

# CHAPTER 1

## Introduction

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*“We have options, but the  
past is not one of them.”*

(Sauchyn and Kulshreshtha, Chapter 7, this volume)

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The Earth's climate is changing. A growing body of scientific literature provides unequivocal evidence of global warming that is associated with changes in a wide array of other climate parameters, including precipitation patterns and extreme climate events (Intergovernmental Panel on Climate Change, 1995, 2001a, 2007a). These changes in climate are having observable impacts on both natural and human systems (Intergovernmental Panel on Climate Change, 2007b), with significant social, economic and environmental implications. This strong body of science has contributed to the development of a range of policy initiatives, at local to global scales, to address both the causes and the consequences of climate change.

While natural factors and human activity influence global climate, the burning of fossil fuels and changes in land-use patterns have been the dominant causes of climate changes observed since the mid-twentieth century (Intergovernmental Panel on Climate Change, 2007a). These human activities are expected to continue to dominate natural factors through the present century and beyond, leading to rates of global warming that far exceed those experienced in the past several thousand years (Intergovernmental Panel on Climate Change, 2007a). Reduction of greenhouse gas emissions, referred to as mitigation in the climate change literature, is critical to limiting the rate and magnitude of future climate change. However, due to the inertia of the Earth's climate system, we are already committed to some

further degree of climate change; temperatures and sea level will continue to rise regardless of global efforts to limit greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007a). As a result, adaptation is necessary to deal with the current and near-term impacts of climate change (Intergovernmental Panel on Climate Change, 2007b).

Adaptation typically provides local benefits that are realized relatively quickly after implementation, as opposed to mitigation, whose benefits are mostly global in scale and generally characterized by long lag times (Füssler and Klein, 2006), although co-benefits may be realized immediately. Mitigation and adaptation are essential and complementary policy responses to meeting the challenges presented by climate change (Figure 1). The amount and cost of adaptation required are a direct function of the rate and magnitude of climate change. Action on mitigation is necessary to “avoid the worst impacts of climate change” (Stern, 2006) and to enhance the feasibility of effective adaptation.

Adaptation refers to any modification in a system or process made in response to changing climate. Adaptation involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, with the goals of moderating harm or taking advantage of new opportunities (Intergovernmental Panel on Climate Change,

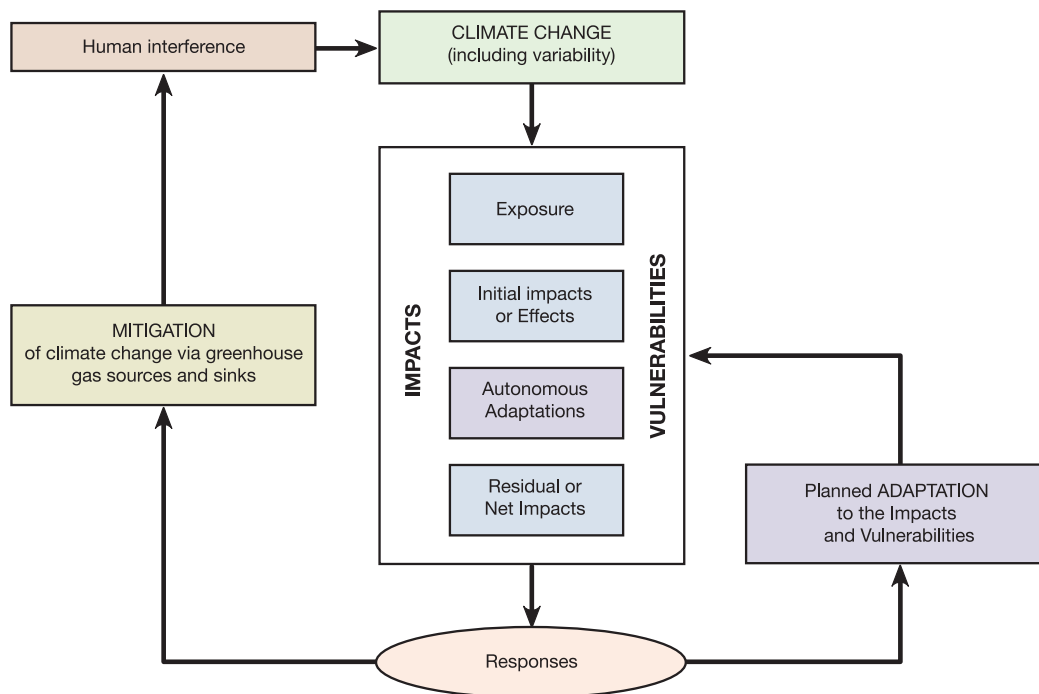


FIGURE 1: Adaptation and mitigation in the context of climate change (from Smit et al., 1999).

Throughout 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 that alters the composition of the atmosphere, and is additional to natural climate variability.

2001b). It is not a new concept: indeed, humans and ecosystems have always adapted to current and changing climates. In natural ecosystems, adaptation occurs spontaneously in response to climate impacts, whereas adaptation in human systems may also be undertaken in anticipation of changes in climate (Smithers and Smit, 1997). While the concept of adaptation is simple, the process of adaptation within human systems is complex. Adaptation actions are tremendously diverse and may involve, for example, behavioural changes; operational modifications; technological interventions; and revised planning and investment practices, regulations and legislation. They entail both monetary and non-monetary costs (cf. Smit et al., 2000; Füssel and Klein, 2006). The most appropriate adaptation actions for any given issue are determined by a wide range of social, economic and environmental factors (see Chapter 2). In many cases, adaptation will involve careful planning, guided by both scientific research on climate change and detailed understanding of the systems involved.

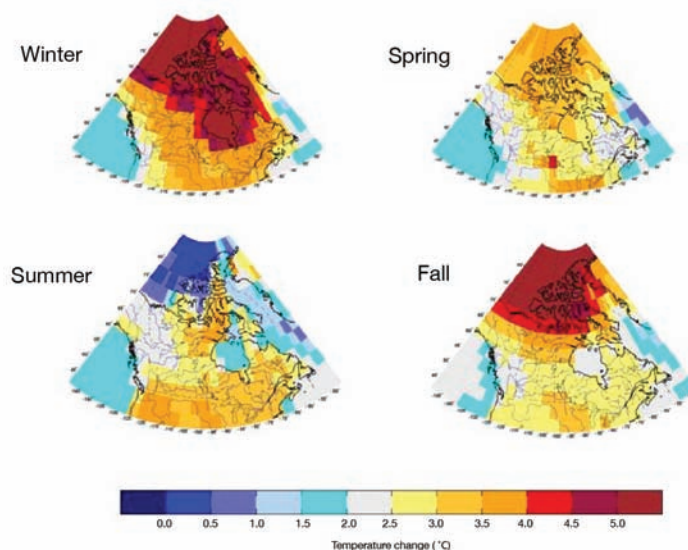
## A CANADIAN PERSPECTIVE

Climate change will affect most aspects of our lives in Canada. Our economic, social and general well-being are all linked, both directly and indirectly, to climate. For example, climate influences the crops we grow, the productivity of our forests, the spread of disease, the availability of water, the health of ecosystems and the stability of our infrastructure. Changing climate brings many new challenges and, with them, the need to re-examine long-standing practices and assumptions.

Our climate is characterized by high variability, on both seasonal and annual scales. Although our economy, health and infrastructure are generally well adapted to current climate conditions, our vulnerability to climate is clearly evidenced by the impacts resulting from extreme weather and climate events. Losses from recent individual weather-related disasters in Canada are often in the hundreds of millions of dollars. Consider, for example, costs associated with the 2003 summer wildfires in British Columbia and Alberta (\$400 million; Public Safety Canada, 2005), the 1991 and 1996 hailstorms in Calgary

(\$884 million and \$305 million, respectively; Public Safety Canada, 2005), the 1997 Red River Flood (\$817 million; Public Safety Canada, 2005) and 2003 Hurricane Juan in Halifax (\$200 million). Multibillion dollar disasters also occur, including the 1998 ice storm in eastern Canada (\$5.4 billion) and the Saguenay flood in 1996 (\$1.7 billion; Public Safety Canada, 2005). The 2001–2002 droughts, which were national in scale, resulted in a \$5.8 billion reduction in gross domestic product (Wheaton et al., 2005). Extreme weather and climate events impact the health and well-being of Canadians beyond monetary costs, as they frequently involve displacement, injuries and loss of life. For example, the 1998 ice storm led to the greatest number of injuries (945) and 17 800 evacuations (Public Safety Canada, 2005). Unusually heavy rainfall following a period of drought was a contributing factor to the *E. coli* outbreak in Walkerton, Ontario in 2000 that resulted in seven deaths and thousands of people becoming ill (O’Connor, 2002).

Increases in temperature and changes in precipitation have been observed across most of Canada over the past century. During the past 50 years (1948–2006; the period for which data are available for both northern and southern Canada), average national temperature has increased 1.3°C (see Chapter 2; Environment Canada, 2006). This is more than double the increase in mean global surface temperature during the same time interval. Canada is projected to continue to experience greater rates of warming than most other regions of the world throughout the present century (see also Chapter 2; Environment Canada, 2006). The magnitude of changes in climate will vary across the country, with northern regions and the south-central Prairies warming the



**FIGURE 2:** Seasonal change in temperature across Canada by 2050 (relative to 1961–1990), based on the median of seven global climate models and using the emissions scenarios of the Special Report on Emissions Scenarios (SRES).

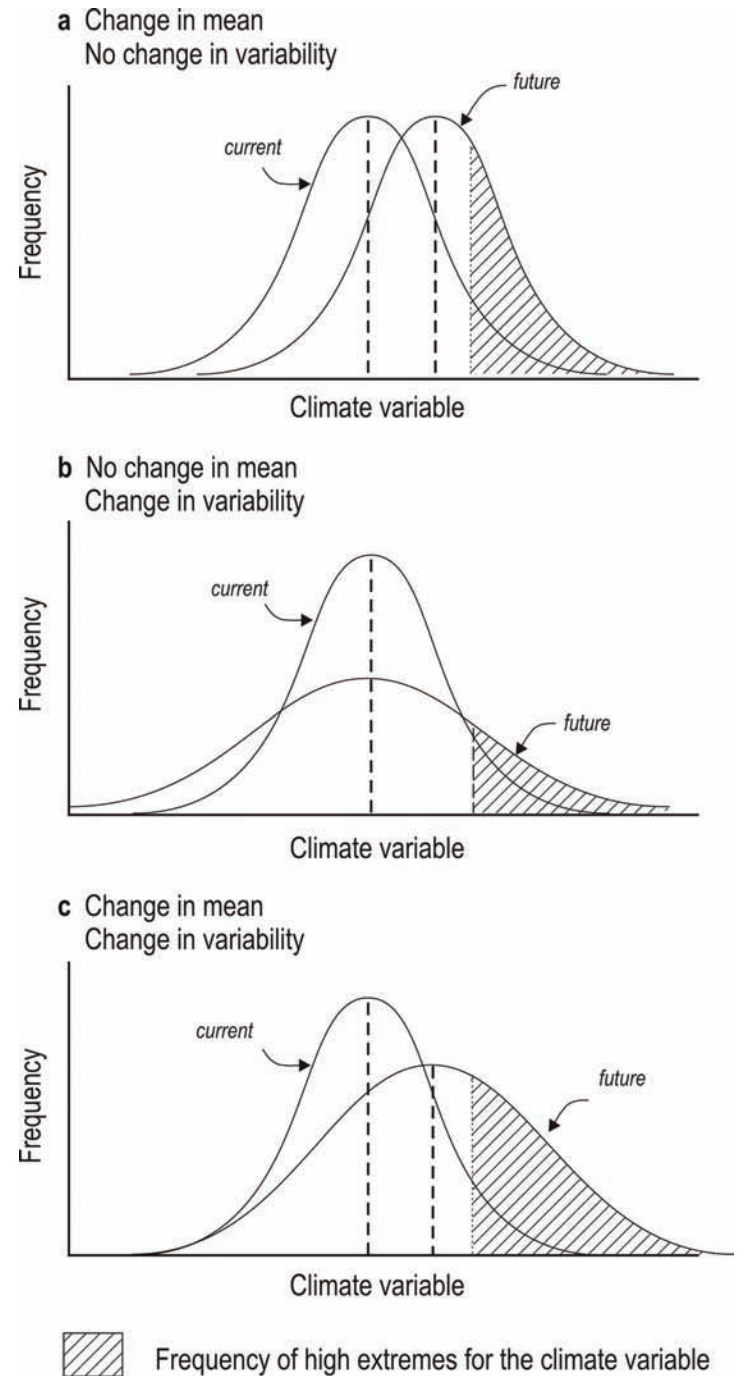
most (Figure 2). Average annual precipitation is also projected to rise, although increases in evaporation and transpiration by plants in some regions are expected to more than offset increases in annual precipitation, resulting in increased aridity. More frequent heavy precipitation events, less precipitation during the growing season and more precipitation during the winter are also projected for Canada.

Gradual shifts in average conditions will be accompanied by changes in climate variability and the frequency of extreme weather and climate events (Figure 3). These changes will result in both positive and negative social, economic and environmental impacts. For example, decreases in the frequency of periods of extreme winter cold benefit human health, energy consumption and many aspects of agriculture, but have significant negative impacts on forestry, northern transportation and non-renewable resource exploration. It is generally accepted that the most severe short-term, negative economic impacts will be associated with increased frequency of some extreme climate events, including extreme rainfall, drought and storm surges (Lemmen and Warren, 2004). Longer term economic impacts associated with changes in average conditions will be both positive and negative, and will depend, in part, on our ability to implement effective adaptation measures in a proactive manner (Lemmen and Warren, 2004).

Aggregate analysis at the continental scale suggests that moderate warming may bring net economic benefits to Canada, due to increased agricultural productivity, reduced cold-weather mortality, lowered winter energy demands, and benefits to tourism (e.g. Stern, 2006). However, such analyses rarely include consideration of the impacts of extreme climate events or the ability to adapt. Nor do they generally capture non-monetary consequences, such as impacts on cultural identity or ecosystem services. Most importantly, however, the impacts of a changing climate will not be experienced equally across the country, and some regions and communities are expected to suffer disproportionately, due to increased exposure to climate stress (e.g. northern and coastal communities), less resilience (e.g. due to limited resources or isolation) or a combination of the two.

Factors such as wealth, education level and access to information and technology are often used as indicators of a country's or region's capacity to undertake adaptation. Another equally important factor, although more difficult to quantify, is experience in dealing with a highly variable climate. By almost any measure, Canada is well positioned to address the challenge of climate change adaptation. Nonetheless, as illustrated in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Intergovernmental Panel on Climate Change, 2007b), all countries, even the most developed, have vulnerable regions, communities and sectors. Adaptation needs to be guided by an understanding of our vulnerabilities to current and future climate. This requires assessment of climate sensitivity and

resilience; how social, economic and political factors influence our ability to adapt; and the options and processes of adaptation. Through a regional approach, this report *From Impacts to Adaptation: Canada in a Changing Climate, 2007* analyzes these issues for Canada.



**FIGURE 3:** Changes in climate means and variability will increase the frequency of climatic extremes (from Smit and Pilifosova, 2003).

## KNOWLEDGE INTEGRATION AND ASSESSMENTS

There have been significant advances in impacts, adaptation and vulnerability research during the past decade, with levels of interest and the volume of scientific literature growing significantly. These advancements are reflected in the global-scale assessment reports of the Intergovernmental Panel on Climate Change and such multi-country initiatives as the Arctic Climate Impact Assessment (see Chapter 3; Arctic Climate Impact Assessment, 2005). The literature increasingly reflects the integrated nature of adaptation issues and the importance of analyses that crosscut both biophysical and social sciences. One of the most important developments is that the value of traditional knowledge in enhancing understanding of climate change impacts and adaptation has been recognized (e.g. Furgal et al., 2006; Nickels et al., 2006; Riewe and Oakes, 2006). Recognition that the local scale of many adaptation issues and applied nature of some research necessitates the early and frequent engagement of practitioners and stakeholders at the community scale also represents noteworthy progress. Despite these major advances, there remain significant shortcomings in the knowledge base, including the scarcity of quantitative analysis of the costs of both impacts and adaptation (see Stern, 2006).

Canada's first national-scale assessment of climate change impacts and adaptation, *The Canada Country Study*, was completed in 1998 (Environment Canada, 1998). The resulting eight-volume report (six regional volumes, one national sectoral volume and one volume on crosscutting issues) concluded that the environmental, economic and social costs in Canada related to both the impacts of, and adaptation to, climate change would be large. The accompanying national summary for policy makers also noted that there was a limited understanding of the range and extent of climate change impacts in Canada, and considerable work was required to refine that understanding and develop workable adaptation approaches (Maxwell et al., 1997). In 2004, the report *Climate Change Impacts and Adaptation: a Canadian Perspective* provided an update to *The Canada Country Study* through a sector-based summary of recent studies. Contrasting the knowledge gaps and research needs highlighted in the two reports reflects an increasing appreciation of the need to better understand adaptation (Box 1).

## SCOPE AND GOALS OF THIS ASSESSMENT

*From Impacts to Adaptation: Canada in a Changing Climate, 2007* reflects the advances made in understanding Canada's vulnerability to climate change during the past decade. Through a primarily regional approach, this assessment discusses current and future risks and opportunities that climate change presents to Canada, with a focus on human and managed systems. It is based

### Climate change impacts and adaptation in Canada: an evolving issue

Reflecting global trends in research related to climate change impacts and adaptation, Canadian research has become increasingly integrative, with more work crossing disciplines and economic sectors. In recent years, greater emphasis has been placed on understanding vulnerability to both current and future climate, and on understanding the social factors that influence adaptation. This trend is evident in comparing the research needs identified in *The Canada Country Study* (1998) with those of *Climate Change Impacts and Adaptation: a Canadian Perspective* (2004). While the research needs of *The Canada Country Study* focused primarily on baseline data, modelling capabilities and first-order impacts (Maxwell et al., 1997), the 2004 report highlighted the need to better understand interactive effects (climatic and non-climatic), the linkages between science and policy, and current and future adaptive capacity (Lemmen and Warren, 2004). This evolution reflects the growing involvement of a wide range of disciplines in climate change impacts and adaptation research.

on a critical analysis of existing knowledge, drawn both from the published scientific and technical literature (peer-reviewed and grey literature) and from expert (including traditional) knowledge. The current state of understanding is presented, and key knowledge gaps are identified. Authors have highlighted advances in understanding adaptation, as well as examples of recent and ongoing adaptation initiatives. Although emphasis is placed on studies conducted within Canada, international references are incorporated as appropriate. Further details on the approaches used in the assessment are presented in Chapter 2.

This assessment highlights what we know regarding vulnerability and the key issues facing each region of the country, with the goal of being policy relevant. It is a science-based assessment that will serve as an up-to-date, readily accessible source of information on climate change impacts and adaptation, providing a foundation that informs adaptation decision-making and policy development.

## FORMAT OF THIS ASSESSMENT

Including this 'Introduction', there are ten chapters in this volume, as well as an accompanying Synthesis Report.

Chapter 2, 'Background Information', contains reference material relevant to the entire report. The various sections of this chapter provide 1) explanations of key concepts that recur throughout the subsequent chapters; 2) a review of the science related to the evidence for, and causes of, past climate change and variability, as

well as projections of future climate change; 3) a broad overview of key factors relevant to understanding climate change impacts and adaptation in Canada, highlighting why these issues are relevant at local to national levels; and 4) a description of the approaches used in this assessment.

Chapters 3 to 8 are regional analyses focused on Northern Canada, Atlantic Canada, Quebec, Ontario, Prairies and British Columbia, and constitute the main body of the assessment. Each regional chapter discusses current and future climate, relevant socioeconomic trends, current sensitivities to climate, and the risks and opportunities presented by climate change (recognizing that there has generally been less research undertaken on opportunities). The regional chapters also discuss adaptation practices, options and planning. In recognition of the significant regional differences in the focus and volume of relevant information, these chapters do not follow a common template; rather, authors have structured each chapter to best capture regional circumstances. For example, considerably more focused information is available for Quebec than for many other regions, in large part due to the activities of the Ouranos Consortium since 2002, whose mandate explicitly includes consideration of adaptation issues (<http://www.ouranos.ca/>). Similarly, the 'Northern Canada' chapter builds directly on the results of the 2005 Arctic Climate Impact Assessment, which represents a more recent and comprehensive synthesis than is available for the other regions. Similarities in structure between chapters include starting with a concise presentation of key findings that emerge from the main body of the chapter and concluding with a synthesis that focuses on adaptation issues. Case studies are used throughout these chapters to provide additional details regarding key issues, and to highlight recent and ongoing initiatives related to climate change adaptation.

Chapter 9, 'Canada in an International Context', examines the potential implications of climate change impacts outside Canada for our country, as well as how impacts within our borders may affect our international relationships. This involves consideration of a wide range of issues, including trade, international development, immigration, tourism, security and sovereignty. Given the integrated nature of the global market place, the impacts of climate change outside of Canada are likely to have greater economic consequences for some sectors of the Canadian economy than the direct impact of climate change on Canadian operations. Nonetheless, research examining these impacts, and their implications for adaptation, is limited not only with respect to Canada but also for most countries of the world.

Chapter 10, 'Moving Forward', builds on the previous chapters. The regional snapshots capture the state of understanding and readiness to undertake adaptation at one point in time. This concluding chapter examines possible future directions to address the adaptation needs identified both within the regional chapters and in other assessments of climate change impacts and adaptation.

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