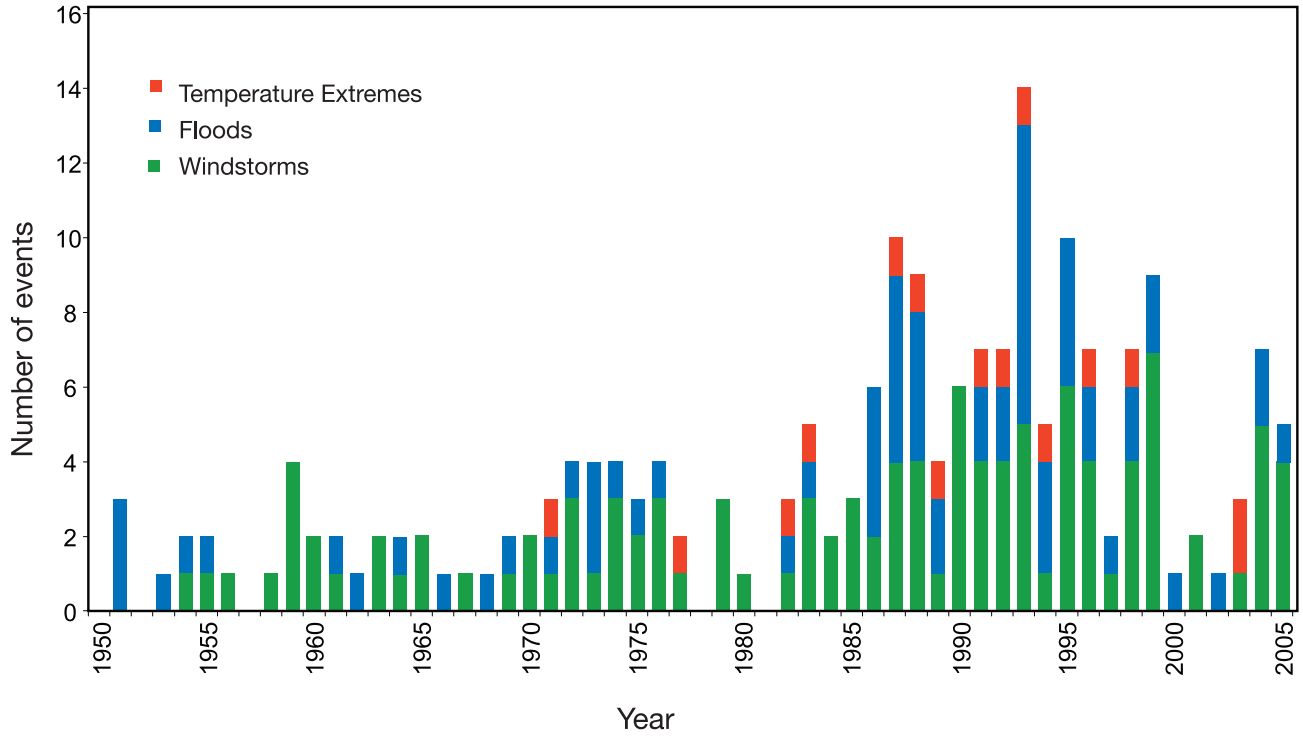


FIGURE SR-4: The number of global climate-related disasters, by event, from 1950 to 2006 (*data from* Munich Reinsurance, 2006).

VULNERABILITY

Impacts of recent extreme weather events highlight the vulnerability of Canadian communities and critical infrastructure to climate change.

The economic costs resulting from extreme weather events in Canada in the past decade (since 1996) have been greater than for all previous years combined. Costs reaching hundreds of millions and even billions of dollars are associated with flooding, wind, hail and ice storms, hurricanes, tornados and wild fires in all regions of southern Canada (Table SR-3), arising from property damage and disruptions in the production and flow of goods and services. Prolonged periods of unusual weather, such as drought, can also result in high economic costs. Six of the ten most costly disasters in Canadian history have been droughts (Public Safety Canada, 2005). The national-scale drought of 2001–2002 resulted in Canada's gross domestic product being reduced by about $5.8 billion, as well as more than 41 000 job losses (Chapter 7). While it is not possible to attribute individual weather events to changing climate, such costs illustrate that Canadian communities and infrastructure are vulnerable to such events. This vulnerability is likely to increase, since climate models project increases in the frequency and magnitude of many types of extreme weather (Chapters 2 and 9).

Extreme weather events affect the health and well-being of Canadians, as they frequently involve job losses, loss of assets, displacements, physical injuries and illnesses, psychological disorders, and loss of lives. The 1998 ice storm resulted in 945 injuries, while wildfires in British Columbia and Alberta resulted in an estimated 45,000 displacements in 2003, both of which are records for natural disasters in Canada (Table SR-3). Heavy rainfall following a period of drought was a contributing factor to the *E. coli* outbreak in Walkerton, Ontario in 2000, which resulted in seven deaths and thousands of people becoming ill (Chapter 6).

TABLE SR-3: Recent costly weather events in Canada, excluding drought (*from* Public Safety Canada, 2005; Environment Canada, 2005; BC Provincial Government, 2003).

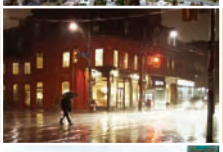
	Event and date	Region	Estimated costs	Deaths	Injuries	Evacuations	Relevant chapters
	**Ice storm**, 1998	Ontario, Quebec, Atlantic Canada	$5.4 billion	28	945	17 800	2, 4, 5, 6
	**Saguenay flood**, 1996	Quebec	$1.7 billion	10	0	15 825	2, 5
	**Calgary hailstorm**, 1991	Prairies	$884 million	0	0	0	2, 7
	**Red River flood**, 1997	Prairies	$817 million	0	0	25 447	2, 7
	**BC/Alberta wildfires**, 2003	British Columbia	$700 million	3	unknown	45 000	7, 8
	**Toronto extreme rain**, 2005	Ontario	>$500 million	0	0	0	6
	**Southern Alberta floods**, 2005	Prairies	>$400 million	4	unknown	>2000	7
	**Calgary hailstorm**, 1996	Prairies	$305 million	0	0	0	2, 7
	**Hurricane Juan**, 2003	Atlantic Canada	$200 million	8	unknown	unknown	2, 4

Photo Credits: Environment Canada, Library and Archives of Canada, Natural Resources Canada, Julian Brimelow and Sam Javanrouh.

Adaptive capacity in Canada is generally high but is unevenly distributed between and within regions and populations.

As a prosperous country with high levels of education, access to technology, and strong and effective institutions, Canada is well positioned to take action on adapting to climate change (Chapter 10). However, there are significant differences in the ability to adapt among different subregions and population groups, resulting in differing vulnerabilities to climate change (Box SR-3). Indeed, the IPCC AR4 has concluded that, in all regions of the world, no matter how prosperous, there are certain areas, sectors and communities that are particularly vulnerable to climate change (Wilbanks et al., 2007).

BOX SR-3

Vulnerability and adaptive capacity

Vulnerability to climate change "is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (Intergovernmental Panel on Climate Change, 2007, p. 21). Three factors influence the vulnerability of any system: 1) the nature of the climate changes to which it is exposed; 2) the climate sensitivity of the system; and 3) the capacity of that system to adapt to changed climate conditions. Therefore, while a sector, community or population may be exposed to significant climate changes, it is not considered vulnerable unless those climate changes could result in significant negative impacts, and it does not have the capability to undertake adaptation actions that would significantly reduce those impacts.

Although extensive research efforts have focused on projecting the magnitude and rate of climate changes, and on understanding the relationships between climate and biophysical systems, the characterization of adaptive capacity is a relatively new area of study. Adaptive capacity is influenced by a number of location-specific social, economic and institutional factors that act to either constrain or enhance the ability to adapt.

Within Canada, there are significant differences in the climate sensitivity of major economic sectors. Among the most sensitive sectors are those dependent upon renewable natural resources, including agriculture, fisheries, forestry and non-commercial food supply, as well as many aspects of tourism and recreation. Adaptive capacity similarly varies widely between sectors, communities and populations. Assessment of vulnerability must consider variability in all these factors.

Since vulnerability refers to the susceptibility of a system to harm, it does not consider the benefits that may result from changing climate. However, the ability to take advantage of such opportunities is also a function of adaptive capacity. Finally, where vulnerability is considered relatively low due to a high capacity to adapt, significant negative impacts may still occur if appropriate adaptation actions are not implemented. Although many societies have high adaptive capacity and the necessary financial resources, they have not taken effective action on adaptation to climate change, variability and extremes (Adger et al., 2007; Field et al., 2007).

Within Canada, differences in adaptive capacity and the perception of the risks presented by climate change have been noted between urban centres and rural/remote communities (Chapters 4–7). Both urban and rural centres have characteristics that enhance or limit adaptive capacity (Table SR-4). Urban centres tend to be places of greater wealth, higher education and skill sets, with easier access to technology and institutions. However, urban centres also tend to have greater reliance on critical energy, transportation and water infrastructure, more severe heat stress and air quality problems, and larger numbers of poor and elderly residents that result in vulnerabilities not shared by most rural communities (Chapters 5 and 6). Northern Canada, with its sparse, widely distributed population, evolving governance and institutions, and significant subsistence economy, has unique limitations to adaptive capacity (Chapter 3). Among population groups, the poor, the elderly, recent immigrants and Aboriginal peoples tend to face greater challenges in coping with climate changes, often due to limited financial resources, health problems and difficulties accessing technology and institutional services (Chapters 2–9).

Resource-dependent and Aboriginal communities are particularly vulnerable to climate changes. This vulnerability is magnified in the Arctic.

Agriculture, forestry, fishing and hunting are vitally important for the economic well-being of many subregions and communities where land- and resource-based activities remain the foundation of economic life. More than 1600 communities in Canada obtain 30% or more of their employment income from these sectors. The economic impacts of climate change at the community scale can be

TABLE SR-4: General differences in adaptive capacity, which affect vulnerability to climate change, between urban and rural communities (note that these do not apply in all cases; Chapters 3, 6, 7 and 8).

URBAN CENTRES	RURAL COMMUNITIES
Strengths	**Strengths**
• Greater access to financial resources • Diversified economies • Greater access to services (e.g. health care, social services, education) • Higher education levels • Well-developed emergency response capacity • Highly developed institutions	• Strong social capital • Strong social networks • Strong attachments to community • Strong traditional and local knowledge • High rates of volunteerism
Limitations	**Limitations**
• Higher costs of living • More air quality and heat stress issues • Lack of knowledge of climate change impacts and adaptation issues • High dependence on critical, but aging infrastructure • Issues of overlapping jurisdictions that complicate decision-making processes	• Limited economic resources • Less diversified economies • Higher reliance on natural resource sectors • Isolation from services and limited access • Lower proportion of population with technical training

significant (Chapter 2). The vulnerability of resource-dependent communities to climate change reflects the high climate sensitivity of many natural resource–based industries, limited economic diversification, and more restricted access to services (Chapters 2–8).

Aboriginal communities, many of which retain strong linkages to the land for both economic and cultural well-being, are also particularly vulnerable to climate change (Chapters 3–8). The subsistence economy may constitute up to 50% of the total income in these communities (Chapter 2). This vulnerability is magnified in Arctic regions, where rates of warming have been, and are projected to be, the greatest in the world. Changes in snow cover and sea-ice conditions, along with ecosystem impacts, are affecting access to traditional food supplies, while permafrost degradation and coastal erosion are affecting community infrastructure (Chapter 3 and 5). The adaptive capacity of many Aboriginal communities is presently being eroded by social, cultural, political and economic changes taking place in response to a range of stresses (Chapter 3). Significant impacts on traditional ways of life are unavoidable (Chapters 3, 4, 5, 7 and 8).

ADAPTATION

Some adaptation is occurring in Canada, both in response to, and in anticipation of, climate change impacts.

The regional chapters of this assessment note that some adaptation is already taking place in Canada. Adaptation initiatives have been undertaken at scales ranging from individuals and community groups to industry and governments (*see* Table SR-5 for examples). Much of this adaptation has been achieved through informal actions or strategies in response to specific events or circumstances, and where the capacity to take action existed (Chapters 4, 6, 8 and 10). There are also some examples of policy initiatives that provide a more structured approach to adaptation, such as the New Brunswick Coastal Areas Protection Policy (Chapter 4) and British Columbia Future Forests Ecosystem Initiative (Chapter 8).

Several adaptation initiatives address current risks and take into account the likely impacts of future climate change. These include most major new infrastructure development in northern Canada, such as mine sites,

TABLE SR-5: Selected examples of adaptation initiatives undertaken by individuals, community groups, industry and governments in Canada.

Actor	Example	Chapter
Individuals	• northerners are more frequently using insect repellents, bug nets and window screens to deal with the increased proliferation of insects.	3
	• hunters in the Arctic have increased the use of the global positioning systems to assist navigation in unpredictable or challenging weather.	3
	• homes and cottages are being built farther back from the coast.	4
	• residents of remote coastal communities are better prepared for shortages (i.e., power, food, transportation) due to recent experience with inclement weather conditions.	8
Community groups and organizations	• the community of Arctic Bay, NU, has shifted a portion of its narwhal quota from spring to summer hunts to reduce risks associated with ice break-up conditions, and to increase chances of hunting success.	3
	• residents of Pointe-du-Chêne, NB organized an emergency shelter in response to increasing flooding risk, and lobbied elected officials for less vulnerable road access.	4
	• a community group in Annapolis Royal, NS undertook mapping of potential storm surges that has resulted in revision of emergency measures.	4
Industry	• thermosyphons have been used in the construction of several major infrastructure projects in the North to induce artificial cooling of permafrost under warming conditions.	3
	• agricultural producers are purchasing crop insurance to offset losses caused by inclement weather.	6, 7, 8
	• some forestry companies have started using high-flotation tires on their vehicles to help navigate wet or washed-out conditions, allowing them to work in a wider range of weather conditions.	7
	• the forest industry in central BC is seeking to extract as much merchantable timber from forests affected by the mountain pine beetle epidemic as possible. The industry is also attempting to develop alternative markets for beetle killed wood.	8
Governments	• municipalities along the Quebec eastern North Shore have introduced regulations to limit development in zones vulnerable to coastal erosion and flooding.	5
	• Westbank, BC, has included climate change in the Trepanier Landscape Unit Water Management Plan.	8
	• the town of Vanderhoof, BC is engaged in a vulnerability assessment pilot project with the Canadian Forest Service with a specific goal of being able to plan adaptation to climate change.	8
	• water meters have been installed in the Southeast Kelowna Irrigation District and several Canadian cities (e.g. Kelowna, BC; Sudbury, ON; and Moncton, NB) to reduce water consumption.	4, 6, 8
	• Regina, SK has increased urban water conservation efforts.	7
	• smog and heat-health warning systems have been implemented in Toronto, ON, and Montréal, QC.	5, 6
	• Greater Vancouver Regional District is considering the impact of smaller snowpack on city water supplies in planning storage capacity management and upgrades.	8
	• Newfoundland is undertaking a thorough review of emergency management practices and response mechanisms.	4
	• New Brunswick's Coastal Areas Protection Policy establishes set-backs for permanent structures and could facilitate planned retreat	4 7
	• Alberta's Water for Life Strategy addresses climate change impacts in areas that are currently water-stressed.	8
	• British Columbia's Future Forests Ecosystem Initiative incorporates climate change adaptation into forest management.	10
	• research and networking has been supported through a range of federal, provincial and territorial programs.	

pipelines and large buildings, where adaptive solutions include the use of thermosyphons to induce artificial cooling of permafrost under warming conditions (Chapter 3). Other examples are the Toronto Hot Weather Response Plan and similar heat-health alert initiatives in other urban areas of Ontario and Quebec (Chapter 5 and 6). The Toronto plan was first developed in response to increasingly hot summers during the 1990s, and the devastating health impacts of heat waves elsewhere in North America. Since its introduction in 1999, the Toronto plan has been continually monitored, evaluated and refined, demonstrating that effective adaptation is a continuing process, which will often involve more than a single action.

Integrating climate change into existing planning processes is an effective approach to adaptation.

Rather than dealing with adaptation in isolation from other factors, integrating (mainstreaming) climate change into ongoing planning and policy decision-making can provide efficiencies in the use of both financial and human resources (Adger et al., 2007; Klein et al., 2007). In such cases, climate change represents one of many factors to be considered in decision-making. Examples of opportunities for mainstreaming, some of which are taking place at a very limited scale, include using recent climate trends and future projections to update building codes and standards to reduce infrastructure vulnerability (Chapter 6), factoring sea-level rise into coastal development planning (Chapter 4), considering the hydrological impacts of climate change on water supply and demand in water and energy conservation initiatives (Chapters 5, 6 and 8) and considering climate change impacts in the environmental assessment process for major development projects (Chapter 3). There are also a large number of programs and policies in the development or review phases dealing with natural resource management, land-use planning, and other climate-sensitive issues that provide ideal opportunities for mainstreaming of climate change adaptation (Chapter 6).

Risk management approaches help decision-makers deal with the uncertainties associated with climate change.

Making decisions regarding adaptation requires dealing with uncertainty. There are uncertainties inherent in projections of future climate, the impacts of these changes and future socioeconomic conditions (which strongly affect adaptive capacity). Risk management provides a means for dealing with these uncertainties in a manner routinely used for non-climatic factors. It offers a practical and credible approach (Figure SR-5) that is well understood by decision-makers for defining measures to achieve

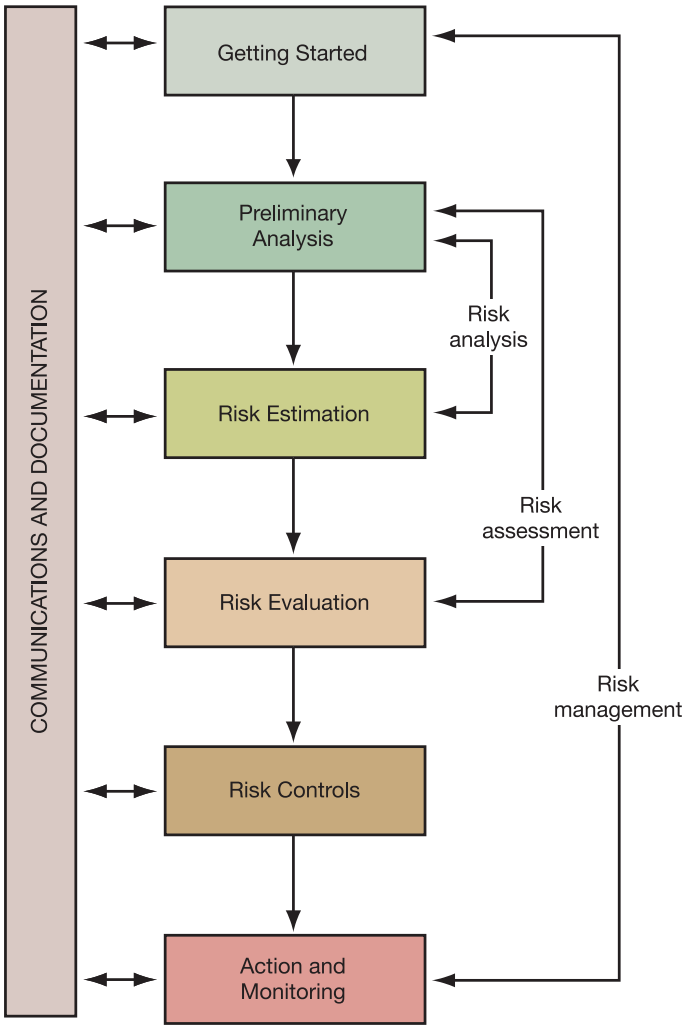


FIGURE SR-5: Steps in the risk management process (Bruce et al., 2006).

acceptable levels of societal risk, and is currently used in many professional fields. Examples of existing risk-based tools to support climate change adaptation include a screening tool for engineered facilities in permafrost terrain that has been used in many northern infrastructure projects since the late 1990s (Chapter 3), and a risk-based guide for supporting adaptation decision-making, which has recently been developed for Ontario municipalities (Chapter 6).

FUTURE DIRECTIONS

Barriers to adaptation action need to be addressed, including limitations in awareness and availability of information and decision-support tools.

Although several examples of recent and ongoing adaptation initiatives are highlighted in this assessment, the number of such actions is small relative to the scope of adaptation needs. As the rate of climate change increases, so does the urgency for adaptation action. Meeting this need will require addressing some of the existing barriers to adaptation actions, such as access to knowledge, data and decision-support tools; specific regulations or legislation that may limit adaptation options; and societal expectations. Some of these barriers to adaptation are jurisdiction or sector specific, involving regulations or application of best practices. Other barriers crosscut regions and sectors. These are best addressed through engagement of industry (including business and professional organizations), community groups, individuals and all orders of government, all of whom can serve as both facilitators and implementers of adaptation actions (Chapter 10). The crosscutting nature of climate change impacts (Figure SR-6) is a challenge in ensuring effective adaptation.

Moving forward on adaptation in Canada will involve building on the momentum established by existing initiatives, and taking new steps to promote and implement adaptation measures. Awareness-raising will be important for overcoming some barriers to action (Chapters 4, 5, 7 and 8). Many decision-makers need a clearer understanding of the risks that climate change presents, and of the local and regional benefits that adaptation provides. Mechanisms to enhance access to, and the sharing of, knowledge and experience contained within industry, academia, government and communities would help to facilitate adaptation decision-making, as would the development of tools to integrate climate change in planning and development processes (Chapters 2 and 10). Strategic approaches to adaptation would help maximize synergies and reduce potential for conflict between and within sectors, industries and regions. In some cases, decision-makers may choose to mandate and regulate consideration of climate change adaptation within their programs and policies (Chapter 10).

Although further research will help to address specific knowledge gaps and adaptation planning needs, existing knowledge is sufficient to start undertaking adaptation activities in most situations.

The chapters of this assessment reveal several research needs to support adaptation decision-making, including:

- quantitative economic analysis, including costs and benefits of impacts and of adaptation options;
- analyses of adaptation processes;
- enhanced climate and socioeconomic scenarios to support more detailed impact assessment and adaptation decision-making, as well as understanding of uncertainty associated with those scenarios;
- improved understanding of thresholds within both natural and human systems, beyond which adaptation is either ineffective or prohibitively expensive; and
- development of methods and tools to assist mainstreaming of climate change adaptation into sectoral planning processes.

The need for more research and the associated scientific uncertainties do not justify inaction. This is demonstrated by the fact that there are numerous examples of anticipatory adaptation in Canada and

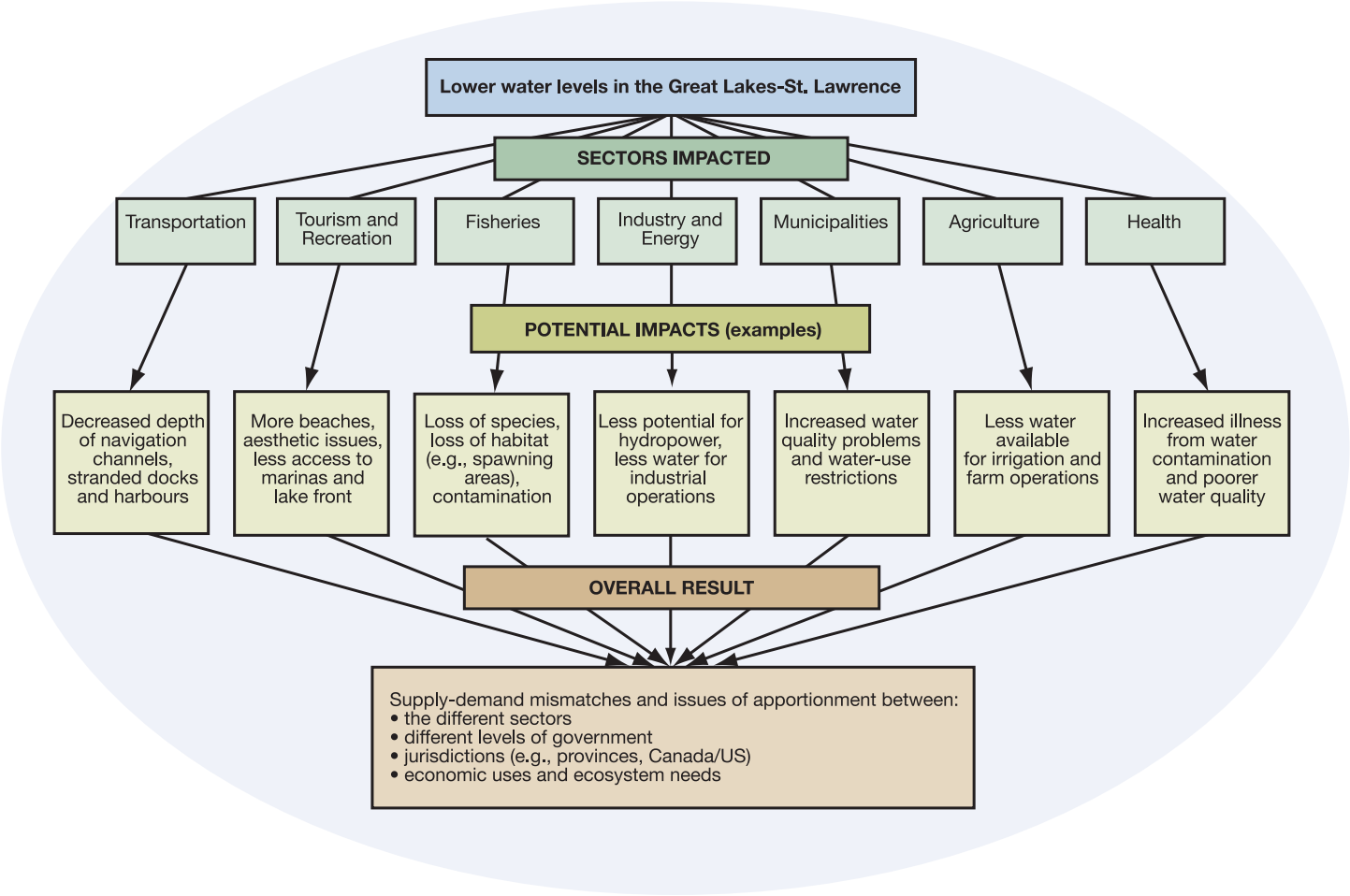


FIGURE SR-6: The crosscutting nature of climate impacts and adaptation, exemplified by lower water levels in the Great Lakes–St. Lawrence basin. Adaptation decisions in one sector will have significant consequences in several other sectors (Lemmen and Warren, 2004).

around the world. Adaptation measures that focus on reducing vulnerability to both current and future climate represent a logical first step that delivers benefits regardless of the rate of future climate changes. For example, adapting building and infrastructure design to reflect both recent climate trends and future projections, implementing water and energy conservation strategies to reduce demand, and reducing reliance on climate-sensitive sectors through economic diversification are actions that will produce both short- and long-term benefits, and enhance the resilience of communities and industry.

Adaptation is an ongoing process that requires greater attention in Canada and globally. In many cases, the responses needed to adapt to changing climate can be accomplished through existing processes and operations. The urgency for action depends on the vulnerability of the system, and the magnitude and life-cycle of investments being made. For example, billions of dollars are invested annually in Canada in climate-sensitive infrastructure that must function effectively and safely for many decades. Similarly, many industries and local governments are engaged in development planning extending 20 to 50 years into the future. Recognition that the climate of the future will differ from that of the present, and designing resilient systems to accommodate ongoing change, will enhance the value of these investments and the sustainability of development efforts.

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