



THE
Security
OF
Canada
AND Canadians

Implications of Climate Change

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The Security of Canada and Canadians: Implications of Climate Change.

Suggested citation: McBean, Gordon et al. *The Security of Canada and Canadians: Implications of Climate Change*. Lawrence National Centre for Policy and Management: London, ON, 2012.

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A Knowledge Synthesis Research Project

Funded by the Social Sciences and Humanities Research Council

**Printed with funding from the Lawrence National Centre for Policy and Management,
Richard Ivey School of Business, The University of Western Ontario**

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This report is the outcome of a Social Sciences and Humanities Research Council-funded Knowledge Synthesis Grant entitled: *Climate Security - the implications of the impacts and response strategies of a changing climate for Canadian health, water, food, economic and social security*. The study looks at both the impacts of climate change, directly and indirectly on Canada, and the implications of response strategies, by all levels of government within Canada and by the global community. Consequently, it is comprehensive in terms of the assessment of impacts of climate change. A Knowledge Synthesis Grant is given to conduct a one-year study of literature and to facilitate interactions with decision-makers across a broad spectrum of society. It is then expected that a synthesis and public policy-relevant recommendations will be provided. It is not a grant to do original research *per se* but instead to synthesize the existing body of research. The academic investigators covered a range of disciplines appropriate for this type of synthesis and the complementary advisory team comprised representatives from the private and non-governmental organizational sectors and all three levels of government.

The preparation of this knowledge synthesis report was completed through three workshops, each with 25-30 participants and held in London, Ottawa and Toronto, Ontario. Although many participants attended all three workshops, some participated only in one or two, so that different perspectives were gained. To support these workshops and the preparation of this final report, there were, in addition to the faculty investigators, research assistants at The University of Western Ontario who prepared, with additional input, the background papers on: vulnerable populations in Canada (Ajibade, Chapter I); water security (Popovich, Chapter II); food security (Harris, Chapter III); personal health security (Harris, Brisbois and Lannigan, Chapter IV); and international stability (Rodgers, Chapter V). An earlier paper, Addressing Climate Change in the Context of Security Policy: Implications for Canada (McBean, 2008) is included as an Appendix. The key points of these papers are included in this synthesis report and the papers are attached as subsequent chapters. 🍁

Introduction

Climate Change as a Security Issue

Gordon A. McBean

1. INTRODUCTION

In December 2009, many national leaders (including Prime Minister Stephen Harper), Ministers, and others, present at the United Nations Framework Convention on Climate Change Fifteenth Conference of the Parties in Copenhagen, agreed to the Copenhagen Accord, with the opening paragraph:

We underline that climate change is one of the greatest challenges of our time. ... We recognize the critical impacts of climate change and the potential impacts of response measures on countries particularly vulnerable to its adverse effects and stress the need to establish a comprehensive adaptation programme including international support.¹ [Underlining added]

In December 2010, the Cancun Agreement² of the United Nations Framework Convention on Climate Change Sixteenth Conference of the Parties adopted similar wording. The 17th Conference of the Parties (held in Durban from 28 November to 11 December 2011) included in its decisions:³

Noting with grave concern the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020 and aggregate emission pathways consistent with having a likely chance of holding the increase in global average temperature below 2°C or 1.5°C above pre-industrial levels,

Climate change has been an issue on the front pages of most newspapers, discussed on radio and television shows and debated in most parliaments, although now, with economic issues predominating, it is less visible. From an environmental issue of the 1980's and 1990's, it has

evolved into a global economic, social and political issue, often pitting energy consumption and development issues against a changing climate. In this Knowledge Synthesis Report, the focus is on security – human security and its relationship to human vulnerability, personal health security, food security and water security. All of these elements of human security are affected by climate change and are interconnected and addressing climate-change impacts on them requires (a) an interdisciplinary approach; (b) a systems (broader) view and (c) mobilization of all involved. Canadian security also is dependent on many international issues. For the purpose of this paper, climate security is defined as: *“that achieved through the implementation of measures that ensure the defence and maintenance of the social, political and economic stability of a country and of the human population, including freedom from fear and want – both state and human security – from the affects of climate change and global-to-local responses to it.”* Since *“providing security for the nation and for its citizens remains the most important responsibility of government”*⁴ security against the impacts of a changing climate and responses to it must be seen as an integral role of government. This report examines climate change through this broad security lens: the security of Canada and Canadians.

2. A changing global climate and its implications for security

Governments' and public responses to climate change have been, in part, driven by major assessments that have examined the scientific basis for concern. The 1990 assessment of the Intergovernmental Panel on Climate Change (IPCC) provided scientific basis for the United Nations Framework Convention on Climate Change of 1992, while the IPCC 1995 assessment was input

1. Copenhagen Accord – <http://www.unfccc.int>

2. Cancun Agreement - draft decision /CP.16. Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention - <http://www.unfccc.int>

3. Decision 1/CP.17 Establishment of an Ad Hoc Working Group on the Durban Platform for Enhanced Action <http://www.unfccc.int>

4. *The National Security Strategy of the United Kingdom, Security in an interdependent world*. Presented to Parliament by the Prime Minister, by command of Her Majesty. March 2008; Newman, 2001- 239; Axworthy, 2001; MacLean, 2000; Ryerson, 2008.

to the Kyoto Protocol (Bruce, 2001). In 2007, the scientific assessment of the IPCC (2007) concluded that “warming of the climate system is unequivocal” and that “most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.” Global mean temperatures have increased by 0.7°C over the past 150 years and over the past 25 years were increasing at 0.18°C per decade. There are no indications of a slowdown or pause in the human-caused climatic warming trend (Copenhagen Diagnosis, 2009). A 2010 United States National Academy of Science report (Matson et al., 2010) as summarized (National Research Council, Report in Brief, 2010a) stated: “a strong, credible body of scientific evidence shows that climate change is occurring, is caused largely by human activities, and poses significant risks for a broad range of human and natural systems.” The IPCC Special Report on Climate Extremes (IPCC, 2012) included in its summary for policy makers:

A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events.

In looking ahead, the IPCC (2012) concluded that:

It is very likely that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future.

There is high confidence that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, movements of mass, and glacial lake outburst floods.

It is likely that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe.

There is medium confidence that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration.

All of these changes will have impacts on Canada and populations around the world.

This Knowledge Synthesis Report takes the view that the principal conclusions of the: IPCC; Copenhagen Diagnosis; US National Academy of Sciences; Arctic Climate Impact Assessment (2005); Canadian National Assessment (From Impacts to Adaptation: Canada in a Changing Climate, Lemon et al., 2008); Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity (Séguin, 2008); and other relevant scientific assessments have been validated by international consensus.

3. **International agreements related to climate change**

The United Nations Framework Convention on Climate Change (UNFCCC—the Climate Convention)⁵ was signed at the 1992 Earth Summit by most government leaders including Prime Minister Brian Mulroney (assisted by his then Environment Minister Jean Charest). The Climate Convention was ratified by Canada and it formally entered into force in 1994. The objective of the Climate Convention is “... the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure food production is not threatened and to enable economic development to proceed in a sustainable manner” (Article 2, underlining added). The Convention also includes in Article 3 the agreement on some principles, including that countries in agreeing to protect the climate system, recognize that they have “*common but differentiated responsibilities*” and the adoption of the precautionary measures such that lack of full scientific certainty should not be used as a reason for postponing action. Under Article 4 on Commitments, Canada, as a “*developed country Party and other Parties included in Annex I*”, undertook to “*adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs.*”

5. <http://unfccc.int/resource/docs/convkp/conveng.pdf>

The Kyoto Protocol⁶ was agreed to by most countries as the instrument to give Annex I countries measurable targets and timetables for reducing greenhouse gas emissions. Its general structure is important in shaping future agreements. Canada accepted a target of 6% emission reductions with respect to 1990 when it signed the Kyoto Protocol in 1997. The Kyoto Protocol was formally ratified by Parliament on 17 December 2002. In June 2007 the Kyoto Protocol Implementation Act was passed by Parliament. Upon returning from the Durban meetings of the UNFCCC, the Canadian Minister of Environment on December 12, 2012 announced that it was withdrawing from the Kyoto Protocol – the first nation to do so.⁷

“The Conservative government’s decision to pull out of the Kyoto Protocol was legal, and it wasn’t obliged to consult Parliament before doing so, the Federal Court has ruled.”⁸

Instead, the legislation was included in the omnibus budget bill that also repealed the Kyoto Protocol Implementation Act.

The UNFCCC 15th Conference of the Parties was held in 2009 in Copenhagen. What happened at Copenhagen? At the Conference per se, not much, but the Conference of the Parties took note of the Copenhagen Accord of 18 December 2009. The Copenhagen Accord, which was primarily negotiated (Antholis and Talbot, 2010) by the leaders of the United States, China, India and few others – not including Canada – states:

1. We underline that climate change is one of the greatest challenges of our time. We emphasise our strong political will to urgently combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities. To achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the scientific view that the

increase in global temperature should be below 2 degrees Celsius, on the basis of equity and in the context of sustainable development, enhance our long-term cooperative action to combat climate change.

2. We agree that deep cuts in global emissions are required according to science, ... peaking of global and national emissions as soon as possible, ...

3. Adaptation to the adverse effects of climate change and the potential impacts of response measures is a challenge faced by all countries. Enhanced action and international cooperation on adaptation is urgently required

9. To this end, a High Level Panel will be established under the guidance of and accountable to the Conference of the Parties to study the contribution of the potential sources of revenue, including alternative sources of finance, towards meeting this goal.

12. We call for an assessment of the implementation of this Accord to be completed by 2015, including in light of the Convention’s ultimate objective. This would include consideration of strengthening the long-term goal referencing various matters presented by the science, including in relation to temperature rises of 1.5 degrees Celsius.

The Copenhagen Accord has now been endorsed by most countries including Canada. The assessment of the Climate Group⁹ is that having the US, China, India and other major developing countries sign a joint climate agreement and for the first time make pledges towards limiting temperature increases to 2°C or less, are significant steps forward. In addition, the Accord broke an earlier deadlock on monitoring, reporting and verification. It also includes a developed country commitment to provide US\$30 billion of short-term funding through to 2012, and US\$100 billion per annum of long-term funding by 2020, although no information is given in the Copenhagen Accord on where the money will come from. The Accord does not include an emission reduction goal for

6. <http://unfccc.int/resource/docs/convkp/kpeng.pdf>

7. “Canada first nation to withdraw from Kyoto Protocol”, published in Toronto Star on Monday December 12, 2011, from The Canadian Press.

8. “Federal Court backs government over Kyoto pullout. Government not obliged to consult Parliament before applying ‘royal prerogative’” By Laura Payton, CBC News Posted: Jul 17, 2012 12:43 PM ET.

9. The Climate Group, London, United Kingdom: Issue 58: Viewpoints, Post COP 15.

either 2020 (for developed countries) or 2050 (for all countries). There is also no timetable for concluding a legally binding agreement. The Accord, as a side agreement of the UNFCCC, leaves uncertainty over the future of the UNFCCC process. Overall the Accord represents an important political step but is conditional on immediate, concrete and ongoing commitments from all major economies beginning in 2010.

In 2010 Canada hosted the G8-G20 meetings and there was pressure on Canada to put the environment issue on the agenda.¹⁰ The G20 Toronto Summit Declaration¹¹ (June 26 – 27, 2010) was focussed on the Framework for Strong, Sustainable and Balanced Growth. It did include:

Other Issues and Forward Agenda

41. We reiterate our commitment to a green recovery and to sustainable global growth. Those of us who have associated with the Copenhagen Accord reaffirm our support for it and its implementation and call on others to associate with it. We are committed to engage in negotiations under the UNFCCC on the basis of its objective provisions and principles including common but differentiated responsibilities and respective capabilities and are determined to ensure a successful outcome through an inclusive process at the Cancun Conferences. We thank Mexico for undertaking to host the sixteenth Conference of the Parties (COP 16) in Cancun from November 29 to December 20, 2010 and express our appreciation for its efforts to facilitate negotiations. We look forward to the outcome of the UN Secretary-General's High-Level Advisory Group on Climate Change Financing which is, inter alia, exploring innovative financing."

The UNFCCC 16th COP, held in Cancun¹² in December 2010 did come to some agreements which included the following key elements. The goal of limiting global warming to below 2 degrees and possibly 1.5 degrees, subject to science review, was confirmed. Quantified economy-

wide emission reduction targets by developed countries are to be communicated and listed and developing countries "will" take mitigation actions. A Green Climate Fund, at least initially, with the World Bank is to be funded at a level of \$30 billion for 2010-12 and \$100 billion per year by 2020. The Cancun Adaptation Framework includes an Adaptation Committee which will be established to help countries adapt to the negative impacts of climate change. The agreements did not specify global emissions targets for 2020 or for 2050 nor determine legally binding outcomes of the negotiations. As noted earlier, the 17th Conference of the Parties (held in Durban) made some further decisions with some sense of positive outcomes.¹³

The 1992 Earth Summit also led to two other international agreements that are indirectly related to climate change. The United Nations Convention to Combat Desertification (UNCCD) was adopted in June 1994 and entered into force on 26 December 1996 and now has been ratified by 193 countries, including Canada (in 1995). The UNCCD objective is: "...to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification." The connections between climate change and droughts and desertification make this largely unknown Convention relevant in this context. Desertification has been among the factors causing destabilization of some African countries and other states.

The UN Convention on Biological Diversity (UNCBD) was ratified by Canada in 1992 and entered into force at the end of 1993. The UNCBD objectives: "...are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" and again is connected to climate change.

Thus, important international legal instruments exist to address many of the crucial issues raised by climate change. Furthermore, Canada is a party to them: hence, it is legally bound to comply with their provisions. Yet implementation remains a major challenge for Canada.

10. "Put environment on G20 agenda, UN chief tells Harper, Secretary-General Ban Ki-moon says Canada has essential role to play in fighting climate change." Mike Blanchfield, Ottawa, *The Canadian Press* Published on Wednesday, May 12, 2010.

11. The G20 Toronto Summit Declaration. <http://www.g20.utoronto.ca/2010/to-communicque.html>

12. Cancun Agreement. <http://unfccc.int/resource/docs/2010/awglca13/eng/107.pdf>

13. Summary of the Durban Climate Change Conference, 28 November-11 December 2011, *Earth Negotiations Bulletin* Vol. 12 No. 534 Published by the International Institute for Sustainable Development (IISD) Tuesday, 13 December 2011 <http://www.iisd.ca/climate/cop17/>

4. **Climate change directly impacting Canadians**

Climate-related events, floods, storms and drought, are directly affecting Canadians. In 2010 Canadians experienced Hurricane Igor, the dry to then drenched Canadian Prairies, BC's expensive forest fires and a \$400 million hailstorm in Alberta.¹⁴ A single heavy rain in Toronto in August 2005 cost the insurance companies approximately \$625M (McBean et al., 2012). The Insurance Bureau of Canada (IBC) Senior Vice President, Policy and Chief Economist G. Robinson stated:¹⁵

"Insurers are seeing the financial impacts of severe weather first-hand. Canadians are already witnessing the impact of severe weather in terms of lost lives and injuries, families displaced from their homes, and towns that are devastated."

In 2011, catastrophic events cost Canadian insurers roughly \$1.7B and almost \$1B in each of the two previous years. The majority of these insured losses were caused by extreme weather events, but smaller weather events also played a role in significant property damage for consumers.¹⁶

In the United States, 2011 was a year of horrific tornadoes. The 199 tornadoes on April 27th, was the most for any single day on record and the 316 fatalities on the same day was the most in the modern record for a 24-hour period. The May 22nd Joplin, Missouri tornado caused 3 billion dollars worth of damage and 158 fatalities, surpassing the previous records for damages and fatalities from a single tornado in the modern tornado record.¹⁷

Tragic events or disasters result when there is the interaction between a hazard such as storm or flood and a vulnerable community (Mileti, 1999). A systems view of disasters involves complex interactions within and between the natural environment (represented by natural systems, human population (represented by human activity systems that frame actions, reactions and perceptions), and built environment (represented by human-made systems) (Simonovic, 2011).

During the period 1980-2005, there were 430 disastrous events (Public Safety Canada, 2009) in Canada with 311 (72%) being storms and floods, resulting in over 460 deaths and hundreds of thousands of people evacuated from their homes. The Canadian National Assessment stated that: *"impacts of recent extreme weather events highlight the vulnerability of Canadian communities and critical infrastructure to climate change"* and *"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"* (Lemmon et al., 2008, underlining added).

The vulnerability of Canadians is dependent on three primary attributes: 1) their exposure to threats associated with climate change; 2) their sensitivity to those threats; and 3) their capacity to resist impacts, cope with losses and/or regain functions when exposed to climate change (Ajibade, Chapter I; Adger et al., 2007). Assessments have identified several vulnerable groups in Canada including the elderly, infants and children. Single women are disproportionately vulnerable due to unequal access to, and control over resources. The poor, unemployed, homeless, recent immigrants, resource-dependent, Aboriginal communities and those with pre-existing health conditions are among the most vulnerable. In total, large sections of Canadian society are vulnerable to climate change and its associated threats as can be seen in the following examples of climate-related hazards that have already occurred.

There have been several billion dollar impact events in Canada. Droughts on the Prairies are the most frequent major events with the 2001-2 drought estimated to have cost \$5.8 billion loss in Gross Domestic Product and loss of 41,000 jobs. The Eastern Canada ice storm of 1998 interrupted electricity and left millions without power resulting in at least 28 deaths and over 900 injured. Insured losses were greater than \$1.4 billion (the largest loss for any single event in Canadian

14. Canada's Top Ten Weather Stories for 2010 <http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=53E29740-1>

15. Insurance Bureau of Canada, Insurance Bureau of Canada releases new research report http://www.IBC.ca/en/Media_Centre/News_Releases/2012/06-04-2012.asp

16. Insurance Bureau of Canada, Insurance Bureau of Canada releases new research report http://www.IBC.ca/en/Media_Centre/News_Releases/2012/06-04-2012.asp

17. State of the Climate, Tornadoes, Annual 2011. <http://www.ncdc.noaa.gov/sotc/tornadoes/2011/13>

history) with estimated total costs exceeding \$5 billion (Public Safety Canada, 2007). The economic impacts of these events are the same magnitude of some recent failures in the manufacturing sector. Severe flooding in the Saguenay-Lac-Saint-Jean region (Brooks, 2008) in 1996 and in the Red River in Manitoba in 1997 (Morris-Oswald and Sinclair, 2005; Simonovic, 2011) are examples of other close to \$1 billion events with thousands of residents being evacuated. The longer-term tragic effects of these types of storms have been documented showing that children whose mothers experienced high stress during this ice storm scored lower on IQ and language performance tests than those whose mothers had not.¹⁸

The wildfires in British Columbia in the summer of 2003 (British Columbia, 2004) led to the evacuation of tens of thousands of people and destroyed more than 300 homes with resulting total losses near \$1 billion. Climate change with more frequent summer thunderstorms and lightning is projected to increase the frequency and areal extent of wildfires and lengthen the wildfire season (Flannigan et al., 2005).

Climate-related hazards can directly and indirectly impact health through exposure to extreme weather events, through increased air pollution and through food-, water-, vector- and rodent-borne diseases. Harris, Brisbois and Lannigan (Chapter IV) explore fully the personal health security issues. The frequency of hot days (above 30°C) is projected to increase in most parts of Canada, such that the number of hot days, by 2050, will quadruple in Calgary, and at least triple in Winnipeg, Toronto and Fredericton (Hengeveld et al., 2005). Summer heat poses a significant risk to public health and safety, as was starkly demonstrated by the 2003 heat wave in Western Europe, which was associated with more than 70,000 deaths (Robine et al., 2008). Actions to better design structures and cities, with use of more green space, shade, passive cooling and implementation of heat alerts and responses with supporting medical advice are necessary.

Extreme heat events can also have indirect negative health impacts since hot summer days are usually smoggy days. The Canadian Medical Association (CMA)¹⁹ has estimated that, in 2008, 21,000 Canadians died from the effects of air pollution with economic costs exceeding \$8 billion and projected that by 2031, almost 90,000 people will die from the acute effects of air pollution with the number of deaths due to long-term exposure to air pollution being 710,000 and economic costs accumulating to over \$250 billion. CMA estimates do not factor in that both heat waves and smog episodes are likely to become more frequent under a changing climate (Lemmen et al., 2008). Approaches that reduce smog by limiting emissions of smog-creating pollutants can also reduce greenhouse gas emissions since the processes that result in air pollution are much the same as those that produce greenhouse gases.

To manage the health risks and safeguard human security, assessments are needed of the vulnerability and planning capacity of health facilities and services to climate change impacts and of the effectiveness of current measures to adapt to the health impacts of climate change. Estimates are needed of the economic costs of the projected health impacts and, overall, how climate-related threats to the human security of people living outside of Canada may impact the health security of Canadians.

Critically important to our health is our food. The interactions of climate change and food, from the food security perspective are discussed by Harris (Chapter III). In some regions of Canada, particularly the north, climate change may enhance opportunities for small-scale agriculture. However food transportation will become more difficult and more expensive in remote communities with the loss of winter roads. The relationship between climate change and food accessibility will depend on the vulnerability of populations. In 2005, more than 30 percent of single-parent families and 20 percent of Aboriginal families in Canada had inadequate access to food.²⁰ Additionally, more

18. Professor S. King, Director of the Psychosocial Research Division at the Douglas Institute and associate professor of the Department of Psychiatry at McGill University: "Climate change and the unborn: Douglas Conference examined the consequences." Press Release, McGill Douglas. 2009/02/03.

19. Canadian Medical Association (CMA) *No Breathing Room. National Illness Costs of Air Pollution*. August 2008.

20. Statistics Canada, 2005.

than 1.1 million Canadian households were food insecure at some point during 2008.²¹ Despite the possible opportunities, residents in northern communities are the most likely to experience food insecurity, with the rate in Nunavut being four times higher than the Canadian average. Changes in snow cover and sea-ice conditions, along with ecosystem impacts, are affecting access to traditional food supplies of peoples of northern Canada and environmental stress and water scarcity issues caused by climate changes can exacerbate political, social, and economic issues related to food security for Canadians.

The myth of Canada's water abundance juxtaposed against a changing climate underlies the threats to what is perhaps Canada's most important resource - water. Popovich (Chapter II) further examines the issues of water security. While 20 per cent of the world's total supply of freshwater is within Canada's borders, only one-third of that is renewable. While two-thirds of Canada's water flows northward, most of its population lives in Canadian southern urban centres and along coastlines. These fundamental challenges provide a backdrop to a changing water reality in Canada. Understanding what percentage of water is renewable and the full amounts and location of freshwater is critical in managing and adapting to the challenges of climate change.

Climate change water issues for Canada are, first, changes in water supply. There will be reduced water levels in lakes and rivers. Droughts in the Prairies region, interior British Columbia and eastern Canada will become more of a threat while, the second issue will be increased frequency and severity of floods at inland (e.g., Red River Basin) and coastal locations. Disaster mitigation and climate change adaptation are inherently linked. Water infrastructure in Canada is aging and often outdated, making it vulnerable to hazards, especially given the expected increase in extreme weather events (Simonovic, 2008). In Canadian urban centres there are increasing water demands, water pollution and in some places a heavy reliance on water-based transport for goods and services.

Deteriorating water quality in major water bodies impacting people, industries, energy supply, the ecosystem and human health with special focus on urban areas and Great Lakes is the third issue. Fourth, water is an economic issue. More than half of Canadian electrical energy²² comes from hydropower which although not consuming water is entirely dependent on its availability. British Columbia, Manitoba and Quebec generate more than 75% of their electric power through hydropower. The main consumptive water uses in Canada include (a) thermal power production (60%); (b) manufacturing (18%); (c) municipal (10%); (d) agriculture (8%); and (e) mining (4%). Water use in nuclear energy production is for cooling only which makes it consumptive through evaporation. The high consumptive use of water for oil comes only from oil sands extraction as conventional oil production has a much lower use. Understanding which percentage of water is renewable and the full amounts and location of freshwater is critical in managing and adapting to the challenges of climate change. While water quantity issues in relation to climate change have been studied extensively there is a lack of adequate research about groundwater and its recharge, water quality issues and climate change.

In the Great Lakes Basin, where only 1% of the water is renewed annually, there are concerns about the potential for decreasing water levels and very high usage rates; appropriately there are significant concerns about large-scale water diversions. The International Joint Commission, a 100-year old institution, serves in many ways as an example to the world for dealing with trans-boundary issues. But there is need for improvement and further institutional development. If any province enters into a water exporting scheme, national control of our water resources would be lost and it could not be reclaimed under international trade agreements. There is a close connection between water and energy that links together the concerns over water security and energy security. Canada's lack of a national water policy is a major institutional threat.

21. Agriculture and Agri-Food Canada (AAFC). 2008. *Follow-up to the Implementation of the World Food Summit Plan of Action: Canada's Fifth Progress Report on Food Security*. Ottawa: Government of Canada. p. 4.

22. Some references from the Commission on Environmental Cooperation that provide further information are: <http://www.cec.org/Page.asp?PageID=924&ContentID=2845>; and <http://www.cec.org/Page.asp?PageID=924&ContentID=2849>

For Canada's East Coast, an increasing threat is the occurrence of intense hurricanes that new analyses of observational data confirm has increased in the past three decades (Trenberth et al., 2007) in line with rising tropical ocean temperatures. Additionally, rising sea levels associated with thermal expansion of the oceans and melting of the Greenland and Antarctic ice sheets, as well as the accelerated loss of glaciers and ice caps, threatens both coasts. Global average sea-level has gone up by 3.4 millimetres a year in the last 15 years and by 2100, global sea-level, for unmitigated emissions, will possibly rise more than 1 metre with an upper limit estimated at 2 metres sea-level rise (Copenhagen Diagnosis, 2009). There are implications for low-lying areas along the East Coast as well as the Fraser River delta near Vancouver and the coast lines of Hudson Bay. Flooding of Arctic communities is also a concern and some have had to be relocated.

In summary, Canada and Canadians are being impacted by climate-related events, such as storms, floods, sea-level rise and droughts. The research papers prepared as part of this project and the existing literature including the Canadian National Assessment (Lemmen et al., 2008), the Arctic Climate Impact Assessment (2005) and the appropriate chapters of the 2007 Assessment of the IPCC have documented the past and projected future events and their impacts and the overall vulnerability of Canadians. The Executive Summary of the North American Chapter of the IPCC 2007 (Field et al., 2007) states (all conclusions were at the highest IPCC level of confidence):

- *North America has experienced locally severe economic damage, plus substantial ecosystem, social and cultural disruption from recent weather-related extremes, including hurricanes, other severe storms, floods, droughts, heat waves and wildfires.*
- *The vulnerability of North America depends on the effectiveness and timing of adaptation and the distribution of coping capacity, which vary spatially and among sectors.*
- *Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.*

- *Climate change will constrain North America's over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses.*
- *Climate change impacts on infrastructure and human health and safety in urban centres will be compounded by ageing infrastructure, maladapted urban form and building stock, urban heat islands, air pollution, population growth and an aging population.*
- *Without increased investments in counter-measures, hot temperatures and extreme weather are likely to cause increased adverse health impacts from heat-related mortality, pollution, storm-related fatalities and injuries, and infectious diseases.*
- *Disturbances such as wildfire and insect outbreaks are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons.*

There is now strong scientific guidance on how Canadians will be impacted by a changing and this can form the basis for the development of policies.

5. **Canadian Security Implications of Climate Change in Other Countries**

Canada and Canadians will also be impacted by a changing climate beyond our borders. There is need to know how climate change will drive international markets and security issues of most relevance to Canada and where the international "hotspots" are with direct or indirect implications for Canada. A changing climate will impact on migration to and from Canada. The broad scope of these issues is addressed by Rogers (Chapter V). The Canadian National Assessment stated: "*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*" (Lemmon et al., 2008, underlining added).

The global impacts of climate-related hazards that have already happened demonstrate the concern. "*Over the last two decades (1988-2007), 76% of all disaster events were hydrological, meteorological or climatological in nature; these*

accounted for 45% of the deaths and 79% of the economic losses caused by natural hazards” (Wahlström, 2009). During the period 2000-2008 more than 220 million people were victims of the about 360 climate-related disasters per year (Rodriguez et al., 2009). A disaster category 5 event is defined as one with more than 500 deaths and/or overall losses of more than \$US 500 million. Whereas in the 1980s there were between five and fifteen category 5 events per year, this number has increased to 15-25 events per year in the period 1990-2005 and is currently 28-41 events per year in the 2006-2008 period (MunichRe, 2010a). Combinations of increases in population, poverty, valuable and vulnerable infrastructure and a changing climate have led to these increases. Nearly 260,000 people died in natural disasters in 2010 (through Nov. 30) (Borenstein and Reed Bel, 2010) compared to less than 115,000 deaths from terrorism in total for the 40-year period 1968 to 2009. Both scientists and insurers expect that as the climate changes, there will be more frequent and intense extreme weather events, resulting in more costly disasters in the years to come (MunichRe, 2010b). UN ISDR Global Assessment Report on Disaster Risk Reduction (UNISDR, 2009) concluded that:

- *Weather-related disaster risk is expanding rapidly both in terms of the territories affected, the losses reported and the frequency of events.*
- *Climate change is already changing the geographic distribution, frequency and intensity of weather-related hazards.*

While the impacts of these hazardous events are felt globally, the impacts are particularly significant for developing countries. The UN ISDR Report also concluded that:

- *Climate change threatens to undermine the resilience of poorer countries and their citizens to absorb and recover from disaster impacts.*
- *Global disaster risk is highly concentrated in poorer countries with weaker governance.*
- *The governance arrangements for disaster risk reduction in many countries do not facilitate the integration of risk considerations in development.*

These developing countries have low adaptive capacity, poor physical infrastructure, weak governance, poverty and inadequate disaster response capacity. With this increasing burden, the economic and social systems of developing countries are being stressed and the possibility of state failures has become more likely.

In the next few decades, as the climate warms there will be more impacts. Some will be positive but most will not. For example, in some African countries yields from rain-fed agriculture could be reduced by up to 50% by 2020 (Parry et al., 2007). As the temperature warms further, any increase in temperature above 3°C is expected to result in significant global average yield reductions with disastrous implications for food security worldwide (Parry et al. 2007, 11-13). With climate zones shifting and droughts worsening, crops that were previously grown and relied on for local consumption or export may no longer thrive. There is also concern that the nutritional value of crops could suffer in a high-production environment and could result in significant soil degradation and loss of soil fertility (Stafford 2007, 526). Elevated CO₂ levels will also affect fish stocks and currently more than 2.6 billion people rely on fish for at least 20 percent of their protein needs. Ocean acidification has detrimental effects on fish growth and development (Carius et al., 2008, 27; Stern 2006, 56). With continued warming, local extinctions of certain fish species, especially freshwater species, will occur (Easterling et al. 2007, 300). These issues will be compounded both by the current over-fishing practices in numerous countries and the increasing demand for food. It is projected that population growth combined with higher living standards will result in a 55 percent increase in global food demand by 2030 and 80 percent by 2050 (Carius et al. 2008, 28). Consequently, more agricultural land and water will be required at a time when both are increasingly scarce. The United Nations Food and Agricultural Organization (FAO) and the IPCC, among others, have identified sub-Saharan Africa and south Asia as hotspots for food insecurity exacerbated by climate change (FAO, 2006; Easterling et al. 2007, 297).

In February 2009, the Government of Canada identified twenty countries based on their current needs and their anticipated capacity to use aid

effectively that would become the focus for Canadian bilateral aid (CIDA, 2009a). The majority of these countries are also expected to experience the worst effects of climate change (CIDA, 2009b; Parry et al., 2007). Some of these countries are trading partners, while others are important sources of Canada's immigrants; consequently the impact of climate change on their food security, stability and well-being is of strategic interest to Canada (Statistics Canada, 2004; CIDA, 2009a).

With related and important impacts on water resources, conflicts linked to climate change may develop (Gleditsch et al., 2007). Environmental migration, linked to the search for new and available resources or the escape from a disastrous event, also has the potential to cause conflict and could put intense pressure on an already fragile state (CNA, 2007). The German Advisory Council on Global Change (2007) refers to climate-induced conflict constellations as 'hotspots,' caused by degradation of freshwater resources; decline in food production; increases in storm and flood disasters; and environmentally-induced migration. It concluded that *"without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades"* which could result in destabilization and violence, jeopardizing national and international security to a new degree.

Other governments have also examined the security-related aspects of climate change and their analyses provide useful insights into issues such as international governance stability, migration, international trade and conflicts that provide reference points for framing a Canadian approach. The United Kingdom's National Security Strategy (2008) identified drivers of insecurity and security challenges and concluded that climate change is *"potentially the greatest challenge to global stability and security and therefore to national security. Tackling its causes, mitigating its risks and preparing for and dealing with its consequences are critical to our future security, as well as protecting global prosperity and avoiding humanitarian disaster."* The UK report noted that *"the direct effects (of climate change) are likely to*

fall most heavily on those countries least able to deal with them, and therefore most likely both to suffer humanitarian disaster but also to tip into instability, state failure, or conflict. ... if the international system fails to respond, the effect on its credibility would have further knock-on effects on security." In 2008, the Council of the European Commission adopted a report on the security implications of climate change²³ noting that *"the impact of climate change on international security is not a problem of the future but already of today and one which will stay with us."*

The United States-based Centers for Strategic & International Studies and for New American Security (2007) concluded that:

- *Perhaps the most worrisome problems associated with rising temperatures and sea levels are from large-scale migrations of people — both inside nations and across existing national borders.*
- *Climate change effects will aggravate existing international crises and problems.*

The United States-based Council for Foreign Relations (2008) stated: *"unchecked climate change is poised to have wide-ranging and potentially disastrous effects over time on human welfare, sensitive ecosystems, and international security."* The CNA (2007) concluded that *"projected climate change poses a serious threat to America's national security"* and that *"climate change acts as a threat multiplier for instability in some of the most volatile regions of the world"* (underlining added). In this regard, they noted that climate change has the potential to result in multiple chronic conditions, occurring globally within the same time frame. Food production, health, water and weakened and failing governments were highlighted. For states where ecosystems or sectors of society are already fragile, the additional imposition of a changing climate may overload those systems perhaps beyond their breaking thresholds leading to failed states. A US National Security Study concluded that *"America is now threatened less by conquering states than we are by failing ones"* where a *"failed state"* is one whose central government is so weak

23. Climate Change and International Security, Paper from the High Representative and the European Commission to the European Council. Paper S113/08, 14 March 2008.

or ineffective that it has little practical control over much of its territory (Chomsky, 2006). The Policy and Fund for Peace (2009) each year produce a failed states index. In commenting on the list, Farris²⁴ stated: *“if you think these failed states look bad now, wait until the climate changes.”* The sense of climate change as a *“threat multiplier”* and the concern for failed and fragile states appear often in security analyses (McBean, Chapter 6). Climate security can serve as an integrative concept which links local/people (human security), national (national security) and global (international security) levels and brings together mitigation and adaptation as both are essential to security from climate risks (Barnett, 2003).

The Centers for Strategic & International Studies and for New American Security (2007) also concluded that: *“at a definitional level, a narrow interpretation of the term ‘national security’ may be woefully inadequate to convey the ways in which state authorities might break down in a worst case climate change scenario.”*

The national security of Canada must go beyond the narrow definition and it needs to be recognized that it is dependent on security abroad. Issues include potential immigration, trade, conflict resolution pressures and circumpolar Arctic issues (see Crawford et al., 2008 for a more detailed discussion). Strategies are needed to reduce the vulnerability and risk and Canada must consider how to best position itself to be resilient to climate change and related pressures arising from global climate change for the benefits of this and future generations.

6. **Adapting to changing climate**

Canada needs to adapt to the changing climate while reducing the risks of these hazards. The Canadian National Assessment defines adaptation to climate change as *“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”* (Lemmen et al., 2008). Disaster risk reduction is defined as: *“the concept and practice of reducing disaster risk²⁵ through systematic efforts to*

analyse and manage the causal factors of disasters including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and environment, and improved preparedness for adverse events.”²⁶ Linking these approaches is necessary.

Viewing adaptation to climate change from a risk management approach offers considerable benefits (Noble et al, 2005). Vulnerability assessment is a central element of risk management and it is increasingly useful for guiding adaptation, since it helps reveal local- and larger-scale system vulnerabilities for which adaptation measures may be necessary to prevent serious adverse consequences. Future climate scenarios, based on climate models, will continue to provide valuable information, but the vulnerability-based approach is critical for helping identify specific risks and potential impacts that reflect the interests and values of people affected.

The concept of “managing risks” seems, from many perspectives, much clearer than the concept of “adapting.” Risk management is a familiar concept, especially in disaster management, whereas the notion of “adapting” is still poorly understood by many. Risk management provides a means for addressing uncertainties explicitly. Uncertainties exist in respect to uncertain future climate conditions and other aspects of climate change adaptation decision-making. Without a risk management view, decision-makers often receive uncertain responses to their question “what are we adapting to?”

Risk management is relatively easy to apply in practice. In Canada, for example, many organizations have developed and accepted generic risk management procedures, and gained first-hand experiences in using risk management techniques (Canadian Standard Association, 1997 - reaffirmed in 2009). Increasingly, these are being applied to manage climate-related risks.

The 2010 Fall Report of the Commissioner for Environment and Sustainable Development (CESD, 2010) to the House of Commons states: *“Government reports have demonstrated that*

24. *Foreign Policy*. http://www.foreignpolicy.com/articles/2009/06/22/failed_states_index_the_last_straw

25. Disaster risk is “the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.”

26. UNISDR, Disaster terminology.

climate change affects all regions of the country and a wide range of economic sectors. These impacts and the need to adapt to them touch on virtually all federal government portfolios, with significant implications for policies and programs related to Canadians' health and the country's industry, infrastructure, and ecosystems."

The Report noted the need to adapt to changing climate and that these issues "touch on virtually all federal government portfolios, with significant implications for policies and programs related to Canadians' health and the country's industry, infrastructure, and ecosystems." The report went on to state that the:

federal government is well positioned to help Canadians reduce their exposure to risks from climate change by providing them with information on impacts and adaptive measures. The concerns we have raised in this report are hardly new. About 20 years ago, the federal government acknowledged that the impacts of climate change would pose significant, long-term challenges throughout Canada, from more frequent and severe storms in Atlantic Canada to changes in the amount of rain available to farmers. And today, the federal government still lacks an overarching federal strategy that identifies clear, concrete actions supported by coordination among federal departments.

The report concluded that:

- *The government has not established clear priorities for addressing the need to adapt to a changing climate. Although the government committed in 2007 to produce a federal adaptation policy to assist it in establishing priorities for future action, there is still no federal adaptation policy, strategy, or action plan in place. Departments therefore lack the necessary central direction for prioritizing and coordinating their efforts to develop more effective and efficient ways of managing climate change risks.*

- *Overall, the departments we examined have not taken concrete actions to adapt to the impacts of a changing climate. With few exceptions, they have yet to adjust or develop policies and practices to better respond to the risks. However, Fisheries and Oceans Canada, Natural Resources Canada, Health Canada, and Environment Canada have taken the first steps of risk management by completing assessments of the risks to their mandate areas from climate change, and they have prioritized the risks. Indian and Northern Affairs Canada has initiated but not yet completed a department-wide assessment of climate change risks it must manage.*
- *The four programs we examined have shared information on climate impacts and adaptation in a manner that responds to the needs of their specific clients, stakeholders, and partners. However, the programs cannot meet the increasing demand for information.*

A recent United States National Academy of Science report (Wilbanks et al., 2010) focusing on the needs for climate change adaptation has been summarized (National Research Council, Report in Brief, 2010b) in part as:

much of the nation's experience to date in managing and protecting its people, resources, and infrastructure is based on the historic record of climate variability during a period of relatively stable climate. Adaptation to climate change calls for a new paradigm — one that considers a range of possible future climate conditions and associated impacts, some well outside the realm of past experience. Adaptation is a process that requires actions from many decision-makers in federal, state, tribal, and local governments, the private sector, non-governmental organizations, and community groups

There has been action at the provincial level. In the aftermath of the Saguenay flood of 1996 and the ice storm of 1998, the government of Quebec established the Ouranos²⁷ Program in 2001. Its

27. <http://www.ouranos.ca/>

vision to provide Quebec and all of Canada with an organization capable of meshing climate science with the adaptation needs of society. Ouranos' mission is to acquire and develop knowledge on climate change, its impact and related socioeconomic and environmental vulnerabilities, in order to inform decision makers about probable climate trends and advise them on identifying, assessing, promoting and implementing local and regional adaptation strategies.

The Government of Ontario appointed an Expert Panel on Climate Change Adaptation in December 2007 to provide the government with advice on how best to plan and prepare for the impacts of climate change. The panel engaged 15 ministries and government agencies (including the Climate Change Secretariat) in a process of extensive discussion on a broad range of policy and program areas to develop recommendations culminating in a report to the Minister of the Environment that was presented in November 2009.²⁸

Pacific Climate Impacts Consortium was created to quantify the impacts of climate change and variability on the physical environment in Pacific North America.²⁹ The British Columbia government has provided \$94.5 million to create the Pacific Institute for Climate Solutions (PICS),³⁰ led by the University of Victoria in collaboration with the University of British Columbia, Simon Fraser University and the University of Northern British Columbia. Its objectives are: understanding the magnitude and patterns of climate change and its impacts; evaluating the physical, economic and social implications; assessing mitigation and adaptation options and developing policy and business solutions; evaluating and strengthening educational and capacity-building strategies to address climate change; and communicating climate change issues to government, industry and the general public. Note that this Institute has objectives related to both emission reduction solutions as well as adaptation options.

7. **Perceptions of Canada's role in international dialogue**

International assessments of Canada's role, image and contribution towards international climate solutions have become increasingly negative. For example, Germanwatch and Climate Action Network International³¹ provide an assessment called The Climate Change Performance Index which compares a country's climate change performance, based on climate change policy, emissions levels and trends of the top 10 emitters and the 60 states that together are responsible for more than 90 percent of annual worldwide carbon dioxide emissions. In 2009, Canada was 10th, the poorest ranking, in the top 10 emitters and 59th overall, only ahead of Saudi Arabia. The Climate Action Network also makes awards to countries that, in their opinion, have performed badly in the UN climate change negotiations. Canada has been awarded the "Colossal Fossil of the Year" award for each of the last four UNFCCC Conferences of Parties.³²

8. **Internal Canadian dialogue and discord on climate change and related energy policy**

In the absence of a nationally-agreed climate change strategy on limiting greenhouse gas emissions, there has been discord among the federal government and the provinces. Prior to the Kyoto Negotiations in 1997, Canadian First Ministers (Prime Minister and all provincial and territorial premiers) agreed that the Canadian target for Kyoto Protocol negotiations was to be 0% reduction with respect to 1990 levels. By the time of opening of the Kyoto meetings, the Canadian delegation was negotiating for a Canadian target of 3% reduction in reflection of perceived national interest and image and the understanding that the United States target would be 2% reduction (Simpson et al., 2007). In the end Canada accepted a target of 6% emission reductions with respect to 1990 when it signed the Kyoto Protocol in 1997 and later, the Protocol was formally ratified by Parliament, after a Parliamentary debate, on

28. <http://news.ontario.ca/ene/en/2009/12/environmental-experts-submit-report-on-climate-change.html>

29. <http://pacificclimate.org/>

30. <http://www.pics.uvic.ca/>

31. GermanWatch is a German government-supported group and Climate Action Network International is a global coalition of over 450 leading non-government organisations who monitor progress at the UN talks. Climate Action Network Canada is part of CAN International.

32. <http://www.climatenetwork.org/fossil-of-the-day>

17 December 2002. Canada announced on December 12, 2012 that it was withdrawing from the Kyoto Protocol.³³

Announced in 2006 and maintained until the fall of 2009, the Government of Canada's target had been a commitment to reducing Canada's total greenhouse gas emissions by 20 per cent from 2006 levels by 2020 and by 60 to 70 per cent by 2050.³⁴ The 20 per cent reduction from 2006 levels by 2020 corresponds to about 3% reduction compared to the internationally agreed reference year of 1990. On January 30, 2010, as part of a commitment under the Copenhagen Accord, the Government announced a new target of 17% reduction from 2005 levels, a target the same as the United States. This target is weaker than earlier and, if implemented, would increase emissions in 2020 by about 2.5%, relative to 1990 levels.³⁵

Canada's total greenhouse gas emissions³⁶ in 2010 were 692 MT (megatonnes) of carbon dioxide equivalent, about 20.3 tonnes per capita, which is about 17% above the 1990 total of 592 Mt and 24% above Canada's Kyoto target of 558.4 Mt. Approximately 45% were from energy-stationary combustion sources, 28% from energy-transport, 8% from energy-fugitive sources (mainly oil and natural gas) and 7% from industrial sources. Alberta with 34% and Ontario, 25%, were the largest emitters by province.

The National Roundtable on the Environment and the Economy (NRT)³⁷, in response to a request from the Minister of Environment Canada, in 2012 produced a report entitled "Reality Check: The State of Climate Progress in Canada" and concluded that:

"Canada will not achieve its 2020 GHG emission reductions target unless significant new, additional measures are taken. More will have to be done. No other conclusion is possible."

The report also notes:

"Unsurprisingly, climate change policy in Canada has proved difficult to develop and divisive to implement."

In some provinces there has been considerable action on climate change. British Columbia, Manitoba, Ontario, and Quebec have joined the Western Climate Initiative,³⁸ (in collaboration with U.S. states: Arizona, California, Montana, New Mexico, Oregon, Utah, Washington) which is committed to working together to identify, evaluate, and implement policies to tackle climate change at a regional level. A regional cap-and-trade program, announced in September, 2008, will, when fully implemented in 2015, cover nearly 90 per cent of the greenhouse gas emissions of the parties in the Western Climate Initiative.

The Ontario government's³⁹ Climate Change Action Plan calls for reducing greenhouse gases by 6% from 1990 levels by 2014, and 15% by 2020. Quebec Premier Jean Charest⁴⁰ announced on November 23, 2009 that, by 2020, the province will reduce its greenhouse gas emissions by 20% below 1990 levels, a goal similar to the target the European Union has adopted. British Columbia⁴¹ plans to reduce emissions by 33% below 2007 levels, (about 14% reduction below 1990 levels) by 2020. These targets for 2020, with respect to 1990 levels, of reductions of 15% (Ontario), 20% (Quebec) and 14% (British Columbia) differ significantly from the new federal target of a 2.5% increase.

The Canadian delegation to the Copenhagen Conference of the Parties included Quebec Premier Jean Charest, B.C. Premier Gordon Campbell, Alberta Environment Minister Rob Renner and Ontario Environment Minister John Gerretsen. Toronto Mayor David Miller, chair of the C40 global cities, travelled to Copenhagen to represent urban citizens. It was clear that there were deep divisions

33. "Canada first nation to withdraw from Kyoto Protocol", Published in *Toronto Star* on Monday December 12, 2011, from *The Canadian Press*.

34. <http://climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1> (accessed 16 January 2010).

35. Shawn McCarthy, *Globe and Mail*, 27 January 2010: Tories hedge on emissions targets; see also Canada. National Round Table on the Environment and the Economy. (2012). *Reality Check: The State of Climate Progress in Canada*.

36. <http://ec.gc.ca/ges-ghg/default.asp?lang=En&n=1357A041-1> (accessed July 26, 2012).

37. Canada. National Round Table on the Environment and the Economy. (2012). *Reality Check: The State of Climate Progress in Canada*.

38. Western Climate Initiative. <http://www.westernclimateinitiative.org/>

39. Ontario Releases Second Climate Change Annual Report December 2, 2009
McGuinty Government Making Progress On Climate Change Goals.

40. November 23, 2009 Quebec splits with Ottawa on climate change By Rhéal Séguin *Globe and Mail* Update.

41. www.gov.bc.ca/premier/attachments/climate_action_plan.pdf

among the provinces and between the federal government and some provinces.

In the May 2010 issue of *Policy Options*,⁴² a lead article by Geoff Norquay⁴³ (2010) entitled “*the gathering storm in federal-provincial relations*” addressed the theme of the “*Fault lines of Federalism*.” These divisions between different levels of government were not only evident within Canada but also to the world community (McCarthy, 2009). Norquay states that the “*second growing flashpoint in federal provincial relations is the environment*” and he notes that in attacking the Alberta oil sands for their greenhouse gas emissions Ontario and Quebec have touched the “*third rail*” of Canadian federalism – equalization. The following article by Robin Sears⁴⁴ (2010) entitled “*The next federal-provincial battles: this time it's different*,” discussed the “*new time bomb, courtesy of the climate change advocates*” in the context of Ottawa-Washington establishing a continental cap and trade or carbon tax regime and the regional winners and losers. Sears also quotes David Emerson (both a former federal Liberal and Conservative cabinet minister)

We continue to be a country without a national approach to the twin issues of energy and environmental stewardship ... [In an] interdependent carbon-dependent world ... a national energy strategy ... would factor in efforts by government and industry to promote energy efficiency through improvements in transportation, building codes, agricultural technologies [and] appliance standards.

A major component of the Canadian economy is presently the oil and gas sector, which has been expanding while traditional manufacturing and some other resource sectors, such as wood, pulp and paper are declining. Some⁴⁵ view Canada as “*slipping down the development ladder, retreating from a complex, diverse economy towards*

dependence on a single primary resource, which happens to be the dirtiest commodity known to man” (Monbiot, 2009).

There are clear economic benefits from having very high oil reserves, in the future primarily due to the oil sands. There have also been statements of concern from provincial leaders about wealth transfers from the oil-producing provinces to others. At the same time, the statements from other provincial leaders have been critical of the impact of the oil sands and other related production in terms of its emissions and potential negative impacts on the rest of Canada, directly and through internationally negotiated climate regimes. From an economics analysis, there are difficulties for countries with a focus on a dominant natural resource. A report of the Parliamentary Research Branch in 2006,⁴⁶ entitled “*Energy, Resources, Boon or Curse, for the Canadian Economy?*” discusses this phenomenon, commonly referred to as the “*Dutch Disease*,” which occurs when large exports of natural resources lead to a strong currency which, in turn, hurts the traditional manufacturing sectors, which in Canada have been primarily in Ontario and Quebec. One conclusion of this study is that unbridled development of the western oil sands will, by keeping the Canadian dollar high, have negative impacts on manufacturing sectors with “*significant wealth transfer*” from one part of the country to another.

In February 2012, Ontario Premier D. McGuinty stated that a “*strong oil sands industry means a high Canadian dollar, which hurts Ontario's wellspring manufacturing and export sectors*”⁴⁷ with strong reaction from Premiers in Alberta and Saskatchewan. In mid-May, 2012, the issue arose again when NDP Opposition Leader T. Mulcair claimed that “*Dutch disease*” has hit the country, blaming energy exports from the Alberta oil sands for artificially raising the Canadian dollar and hollowing out the manufacturing industry.⁴⁸ There

42. *Policy Options* is the publication of the Institute for Research on Public Policy and is available at www.irpp.org

43. Norquay is a former senior policy adviser to Prime Minister Harper.

44. Sears is a former national campaign director of the NDP during the Broadbent years. An earlier (2006) article by Sears is also interesting in this context: Sears, R., 2006: The politics of climate change: from one government to the next. *Policy Options*, October 2006, 6-11.

45. George Monbiot. 2009. *The Guardian* (Monday 30 November).

46. Parliamentary Research Branch report PRB 05-86F, *Energy, Resources, Boon or Curse, for the Canadian Economy?* Prepared by: Philippe Bergevin Economics Division 31 March 2006.

47. Brad Wall calls Dalton McGuinty 'divisive' on oilsands. *The Canadian Press*

Posted: Feb 28, 2012 <http://www.cbc.ca/news/business/story/2012/02/28/sk-brad-wall-oilsands-120228.html>

48. Is Canada suffering from 'Dutch disease'? <http://www.cbc.ca/news/canada/story/2012/05/18/f-dutch-disease-mulcair.html>

followed media coverage of reports that supported (Pembina, OECD, Vancouver Sun economist) or denied (MacDonald Laurier Institute) the analogy.⁴⁹ It was also noted that a study funded by Industry Canada found that a third of manufacturing job losses were due to inflated currency⁵⁰ although a spokeswoman for the Industry Minister said the study does not reflect the views of the Harper government. It is clear that further in-depth and open analysis is needed on this issue.

A comparison can be made of the situation in Norway, which has vast oil reserves and has experienced a booming economy for two decades. Its strategic macroeconomic policies have made it one of the richest countries in the world in terms of Gross Domestic Product (GDP) per capita. Norway's decision makers recognized early on the potential side effects of large revenues from natural resources, and acted upon that knowledge. Norway implemented a carbon tax of \$50 per tonne in 1990, its economy and oil production are still moving ahead and its emissions have increased by only 8.8%, while Canada's emissions have increased three times as much. Sweden, a northern country but not an oil exporting state also has some lessons for analysis. It has reduced emissions by 7.3 percent by implementing a "green tax shift" in 1990 where taxes on energy and on carbon dioxide emissions were raised and other taxes, such as payroll taxes were decreased by an equivalent amount. Canada now uses 50% more energy than Sweden to produce the same amount of goods and services as measured by per capita Gross Domestic Production.⁵¹ Canada can learn from these experiences and can manage the current situation in a manner that ensures positive economic and social consequences for the country as a whole.

9. Need for leadership to achieve action

The Copenhagen Accord *"underline(d) that climate change is one of the greatest challenges of*

our time. We emphasise(d) our strong political will to urgently combat climate change ..." endorsed the 2 degrees Celsius target and agreed that deep cuts in global emissions are required. Global mean temperature has already increased by 0.7°C, leaving only 1.3°C before a critical threshold is reached. Because carbon dioxide has a long lifetime⁵² in the atmosphere, and the climate system (including the oceans) is slow to adjust, the IPCC (2007) has projected a warming of 0.2°C per decade for the next 3-4 decades – a further warming of 0.6-0.8°C. Even if emissions were to stop, the climate system would still be coming into equilibrium for the rest of this century with a warming rate of about 0.1°C per decade; which means at least another 0.5°C by the end of the century. Hence, the globe is effectively committed to at least 2°C warming with the assumption of essentially no emissions following mid-century. And global carbon dioxide emissions (Copenhagen Diagnosis, 2009) from use of fossil fuels are rising more rapidly than ever before and in 2008 were nearly 40% higher (they did drop in 2009 due to the recession) than those in 1990.

The urgency is reinforced by recent re-analyses (Smith et al., 2009) of the growing literature that lead to the conclusion that smaller increases in global mean temperature (i.e., less than 2°C) are now estimated to lead to significant or substantial consequences. The Copenhagen Accord reflects this concern by calling for: *"an assessment of the implementation of this Accord to be completed by 2015, This would include consideration of strengthening the long-term goal referencing various matters presented by the science, including in relation to temperature rises of 1.5 degrees Celsius"* (underlining added). At our current rate of progress, there is no realistic possibility of meeting a 1.5°C target and almost no possibility of achieving the 2°C target.

Canadians collectively seem to understand the threat of climate change. When surveyed⁵³ about

49. 'Oil sands fever' seen as Canada's Dutch Disease. *The Canadian Press* Posted: May 30, 2012.

<http://www.cbc.ca/news/world/story/2012/06/13/oecd-canada-outlook.html>; Dutch disease infects think-tank report on oil boom Robyn Allan, Vancouver Sun.

<http://www.vancouversun.com/business/Dutch+disease+infects+think+tank+report+boom/6767649/story.html#ixzz21kjsQavr>;

Canada economy showing symptoms of Dutch Disease, OECD warns. Gordon Isfeld. Jun 13, 2012

<http://business.financialpost.com/2012/06/13/oecd-sees-signs-of-dutch-disease-affecting-canada/>

50. Harper government funded study on 'Dutch disease' Study for Industry Canada found a third of manufacturing job losses due to inflated currency.

The Canadian Press. Posted: May 18, 2012. <http://www.cbc.ca/news/business/story/2012/05/18/pol-cp-dutch-disease-industry-canada-jpbs.html>

51. L. Alvin, Swedish Ambassador, "Kyoto critics are wrong: you can get rich by going green. Sweden will happily show you how". *Globe and Mail*, 25 May 2005.

52. Carbon dioxide remains in the atmosphere between 50 and 200 years; the oceans can take decades to centuries to warm up.

53. Canadian Defence and Foreign Affairs Institute (CDFAI) – see www.cdfai.org See also article by Michael Jeffrey, Lieutenant General (Ret'd), *Ottawa Citizen Special*, January 11, 2010, "Don't underestimate the threats that we face."

their perceptions of the threats to vital Canadian interests in the next 10 years, half of Canadians said climate change is a critical threat, making climate change the most important threat in the view of many Canadians. The level of concern varied from province to province, in a way consistent with the way climate change is being treated in the province – from 62% in Québec, down to 28% in Alberta. Overall, another third of Canadians felt climate change was an important but not critical threat, while only about one-in-six felt it was not an important threat at all (CDFAI 2010).

In the speech from the Throne⁵⁴ on March 3, 2010, the position of the Federal Government on many issues was enunciated. These included:

- *“Our Government will use its voice to speak on behalf of Canada’s commitment to global security and human rights.”*
- *“Nowhere is a commitment to principled policy, backed by action, needed more than in addressing climate change.”*
- *“The Copenhagen Accord reflects these principles and is fully supported by the Government of Canada.”*

On July 19, 2012, the Standing Senate Committee on Energy, the Environment and Natural Resources⁵⁵ released a unanimous report on Canada’s energy future, outlining an energy vision for Canada based on a clear and responsible path for Canadian energy development and a low-emissions economy. One of their priority recommendations was for: *“Canada must strive for collaborative energy leadership. Federal, provincial, territorial and municipal governments, industry, environmental groups and Aboriginal leaders need to come together to chart a course for responsible development and marketing of our energy resources.”* A few days later, the Premiers representing all provinces started their annual meeting with energy issues as a main issue of contention.⁵⁶

10. Recommendations

This Knowledge Synthesis Report has been prepared to enable decision makers to be more informed in their choices through a better understanding of the intersections of these broad issues. Decisions made in the context of climate policy will affect, and be affected by, decisions made in other contexts.

Principal Recommendation

Canada should, based on a national, open and publically-informing dialogue, adopt a comprehensive and integrated climate-energy-water national strategy that includes consideration of food, water and health security issues.

As part of adopting this strategy, parties from all levels of government, industry, non-governmental organizations, think tanks, academia, as well as public agencies, should be involved in an open, transparent process with reporting back to Canadians.

A Canadian strategy should build upon similar strategies of other countries. The United Kingdom’s National Security Strategy (2008) concluded that climate change is *“potentially the greatest challenge to global stability and security and therefore to national security.”* The German Advisory Council on Global Change (2007) security analysis identified climate-induced conflict constellations or *“hotspots”* and identified four specific climate-induced types, namely: degradation of freshwater resources; decline in food production; increase in storm and flood disasters; and environmentally induced migration. The development of a Canadian integrated climate-energy-water national strategy should consider the concept of hotspots, both nationally and internationally, and will also have to broaden the strategic framework to fit the Canadian scene.

54. Speech from the Throne to Open the Third Session of the Fortieth Parliament of Canada. March 3, 2010. “Now and for the Future”. ISBN 978-1-100-14874-8. Cat. no. S01-1/20109E-PDF, ISSN 1493-3551. Available at www.pco-bcp.gc.ca

55. <http://senate-senat.ca/enev-e.asp>

56. Energy, health care dominate agenda on eve of premiers summit. Jane Taber, Josh Wingrove, Karen Howlett and Les Perreux. *The Globe and Mail*. Published Tuesday, Jul. 24 2012, 10:39 PM EDT.

Recommended Sub-Components

1. Develop, adopt and implement a national energy-climate strategy

Canada is committed to reducing our total greenhouse gas emissions by 17 percent from 2005 levels by 2020. On April 6, 2010, Environment Canada and British Columbia⁵⁷ agreed in principle on efforts to address climate change noting the need for a national, coherent climate change approach. Most recently, Roger Gibbins⁵⁸ (*“Creating a Canadian energy framework: if you build, they will come,”* 2010) and Daniel Gagnier⁵⁹ (*“Fault lines or energy lines: Canada’s potential to be a clean energy superpower,”* 2010) have addressed the need for a national energy policy. Gibbins notes that the provinces have been more engaged in energy and climate policy development than the Government of Canada. Although admitting that an intergovernmental engagement on the energy file will not be easy, he concludes that *“there is simply too much at stake.”* Gagnier argues that *“Canada must make the transition to a new, clean energy super power status in order to improve the environment, deal with climate change and continue to grow and prosper. All governments must meet this challenge, but first and foremost, the federal government must meet the leadership challenge.”*

The strategy to achieve Canada’s targets need to be clear. Is it based on absolute targets or intensity targets? Is the reference year 1990, as Canada agreed in 1992, or 2005, as Canadian negotiators now suggest at UNFCCC negotiations in an attempt to mask our increased emissions? There has been a focus on “clean technologies” or essentially carbon capture and storage (CCS); the economic as well as technical feasibility of that approach has been questioned⁶⁰ and it needs open analysis.

If the targets are based on cap-and-trade, what is included and how will the caps and rules of trade be defined? Pricing carbon is seen by most economists as the most effective, easiest and fairest way to implement emissions reductions. This approach was recently recommended by

a report of the United States National Academy of Sciences (Fri et al., 2010). Their report is summarized (National Research Council, Report in Brief, 2010c) as: *“meeting internationally discussed targets for limiting atmospheric greenhouse gas concentrations and associated increases in global average temperatures will require a major departure from business as usual in how the world uses and produces energy. ... Recommendations: 1. Adopt an economy-wide carbon pricing system.”*

An open analysis of the economics of all approaches, including all subsidies, is needed to determine the best approach for Canada as a whole. Canada needs a process to carefully and fully assess all options.

2. Develop, adopt and implement a national adaptation-disaster risk reduction strategy

An outcome of the national dialogue on climate change adaptation and disaster risk reduction should be a national strategy effectively linking climate change adaptation and disaster risk reduction. The Canadian National Disaster Mitigation Strategy (NDMS)⁶¹ has as its goal: *“to protect lives and maintain resilient, sustainable communities by fostering disaster risk reduction as a way of life.”* It also states that the *“NDMS should leverage, acknowledge and encourage new, developing and existing mitigation activities (e.g. climate change adaptation,...)”* (Underlining added). Protecting Canadians and enhancing our economy will be outcomes of integrated strategies to reduce risk and develop opportunities and these need to be based on strong scientific and technical bases.

3. Build a stronger climate change research enterprise

The National Research Council, Report in Brief (2010a) on advancing the science of climate change (Matson et al., 2010), noted that:

as decision makers respond to these risks, the nation’s scientific enterprise can contribute both by continuing to improve

58. Gibbins is president and CEO of the Canada West Foundation in Calgary.

59. Gagnier is Chair of the International Institute for Sustainable Development and former Chief of Staff to Premier Jean Charest.

60. “Carbon Capture and Storage – Trouble in Store,” *Economist*, March 2009.

61. Public Safety Canada. 2008. *Canada’s National Disaster Mitigation Strategy*. See http://www.publicsafety.gc.ca/prg/em/ndms/_fl/NDMS_Web_E.pdf

understanding of the causes and consequences of climate change, and by improving and expanding the options available to limit the magnitude of climate change and to adapt to its impacts. To do so, the nation needs a comprehensive, integrated, and flexible climate change research enterprise that is closely linked with action oriented programs at all levels. Also needed are a comprehensive climate observing system, improved climate models and other analytical tools, investments in human capital, and better linkages between research and decision making.

Canada also needs a stronger climate change research enterprise.

11. **Conclusion**

Addressing climate change in the broad sense and for the reasons discussed here, developing, adopting and implementing national strategies for energy-climate and climate change adaptation-disaster risk reduction, built on and supported by a stronger research enterprise, is necessary for our children and grandchildren and those of others around the globe. The legacy of an integrated energy-climate policy, respecting the issues of water-food-health security will leave an enhanced economic and healthy legacy of this generation for the future. 🍁

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Climate Security Project Workshops

1. 25-26 May 2009 in London, Ontario.
2. 13-14 October, 2009, in Ottawa. Hosted by Agriculture and Agri-food Canada
3. 29 October, 2009, in Toronto. Hosted by the Institute for Catastrophic Loss Reduction

Participants in Workshops (one or more)

Note: all participants were there in their personal capacity and have not necessarily endorsed this report.

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CHAPTER ONE

Climate Security and Vulnerable Populations in Canada

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1. INTRODUCTION

The dominant perspective on climate security has centered on traditional security issues of conflict and on how climate change will interact with existing problems of environmental degradation and resource scarcity to produce overwhelming harsh effects in unstable regions of the world. This article departs from that tradition; it focuses on the complex security challenges superimposed on a broad range of sectors in a country with relative stability, such as Canada. The paper is divided into three broad sections. The first section gives a brief conceptual analysis of security and investigates how climate change and security are interlinked. The section expands on the idea of climate change as a threat multiplier and explores how anticipated impacts will affect the security and welfare of Canadians domestically. The last section highlights vulnerable populations in Canada, the underlying socio-economic factors contributing to vulnerability and policy response to these challenges. Existing gaps in Canada's national adaptation action are also discussed. It concludes by suggesting the need for a stronger and more coordinated intervention on climate vulnerability vis-a-vis long-term anticipated impacts.

1.1 Defining Security

Humankind, in the twenty-first century, faces several threats including environmental degradation, impoverishment, conflicts, terrorism, health pandemics and other challenges caused by these factors. The changing climate, largely the result of anthropogenic activity, is also a major global threat altering the ecological balance that sustains life on earth (IPCC, AR4) and increasingly changing the landscape of other traditional threats, thus, redefining security. Climate change leads us to rethink and question our understanding of security. What does it mean to be secure in a changing climate? What are the critical thresholds for identifying an issue as a security threat? Whose security is at stake (a people, a nation, an

international system, the whole of humanity)? The answers to these questions depend on the goal of analysis. The goal of this paper is on vulnerable populations in Canada and therefore the focus is largely on human security

To address some of the questions above, it is important to clearly define terms (i.e. human security, national security, environmental security and climate security), at least, in the context in which this paper utilizes them. Security is an essentially contested concept; it conjures varying interpretations of threat across space, over time and in multiple scales, to different individuals, communities and nations. Some schools of thought conceive of security as "freedom from conflict" while others conceive of it as freedom to create enabling environment for the flourishing of human dignity. Barnett (2001), for example, argues that to be secured is a condition of being protected from, or not exposed to danger. Soroos, on the other hand, defines security as the "assurance people have that they will continue to enjoy those things that are most important to their survival and well-being" (Soroos 1997, 236). The diverging views of security suggest that the concept is subjective and socially constructed (Dalby, 1996; Deudeny, 1991). Barnett (2001) stresses the links between security and vulnerability, stating that security is an accentuated discourse on vulnerability. Like vulnerability, the assessment of security requires considering risks of exposure, susceptibility to loss, and capacity to recover. The distinction between the two concepts, however, is that security is often attached to the most important vulnerable entities -- for example the nation (national security), people/basic needs (human security), environment/preservation of biodiversity (environmental security), and property (home security).

Many important relationships between environmental change and security have long been acknowledged by security specialists as far back 1950s,¹ and reiterated in the pioneering works

1. See The 1952 Paley Commission Report to President Truman, *Resources for the Future*.

of thinkers like William Ophuls (1976), Lester Brown (1977), Richard Ulman (1983) and Jessica Tuchman Mathew (1989). The two concepts, however, were not explicitly linked until after the end of the Cold War, when countries began to pay attention to the international and unintentional environmental damage caused by war. For example, the U.S military's use of defoliants in Vietnam raised major environmental concerns in the early 1980s (IHDP Report No. 11 1999, 15). By mid-1990s, the Cold War lost much of its resonance, as scientific evidence of the unprecedented magnitude of human-generated pollution, ecosystem destruction, and resource depletion became more compelling (Mathew 2000, 101). Around the same period, papers² published by Jessica Tuchman Mathew and Norman Myers asserts that certain aspects of the global environment are so intimately connected to deep national values and are constitutive of security interests. Myer (1989, 41) and Jessica Mathew (1989, 162) claim when environment is threatened; national security is threatened, *ipso facto*. Renner (1989) adds that environmental degradation imperils nations' most fundamental aspect of security by undermining the natural support systems upon which all humans depend.

Researchers and analysts who take a traditional security perspective tend to discount the role that environmental degradation or resource depletion play in exacerbating common threats. They argue that broadening the definition of security to include a laundry list of modifiers (environmental, ecological, economic, food, human, comprehensive, common) undercuts the term's utility by making it mean something different to multiple constituencies (IHDP Report No. 11 1999, 3). In the late 1980s, The UN Commission on Disarmament and Security Issues, chaired by Olaf Palme of Sweden, made a distinction between collective security issues and common security, stating: the former implies more traditional interstate military security issues, while the latter reflects the growing array of non-military threats, including economic pressure, resource scarcity, population growth, and environmental degradation (IHDP Report No. 11 1999, 3). This

distinction was carried through by Westing (1989, 130) who noted that comprehensive security comprised of the two intertwined components: political security, with its military, economic, and humanitarian subcomponents, and environmental security, which include protecting and utilizing the environment. Thus, according to Westing, comprehensive security meant freedom from various threats, including nuclear war, poverty, and global environmental issues.

At the dawn of the twenty-first century, patterns of threat and perceptions of security changed from sole focus on state security (i.e. protection from external aggression), to common global issues of epidemic disease, hunger, natural hazard, environmental change, and intra-state conflicts, to being centered on individuals/collectives' (human security). Scholars argue that a 'state centric' view of security leaves out the most elementary and legitimate concerns of people regarding security in their daily lives, since such an approach diverts substantial portions of national wealth and human resources into armaments and armed forces, while countries fail to protect their citizens from chronic insecurities of hunger, infectious disease and environmental hazards (ICISS, 2001). The human security approach therefore refocused the 'object of security' on human well-being and factors that threaten or enhance it.

The idea of putting 'people' at the center of security discourse was first popularized by Mahbub Ul Haq in the 1994 (UNDP) Human Development Report. The report itemizes seven aspects of human security, which are: economic security – freedom from poverty, it refers also to food security, access to water, and basic needs of life; health security – access to healthcare and protection from disease; personal security – physical protection from torture, war and criminal attacks; environmental security – protection from pollution, reduction in loss of biodiversity, protection of endangered species; community security – survival of traditional cultures; and political security – freedom from oppression.

2. The suggestion to broaden the definition of threats to security to include environmental change, whether it is referred to as common, comprehensive, or sustainable livelihood, came from a variety of sources. Although the report of the World Commission on Environment and Development (WCED), *Our Common Future*, is best known for its definition of "sustainable development." The Commission highlighted the causal role environmental stress can play in contributing to conflict while also stating that "a comprehensive approach to international and national security must transcend the traditional emphasis on military power and armed competition" (WCED 1987, 90).

Following the 1994 UNDP report, the United Nations Commission on Human Security jointly chaired by Sadako Ogata and Amartya Sen, explained that human security focuses on shielding people from critical and pervasive threats and empowering them to take charge of their lives. "It also means creating systems that give people the building blocks of survival, dignity and livelihood." They emphasized that human security connects different types of freedoms – "*freedom from want, freedom from fear and freedom to take action on one's own behalf*" (ICISS, 2001). To achieve this, they offer two general strategies: protection and empowerment. Protection shields people from danger it requires concerted effort to develop norms, processes and institutions that systematically address insecurities, while empowerment enables people to develop their potential and become full participants in decision-making. Protection and empowerment are mutually reinforcing and both are required in most security situations (ICISS, 2001).

It must be underscored that human security does not replace or dispel the idea of state security, but complements it by being people-centered and addressing insecurities that have not been traditionally considered as state security threats (ICISS, 2001). Most current work, in fact, argues that the state remains the most effective guarantor of peoples' human security needs. In other words, providing security for citizens remains the most important responsibility of government (Newman 2001, 239; Axworthy, 2001; MacLean, 2000; Ryerson, 2008). Much attention has therefore been paid to the reconfiguration of states to make them willing and able to protect their citizens, and in a changing climate, the role of the state can certainly not be overemphasized.

1.2 Climate Change and Security

That climate variability and change poses risks to human welfare is relatively uncontroversial in climate science and environmental policy circles (Barnett 2003, 13). The Intergovernmental Panel on Climate Change (IPCC) reports (2001, 2007) document the possible implication of climate change this include, sea level rise, droughts, flooding of low-lying coastal regions, increases in heavy precipitation events over most areas, and increased extreme events such as cyclones,

hurricanes and tropical storms, all of which will have particularly severe consequences for human settlement and populations. They also elaborate on several pathways through which impacts of climate change can affect human well-being, these include, impacts on: agricultural production and food security; water security; land degradation, and desertification; health and the incidence of various vector-borne diseases; biodiversity loss and species extinction, and large-scale disruption of local and global economies. Under the current climate change scenario, with increasing greenhouse gases, IPCC (AR4, WGII, *Summary for Policymakers*, 13-15) estimates 120 million to 1.2 billion will experience increased water stress by 2020s. Up to 250 million people across Africa are expected to face severe water shortages by 2020. About 5 million people in mega-delta regions in South, East and Southeast Asia are projected to be at greatest risk due to increased flooding from sea and flooding from rivers, and about 30% of Asian coral reefs are expected to be lost in the next 30 years. In Latin America, 26 million people by 2050 are likely to be at risk from hunger, and by 2020 between 7 million to 77 million are likely to suffer from inadequate water supplies. Indeed, more than 200 million people are expected to migrate from their home countries due to various climate-related stresses (Myer, 2002).

Are these impacts tenable or sufficient to describe climate change as a security issue? What is the added-value of framing climate change as a security issue? Richard Ulman's (1983, 133) response to the former is in the affirmative. He argues that a 'security issue' is any action or sequence of events that (1) threatens drastically and over a relatively brief period of time to degrade quality of life for the inhabitants of a state, or (2) threatens significantly to narrow the range of policy choices available to a state or to private, non-governmental entities (persons, groups, corporations) within the state.

Levy (1995, 40) proposes that for any environmental threat to be considered a security issue there must be some demonstrable connection to some vital human or national interest/value(s). The connection may be clearly stated or implied. Classical examples are: the case of environmental refugees – connection with humanitarian relief, migration and regional stability; and, in the

case of ozone layer depletion, the connection to public health and human lives. The problem of stratospheric ozone layer depletion caused by the use of chlorofluorocarbons (CFC)³ has much in common with conventional security risks. The interest/value(s) that are threatened are lives and well-being of populations, crop productivity and ecosystem health (Levy 1995, 43).⁴ The threats posed (i.e. to human lives and well-being) bordered on important national values such that it required immediate governmental intervention and financial commitment similar to traditional security issues.

For certain communities and countries, climate change threats are direct and implacable. In the atoll-countries, such as, Tuvalu or Kiribati, projected sea-level rise threatens not only elements of human security but is also capable of undermining the territorial integrity and political independence of these countries. In the case of the Tuvaluans, the continued existence of their homes, country and political life is now determined by rising sea level which may submerge the entire Tuvalu Island (Barett, 2001; Watson, 2000). The island of Maldives is faced with similar problems, as none of its 1,190 islands in the Indian Ocean lies more than two metres above sea level.⁵ Such effects of climate change not only constitute serious security concerns but also infringes on people's right to nationality and statehood as stated under the United Nations Charter, the Universal Declaration of Human Rights and other international instruments. The president of Maldives, Mohammed Nasheed, at *the Times World Forum on Enterprise and the Environment*, stated that climate change should not be seen as an environmental crisis, but a security issue and a human rights issue because it imposes unbearable risks on the lives, livelihoods and homes of millions of people across the world, particularly those who are not major contributors to the problem.⁶

The climate change conundrum is perhaps the most complex security issue of any experienced in the history of humankind. Its anticipated impacts, in the absence of mitigating measures, could disrupt domestic economies, reduce food production, undermine health and wellbeing thus causing Canadians, or any other group of people for that matter to suffer greater hardship than they consider tolerable as a society. In other words, the extent to which climate change impacts constitute a security risk to Canada hinges on the magnitude of welfare losses, ecosystem destabilization, species extinctions, risk to health, and raging threats from around the globe, and the speed with which they might occur. Encapsulating climate change as a security risk thus communicates a certain *gravitas* that warrants a policy measure commensurate in effort, if not in kind, with war. Better than concepts such as vulnerability or sustainability, it offers a framework in which danger can be recast as widespread risks to welfare and sovereignty of states (in the case of small island countries) (Barnett 2003, 14). Climate security thus serves as an integrative concept that links local/people (human security), national (national security) and global (international security) levels of environmental change and response (Barnett 2003, 14). It also integrates mitigation and adaptation as both are essential to building a defense against climate risks.

1.3 Security Sector and Climate Change Discourse

It is not surprising that the security community now regards climate change as an appropriate area of concern (CNA, 2007; Homer-Dixon, 2007; O'Brien, 2005; Barnett et al., 2007). Long- and short-term impacts of sea-level rise on civilian and military infrastructure, including on naval bases, low-lying airfields and energy infrastructure have been considered potential threats to state security.

3. A benign industrial chemical used as a propellant, a refrigerant, and a solvent.

4. The United States Environmental Protection Agency calculated that in the absence of corrective measures a total of 12 million additional Americans would contract skin cancer, and that 200,000 of these cases would be fatal. Levy points that though the ozone problem may be framed by people as a public health issue rather than a security issue, yet it cannot be disputed that its reverberating effect on the American society meets fairly traditional criteria of security threats as well.

5. *The Times* July 6, 2009, Maldives president Mohammed Nasheed demands action on climate change.

<http://www.timesonline.co.uk/tol/news/environment/article6643750.ece> (accessed July 31, 2009) Scientists estimate that sea levels may rise globally between 20 cm and 60 cm by 2100, signifying that many island countries will face complete inundation and even the elevated ones will experience increased flooding.

6. President Nasheed further stated "defending his island nation against rising sea levels was a humanitarian challenge as critical as defending Poland against Nazi Germany in 1939." The statement made by President Nasheed connects the human and national security imperative triggered by climate change.

The Times July 6, 2009, Maldives president Mohammed Nasheed demands action on climate change.

<http://www.timesonline.co.uk/tol/news/environment/article6643750.ece> (accessed July 31, 2009).

This was stated as one of several reasons why the United States considers climate change a national security issue (Busby, 2008; NIC, 2008b; Dabelko, 2009, 16). Resource conflict and international migration commonly cited as a possible indirect impacts of climate change are also of concern to the state security advocates (Myers, 2002; Gleditsch et al., 2007; NIC 2008b), although migration issues have to be viewed in a broader context of other environmental push and economic pull factors (Tacoli, 2009; Brown, 2007).

Furthermore, predictions of more intense weather events are leading security planners to anticipate increased demands for humanitarian relief missions, with all the training, procurement, deployment and opportunity cost implications that such missions imply (CNA 2007, 37; Dabelko 2009, 16). Though many of these concerns are valid, they do not translate to militarizing response to climate change and its anticipated impacts. A military-based approach may be counterproductive since it could warrant the use of force and other traditional tools of military. Additionally, a militarized response to climate change problems may create “us versus them” mentality (both humans versus nature and humans versus humans) which may undermine the co-operative solutions required to mitigate climate change (Waever 1995, 48). Clearly, no one can have an armed struggle against a rising sea.

Militaries are major emitters of greenhouse gases and hence must be a part of the solution by reducing the climate impacts of their activities (Mabey 2008, 4). Governments can play a key role in this area by reducing budgetary spending on military and increasing spending on climate security. In a 2009 report by the Institute for Policy Studies, *Military vs Climate Security, Mapping the Shift from the Bush Years to Obama Era*, the Bush Administration in 2008 fiscal year allocated \$88 federal dollars to military forces for every dollar it devoted to stabilizing the climate. The report

notes that the Obama Administration is working to narrow the budget gap of 88:1 between military and climate security to 9:1, using two principal vehicles: the American Recovery and Reinvestment Act, passed in February 2010; and the allocation for individual departments in its 2010 fiscal year budget request.⁷ The 2010 budget request allocates \$10.6 billion to the mission of arresting climate change.

Specific research comparing military expenditure vs. climate security investment is yet to be done in Canada. Nonetheless, a crude analysis suggests that Canada may in fact be lagging behind on climate security investments. For the 2008-2009 fiscal year, Canada allocated CAD \$18.9 billion for defense, with planned spending for 2009 estimated to be more than CAD \$19.1 billion.⁸ On the other hand, two of Canada’s major investments on climate security was CAD \$850 million investment in ‘carbon capture and storage’ – an emission-reducing technology for fossil fuel (NRcan, 2009), and CAD \$86 million over five years earmarked to increase adaptation action in Canada (Policy Research Initiative, 2009). The huge gulf between what Canada spends on climate security vs. military is very clear. Investing more on climate mitigation and adaptation rather than military will make the balance of security resource more consistent with the relative magnitudes of threats faced by Canadians in a changing climate.

Compared to state security advocates, human security groups focus more on the range of climate threats that endanger the lives and livelihoods of individuals and communities. They seek a better understanding of many interrelated variables – social, political, economic, technological and environmental factors exacerbating climate change threats. The problem is not only the long term bio-physical changes in mean conditions, increasing variability and extreme weather events, but also increasing adjustments in institutions and governance regimes, the possibility of conflicts,

7. The Bush climate change budget focused on four domains of spending- climate change science, technology development, international assistance, and tax incentives – whereas the Obama administration is investing substantial amount in several other areas, particularly mass transit, energy efficiency, and renewable energy, which are considered part of climate change budget. The climate change-related spending in the American recovery and Reinvestment Act of 2009 specifically contains (Technology Program - \$16.4 Billion; Science Program, \$ 0.53b; Energy Tax Provision, \$3.1 b, Transportation, \$19.42b ; Domestic Adaptation/ Mitigation, \$.073b, Energy Efficiency Programs and Renewable Energy Programs, \$28.2; Green Job Training Programs , \$ 0.5 b) A total of \$ 68.86 billion is earmarked for climate security concerns. See Pemberton, 2009.

8. Treasury Board of Canada Secretariat. “Departmental Planned Spending and Full-Time Equivalents.” Queen’s Printer for Canada. <http://www.tbs-sct.gc.ca/rpp/2008-2009/inst/dnd/images/sec1f-table1-1g-eng.jpg>. Retrieved 30 November 2009. See also CBC News, Funding the Forces written by David MacQuarrie, Thursday, January 22, 2009. <http://www.cbc.ca/money/story/2009/01/20/f-militarybudget.html>

equity issues, and increasing vulnerability that may render welfare and livelihood less secure (Barnett 2003, 13). For example, drought caused by climate change may severely affect resource-dependent families with already low incomes and limited access to irrigation technology. This, in turn, may affect their food security and which may have implications on their health and psychological well-being. The added impacts of climate change on existing socio-economic disparities can lead to double vulnerability, particularly for people already on the precipice of poverty. This clearly is where climate security issues are of paramount interest to human security advocates. In other words, human security takes a more comprehensive approach in assessing vulnerability and the security implications of climate change by asking which segments of society have their security interest threatened by climate change? What are the social, economic and political factors that exacerbate insecurities?

2. Climate change as a threat multiplier

Much of 'climate security' attention is centered on climate change as a "threat multiplier" (McBean 2008, 25; German Advisory Council, 2007; Brown and Crawford, 2009; National Security Strategy of United Kingdom, 2008). The challenge superimposed by climate change is diffused across a broad spectrum of concerns – economic, social, cultural and political. Unlike most conventional threats that involve single entity acting in specific ways and points in time, climate change has the potential to result in multiple chronic conditions, occurring locally and globally within the same time frame (CNA 2007, 44).⁹ It is already eroding economic and environmental conditions in fragile regions. Even more stable countries will face some challenges too, as food production declines, disease increases, clean water becomes increasingly scarce and large populations move in search of resources (CNA 2007, 44). More so, being a macro driver of

natural disasters, climate change will threaten vital sectors of the human system – health, housing, food and water (McCarthy et al, 2001). It may jeopardize the assurance people have that they will continue to enjoy those things that matter most to their survival and well-being (Soroos 1997, 236). The discourse of climate change as a threat multiplier far trumps generalizations linking climate threats solely with resource conflicts (Homer-Dixon, 1999; Baechler, 1999; Gleditsch, 1998) by bringing to bear other multiple direct and indirect threats superimposed by climate change.¹⁰

Several countries, including the United Kingdom, the United States, Australia, Germany and the Maldives, have acknowledged the multidimensional problem of climate change. In the United Kingdom's national security analysis report 2008, the United Kingdom openly declared climate change as a security threat, stating "*climate change is ... potentially the greatest challenge to global stability and security and therefore to national security. Tackling its causes, mitigating its risks and preparing for dealing with its consequences are critical to future security, as well as protecting global prosperity and avoiding humanitarian disaster.*" The report further notes that "*climate change and related effects on water, energy and food security will multiply other threats and interact with other drivers of insecurity, including demographic pressures and the spread of disease.*"¹¹ In April 2008, the German Advisory Council on Global Change presented its report *World in Transition, Climate Change as a Security Risk* – the core message is that "*without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades*"¹² which could result in destabilization and violence, jeopardizing national and international security to a new degree.

Like other countries, Canada is increasingly concerned about the multiple dimensions of security risks arising from climate change. Federal

9. The Center for Naval Analyses (CNA) 2007 report described unchecked global warming as threat multiplier, creating failed states and triggering instability across the conflict spectrum. The report also examined rapid migration patterns created by environmental refugees fleeing stressed regions; overwhelming disaster relief efforts; threats to submarines and warships arising from shifting ocean navigation patterns; and drought intensifying competition for dwindling food and energy, potentially even stimulating nuclear proliferation.

10. Treasury Board of Canada Secretariat. "Departmental Planned Spending and Full-Time Equivalents." Queen's Printer for Canada. <http://www.tbs-sct.gc.ca/rpp/2008-2009/inst/dnd/images/sec1f-table1-1-g-eng.jpg>. Retrieved 30 November 2009. See also CBC News, Funding the Forces written by David MacQuarrie, Thursday, January 22, 2009. <http://www.cbc.ca/money/story/2009/01/20/f-militarybudget.html>

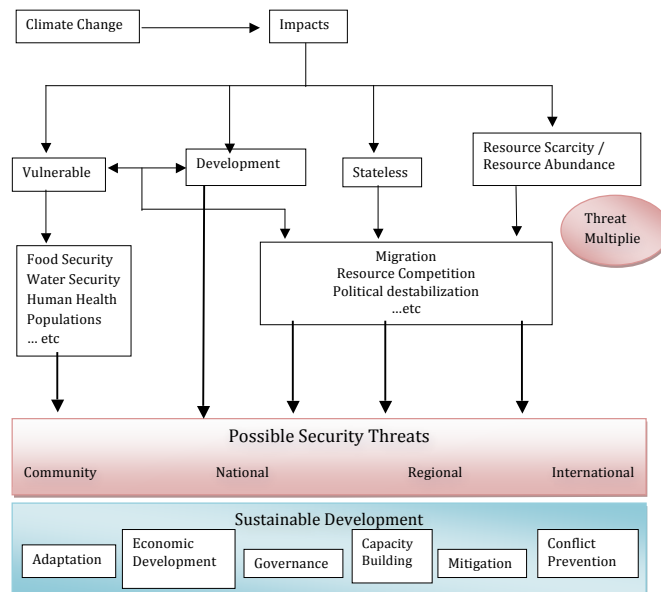
11. The National Security Strategy of the United Kingdom, Security in an interdependent world, presented to Parliament by the Prime Minister at the command of Her Majesty March 2008.

12. German Advisory Council on Global Change, 2007. *World in Transition; Climate Change as a Security Risk*, Berlin, Germany. http://www.wbgu.de/wbgu_jg2007_eng.pdf

ministries, including Environment Canada, Health Canada, Natural Resources Canada, Canada Forestry and Fisheries department, and private insurance companies are paying stronger attention to climate-related risks, its impacts on human and natural systems, infrastructure and local economy, and on Canada's foreign and trade relations (McBean 2008, 21). In a report prepared at the invitation of the Conference Board of Canada, McBean (2008) notes that climate security for Canadians also relates to the security of global communities and how a changing climate in other countries, with resulting economic and social impacts, affects trade, migration, travel and overseas assistance. McBean (2008, 6) stressed that *"climate security is achieved through implementation of measures that address both the obvious implications for national defense and other measures which address the maintenance of social, political and economic stability of a country and of human populations, and protect them from the effects of climate change and the global-to-local response to it."*

While the notion of climate change as "threat multiplier" has gained attention, by the same token, conditions, policies, institutions and actions that serve to relieve and manage stresses effectively can be considered "threat minimizers".¹³ Potential linkages and interplay between climate change and security issues are mediated by a number of contextual factors – including governance, institutions, access to information and external resources and availability of alternatives. At the United Nations level, five broad elements were considered essential threat minimizers: effective international and national mitigation actions, supported by finance and technology flows from developed to developing countries; inclusive economic growth and sustainable development, which will be critical to building resilience and adaptive capacity; effective governance mechanisms and institutions; and timely information for decision-making and risk management (UN Report A/64/350). Many of these actions are already being taken, though in a piecemeal fashion, by different countries, including Canada.

Threat multipliers and threat Minimizers: the five channels.



United Nations Report of the Secretary-General, Climate Change and its possible security implications, 2009

13. United Nations Report of the Secretary-General, Climate Change and its possible security implications. A/64/350, 11 September, 2009. Diagram based on submissions of Member states and relevant organizations..

2.1 Climate Security: the Canadian Context

There are growing concerns about how climate change will affect Canada. Several reports have shown climate change may have potentially large ramifications on the country as a whole, its provinces, communities – urban and rural, and existing infrastructures: ‘built systems,’ i.e. roads and bridges; ‘natural systems,’ i.e. watersheds and forest; and ‘human systems,’ i.e. health and education (NRCan, 2004; NRCan, 2007; Seguin and Berry, 2008; Public Safety Canada, 2005; C-CIARN, 2006, Lemmen et al., 2008). Other indirect impacts will be the subsequent social, financial and economic implications of climate extremes, taken together with additional tensions of international security dimensions such as terrorism and pandemics, all of which will test Canada’s resilience and capacity to respond to multiple and repeated challenges of climate change.

A considerable threat to Canada’s security lies in the Arctic. The rapid melting of the Arctic sea ice may create new challenges for the health and security of Arctic ecosystems and indigenous populations. More so, the receding sea and land ice could open up the previously inaccessible Northwest Transit routes to various state and non-state actors whose presence in the Arctic may conflict with Canada’s national interest (McBean 2008, 21). There are potentially overlapping claims to economic rights over certain areas of the Arctic seabed, including the vast reservoir of oil and gas resource.¹⁴ Contestations over these issues are already on-going between the United States, Russia, Denmark and Canada.¹⁵ This burgeoning dispute and other associated security risks pose serious threats to Canada’s sovereignty in the Arctic.

Another issue of great concern to Canadians is an expected increase in climate variability, extreme weather events and invasive species (NRCan, 2004). Since Canada is susceptible to high weather variability (McBean 2008, 25), increases in climate extremes and related hazards such as floods, hailstorms, tornadoes and heat

waves are projected to occur. They will affect the health and well-being of Canadians because such events frequently involve job losses, loss of assets, displacements, physical injuries, illness, psychological disorder and death (Lemmen et al., 2008, 12). For example, the 1998 ice storm in Ontario, Quebec and Atlantic Canada killed 28 people, 945 were injured and 17,800 people had to be evacuated from their homes Doyon, Belanger and Gosselin, 2008). The estimated cost of damage was CAD \$5.4 billion (Statistics Canada, 2007). Also, wildfires in British Columbia and Alberta resulted in 45,000 displacements in 2003 (Armstrong, 2003). In Halifax in 2003, Hurricane Juan shattered the city, causing extensive damage to property, infrastructure and the environment. The estimated cost was more than CAD \$100 million (C-CIARN, 2004). These different climate disasters result in great inconvenience, disrupting services and daily lives.

Overall, climate change will have widespread impacts on Canada; affecting food production, water, energy security and safety of infrastructure, all of which have implications for health, local economy and general well-being of Canadians (McBean 2008, 21). The toughest impact, however, will be borne by vulnerable groups as their cultures and livelihoods become severely threatened by anticipated and unforeseen impacts of climate change. Those dependent on climate-sensitive forms of natural capital are probably the greatest at risk.

3. Vulnerable Populations in Canada and Adaptive Capacity

Insecurities associated with climate change and anticipated impacts are often linked with the vulnerability of a people, a system, an economy, or a country. There are several definitions of vulnerability. Within climate change discourse, vulnerability is often defined in terms of three primary attributes: 1) the exposure of a particular population or system to threats or suites of threats associated with climate change; 2) the sensitivity

14. The United Nations Convention on the Law of the Sea provides the legal framework for the establishment of maritime zones, including the delineation for the outer limits of the continental shelves of coastal states, where those shelves extend beyond 200 nautical miles. The current legal framework is well developed and nearly universally adhered to and recognized. The Arctic states are also Member States to the Arctic Council, which provides forum for discussion and fosters the process and spirit of cooperation. See http://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf

15. See generally - A lecture to the Royal United Services Institute for Defence & Security Studies (RUSI) Conference on “Climate Change: The Global Security Impact.” At RUSI, Whitehall, London; 24 January 2007. <http://www.crispintickell.com/page116.html> (accessed July 10, 2009).

of population or system to those threat(s); and 3) the capacity of a population or system to resist impacts, cope with losses and/or regain functions when exposed to climate change (Adger, 2006; Eakin, 2008; IPCC, 2001; Smit and Wandel, 2006, McCarthy et al, 2001; O'Brien et al, 2004). Exposure and sensitivity increase vulnerability, while adaptive capacity and resilience acts decrease it.

Generally speaking, everyone is vulnerable to climate change threats, in some way, the issue cuts across rich and poor, urban and rural, North and South. What differentiates “more vulnerable” from “less vulnerable” is the ability of a people or a society to adapt and cope with change. Having appropriate information and skills, institutions, infrastructure, technology and resources to boost adaptation can make a huge difference between those who suffer great loss and those who lose close to nothing. Vulnerability can thus be considered a dynamic human condition influenced by both biophysical and socio-economic conditions (Kasperson et al. 2001, 248; Liverman 2001, 203; O'Brien et al. 2004, 194).

O'Brien et al. (2004) point out three important features of vulnerability. First, vulnerability is inherently a differential concept, because risks of changes and ability to cope with them vary across physical space, as well as among and within social groups. For example, changing environments will be experienced differently in communities dispersed across Canada's highly diverse provinces. The experience of environmental change in the Arctic Red River will be different from that in Baker or Sachs Harbour, even communities within the same eco-zone may experience differential impacts from identical climate-related events because of marked local variations in site, situation, culture and economy (Dueren 2004, 205). Second, vulnerability is scale-dependent. That is, it varies depending on unit of analysis, from 'country' to 'region', 'community' or 'social group.' Canada has regions with dramatically different natural environments, and social and economic characteristics (i.e. north versus south). This suggests there are regions, sectors and groups within Canada that are more vulnerable than others (Berry, Clarke and Soskolne 2008, 28). Finally, vulnerability is dynamic, and may change over time as underlying structures and conditions change. In other words, vulnerability can either be increased or decreased depending on

type and scale of adaptation strategies and policies implemented.

Different vulnerability assessment models have been developed by scholars from different research traditions, including climate science, disaster risk reduction, human health, economics, engineering and policy analysis (Fussel 2007, 156). The type of model employed depends on several elements, such as, the type of system (population, infrastructure, economy, health, etc.) being examined, type and scale of stressor(s), the 'attribute of concern' (life, livelihoods, culture, health) and the level of concern (i.e. national, regional, or municipal level).

3.1 Vulnerability Assessment Model

Vulnerability assessment tools developed by traditional disaster risk communities such as the International Federation of Red Cross and Red Crescent are relevant in human-climate vulnerability assessment. The IFRC, for instance, employ vulnerability and capacity assessment (VCA) combined with participatory rapid appraisal (PRA) tool to diagnosis vulnerability at the level of villages and urban neighborhoods to assess a community's risk, and work together to devise ways of increasing their capacity to resist hazard impacts (Van Aalst et al. 2008, 166). However, the disaster risk communities often consider natural hazards (i.e. earthquakes, typhoons) as local-based and stationary, and further assume vulnerability to be constant. The long-time scales of climate change, in contrast, shift the focus to future risks, which require a dynamic assessment framework that accounts for changes in all vulnerability factors over time (Fussel 2007, 164). Climate change is a complex problem influenced by many processes, such as globalization, economic priorities, regulation, cultural perception and preferences. Assessing vulnerability under such conditions requires a more comprehensive approach that takes into account the aforementioned variables, the dynamic nature of expected changes, the degree of preparedness, regulatory policies and the differential factors such as, geographical location, socio-economic status, health, age, education and gender. Fussel's (2007) climate-vulnerability integrated model captures many of these elements, hence, the reason for utilizing it in this paper.

The Fussel model is based on the following (1) the characteristics of the vulnerable *system* (2) *the attribute of concern* (3) *the type of stressor*

(Hazard) (4) the time of horizon *Temporal reference*, (5) *sphere or scale of impact*, (6) *knowledge domain*. The framework explains:

- **Systems:** refer to the human-environment system, a population group, an economic sector, a geographical region or a natural system.
- **Attribute of concern:** refers to the valued attribute (s) of the vulnerable system that is/are threatened by its exposure to a hazard. Examples of attributes of concern include human lives and health, existence, income and cultural identity of a community, biodiversity, carbon sequestration potential and timber productivity of a forest ecosystem.
- **Stressor/Hazard:** is a potentially damaging influence on the system of analysis; it could be a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (United Nations, 2004).
- **Temporal reference:** is the time period of interest. Specifying a temporal reference is particularly significant during the time of horizon of vulnerability assessment, such as for long-term assessments of anthropogenic climate change (i.e. impacts expected over next 100 years). Current and/or future impacts can be assessed.

For example, assessing the vulnerability of the tourism or fishery sector in Atlantic Canada to climate change impacts over the next 30 years.

- **Sphere:** refers to the endogenous (internal) and exogenous (external) vulnerability factor, which could be geographic boundaries or the political power to influence change. Designating a specific factor as internal or external depends on the scope of vulnerability assessment. National policies, for instance, would be regarded as internal in a national assessment but as (largely) external in a local context.
- **Knowledge domain:** is relevant in determining the socio-economic vulnerability factor. These include economic resources, the distribution of power, social institutions, cultural practices and other unique characteristics relevant to a community or social group. This also covers the adaptive capacity of the community or individuals to cope with the effects of destabilizing conditions to which they may be exposed and susceptible.

The vulnerability diagrams below are inspired by Fussel's integrated model and based on information from other literature on climate change vulnerability in Canada. Diagram (a) highlights vulnerability based on geographic location/region. Diagram (b) shows demographic distributions of vulnerability.

Diagram (a) vulnerability based on geographic location/region.

<i>Vulnerable system</i>	<i>Attribute of concern</i>	<i>Hazard</i>	<i>Temporal reference – C/F</i>	<i>Implication</i>
Northern Canada	Traditional life & culture of aboriginal communities, local economy, infrastructure	Warming permafrost, melting glaciers and ice-sheets, sea-level rise.	C & F	Loss of biodiversity, Loss of culture, security concerns due to increase navigability of Arctic waters.
Atlantic Canada	Coastal communities, infrastructures and industries, fishery operation.	More storm event, sea level rise, coastal erosion, storm surge, flooding	C & F	Increase pressure on water sources, loss of specific fishery like salmon. Stress on built infrastructure.
Quebec	Traditional ways of life of Northern Quebec, health ecosystem, hydroelectricity supply and forestry, built infrastructure, water supply	Extreme weather, hurricane, ice storm, flood, heat waves, landslides, increased precipitation event, outbreak of pathogenic insects, floods.	C & F	Breakdown in critical infrastructure, loss of traditional life, injuries, psychological impacts on families, destruction of properties.
Ontario	Remote and resource-based communities health of residence, forest based economies	Heat wave, smog vector-borne disease, flood, combined stress from human and natural disturbances.	C & F	Disruptions to critical infrastructure, including water systems, energy generation and supply.
Prairies	Water resource, livelihood of communities, local economy.	Increased wildfire and insect disturbances, severe flood, severe drought, hail, tornadoes	C & F	Water scarcity, stressed aquatic habitat.
British Columbia	Forest industry – timber, fishery industry forest-dependent communities	Flood, droughts, forest fires, pest infestation – pine beetle	C & F	Positive and negative benefit from climate change in agriculture sector.

(adapted from Fussler, 2007; McLeman and Smit, 2006; Furgal & Prowse, 2008).

3.2 Demographic Vulnerability

The specific statistics on the number of people vulnerable to climate change in Canada is not provided in this paper. The paper only maps out segments of the societies that are or might be considered vulnerable and the ‘attribute of concern’ (i.e. health, income, culture, existence) that may be threatened. Depending on geographic location, age, income, gender, or health status, different ‘attributes of concern’ may be threatened. For example, elderly men living alone in Toronto might be vulnerable to heat waves, while elderly men living alone in Nunavut might find melting of the Arctic ice-sheet a threat to their sustenance and traditional hunting and travelling lifestyles. Furthermore, an individual or group may have more than one ‘attribute of concern’ threatened by climate change. An aboriginal single-mother in

Northern Canada, for instance, may not only have her physical health and access to food threatened by climate change but also her traditional culture and means of subsistence. Such ‘double’ or ‘multiple’ vulnerability to climate impact must be carefully considered when designing long-term provincial and community based adaptation programs. Particular attention must be paid to individuals or groups at the lowest vulnerability ranking so proper social and institutional support can be put in place to address their concerns.¹⁷

Elderly

The elderly population is the most vulnerable age group to climate change due to diminishing ability to acclimatize to changing temperature and other pre-existing health conditions (C-CIARN, 2004). Elderly people are less likely to perceive

16. Temporal reference is based on evidence of current and anticipated impacts of climate change. The scale of the impacts is not expressed in the model.

17. It is important to note other factors may affect an ‘attribute of concern’ (i.e. transportation systems in case of accessibility to food, and equity issues in case of access to jobs) which may not be directly or even indirectly attributable to climate change.

excessive heat and hence are less likely to use air conditioning, social isolation or physical frailty may also stand in the way of necessary cooling (Borque and Simonet 2008, 176; Belanger, 2006). A study conducted by Toronto Public Health found that when air pollution combines with extreme heat, elderly people become vulnerable to premature mortality (McKeown 2005, 4). Another report revealed that older men may be particularly vulnerable to climatic extremes because they tend not to be as well integrated into a defined social structure and therefore have less access to assistance through family members or community volunteer organizations (Soskolne et al., 2004). Seniors are the fastest growing age group in many big cities, for examples, in Toronto, and it is expected that 16 per cent of the population or 480, 000 people, will be over the age of 65 by the year 2031 (C-CIARN, 2004). With increasing climate change and low adaptive capacity, the vulnerability of this age group may likely increase too. It is therefore imperative that targeted adaptation measures such as the City of Toronto Hot Weather Response Plan¹⁸ become a common adaptation practice across Canada.

Infants & Children

Infants and children are vulnerable to climate change and environmental degradation due to their inability to protect themselves, their relatively high intake of water and certain foods, and their immature physiology and metabolism (Wigle, 2003). Additionally, infants and children are not able to move swiftly out of disasters or extreme hot events and may be unable to communicate their discomfort or anxiety to adults or guardians (Berry et al., 2008). Recent research shows that children exposed to traumatic events or disasters, such as the 2004 tsunami, suffered serious and persistent physiological effects which influenced their personality development,¹⁹ leading them to live in constant fear and anxiety about the present and the future (Math et al. 2008, 32). Adult and community-based groups have important roles to

play in building children's adaptive capacity and resilience against climate change.

Women

Studies on gender and environment have shown how gender mediates the use of the environment through roles, responsibilities, expectations, norms and the division of labour, including livelihood strategies (Seager and Hartmann, 2004). Women's disproportionate vulnerability to consequences of climate change, particularly in developing countries, has been linked to unequal access to and control over resources (Denton, 2002). The Canadian experience is not significantly different as socio-economic trends still place women at a disadvantage in absorbing any additional costs associated with recovering from or preparing for the effects of climate change (Eyzaguirre, 2008). In a case study in Canada's Red River Valley, Enarson (1999) found that disaster actions are explicitly gendered social experiences; women are more likely to feel greater impacts of climate change since they are more economically insecure than men before, during, and after disaster (Enarson 1999, 120). Moreover, gender-based evacuation orders privileged fathers over mothers by reinforcing the construction of women as distractions in the male-dominated hazard-fight, institutionalizing child care as women's responsibility, and expanding women's disaster work (Enarson 1999, 19). Aboriginal women in Canada face double vulnerability as they have lower adaptive capacity owing to lower income and higher rate of poverty; 33% of female single Aboriginal parents are at higher risk of being food insecure than other female populations in Canada (Statistic Canada, 2001a; Seguin et al. 2008, 332). Furthermore, a Canadian study of the 1998 ice storm in Quebec, Eastern Ontario and New Brunswick, linking children's long-term health effects to the stress of natural disasters on mothers, concludes that pregnant women are also vulnerable to climatic destabilization, their exposure to stress and anxiety affected the general intellectual

18. The city of Toronto has developed and implemented two extreme weather alert plans: Extreme-Cold Weather Alerts in 1996, and Heat-Health Alerts in 2001. These plans are designed to protect the city's most vulnerable populations – the elderly, children, medically at-risk persons and the homeless, from extremes of heat and cold. For detailed explanation see C-CIARN (2004).

19. World Health Organization (WHO)-funded study conducted in Indonesia reported that 20% to 25% of children affected by the 2004 tsunami in south and Southeast Asia required professional treatment for psychosocial problems. Depending on the cultural and social contexts, special measures must be taken to ensure the protection from harm of all children, as well as their equitable access to basic service (Adventist Development and Relief Agency. Tsunami Response Report No. 34. Indonesia, Sri Lanka, India, Thailand; May 16. 2005. http://www.adraasia.org/pdfreports/Tsunami%20Update31_web.pdf (accessed July 5, 2009)

development of children born shortly after the storm (Borque and Simonet, 2008; Eyzaguirre, 2008). The gendered vulnerabilities exacerbated by climate change are significant but still poorly understood; hence, gender considerations should be incorporated into vulnerability mapping and emergency management planning. Enarson (1999, 121) suggests that community consultation with women, before, during and after disaster event is essential to gaining better understanding of the challenges they face.

Socio- Economic groups

The poor, unemployed, homeless and recent immigrants are also considered vulnerable to climate change (Health Canada, 2005). Poverty often serves to exacerbate their vulnerability, causing low-income individuals to live in areas with poor housing, less money to buy food and less access to proper health care. Some communities in Canada's North earn lower income and lack adequate access to health-care services to respond to climate change (Health Canada, 2002). An important issue worthy of further research is the psycho-social well-being of people, particularly in the event and aftermath of disasters.

Resource-dependent communities

Resource-dependent and Aboriginal communities (Ford, Smit et al. 2008, 45; Martello 2008, 352; Riedel, 2004) are perhaps the most vulnerable segment of the Canadian society. Communities dependent on agriculture, forestry and fishing are exposed to high climate variability and change that may affect a wide range of 'attribute of concern' – economic productivity, traditional livelihoods,

and well-being, among others. The greatest threat lies in the Canadian North, particularly among northern Inuit communities. Anti-poverty programs such as provision of micro-credit and micro-insurance facility can serve as a double-edged sword to combat poverty, while also helping to bolster adaptive capacity to cope with climate change impacts.

Chronically ill and people with disabilities

Health Canada in its 2002 and 2008 report, identified people with existing health conditions, such as cancer, AIDS, obesity and diabetes, as more susceptible to water-borne and vector-borne disease and physical stresses, including those resulting from experience of cold spells, floods, or severe storms. Poor air quality, resulting from smog and air pollution, has been associated with asthma, chronic respiratory disease and cardiovascular disease in Canada. With increased emissions of greenhouse gases, smog and air pollution are expected to increase. Toronto public health recently predicted that climate change would cause a 20% increase in air-pollution related deaths in the city by 2050 (Ford Lea 2009, 80; Campbell & Cheng C, 2005). People with visual, mobility or other impairments are also vulnerable to climate change due to their health status and low capacity to evacuate during emergency situations. The vulnerability of these groups, especially those who are mobility-impaired, can be reduced through measures targeted to protect them, such as, arranging special transportation on stand-by for their evacuation during emergencies (Christensen, Blair, and Holt, 2007).

Diagram (b) vulnerability based on demography.

<i>Vulnerable system</i>	<i>Attribute of concern</i>	<i>Stressor & root causes</i>	<i>Knowledge domain</i>	<i>Sphere - internal vs. external</i>
<i>Elderly persons</i>	Health and well-being	Heat wave, infectious disease, pollution, pre-existing health condition	Low income, low social network, lack of access to information.	Internal
<i>Infant & Children</i>	Physical health, psychological well-being, personality development	Air and water pollution, exposure to climate extremes such as storms, hurricanes	Household income, information held by guardian and parents	Internal
<i>Women</i>	Livelihood of aboriginal single women, food security	Exposure to climate extreme	Household income, high rate of poverty, unequal access to resources	Internal
<i>Resource dependent groups</i>	Livelihood of communities, psycho-social well-being	Exposure to climate variability & extremes – droughts, floods, environmental degradation	Low income, poverty, global trends and internal market, national and provincial policy adjustments, property rights and land claim	Internal and external
<i>Aboriginal communities in Northern Canada</i>	Traditional food supply, traditional life and culture, health	Sea-level rise, melting Arctic ice, environmental change	Low income family	Internal
<i>Chronically ill & people with disability</i>	Health	Exposure to climate extreme – severe storms, heat waves, hurricane, cold spell, flood, pre-existing health condition	Low income, low social network, lack of information & social network, transportation and mobility challenges	Internal & external

(Source Fussel, 2007; Health Canada, 2005; Health Canada, 2008; Ford et al 2005; Ashford et al, 2001; C-CIARN, 2004; NRCAN, 2008).

3.3 Building Adaptive capacity

Adaptive capacity is a crucial “threat minimizer” required for reducing vulnerability and enhancing adaptation to climate change at the national and local level. It is an attribute of a system or population to cope with impacts of climate change (Warren and Egginton 2008, 32). It also signifies the ability of society to adjust to practices, processes, or structures to moderate or offset the potential damage associated with climate change this may, include, economic wealth, technology, information and skills, infrastructure, institutions and equity (Schneider et al. 2001, 895).

There is no consensus on the criteria required for evaluating determinants of adaptive capacity. Neither is there a settled agreement on indicators that should be used (Lemmen et al., 2008). Common indicators used to measure adaptive capacity present significant challenges because they say little about the processes that make a system or population vulnerable and which determine whether systems and the population can adapt to new climate hazards (Brooks and Adger, 2004). In spite of these difficulties, some

pointers for assessing adaptive capacity have emerged in literature, these include, economic wealth, availability of technology, information and skills, appropriate decision-making capabilities, human capital, social risk spread (i.e. insurance), ability to share and manage information, public infrastructure, institutional arrangement, perception and interpretation of risks, and equity considerations (Grambsch and Menne, 2003). Countries such as Germany, Japan, the Netherlands, Norway, United Kingdom and Canada rank high on some of these indicators.

Adaptive capacity in Canada is generally, high but is unevenly distributed between and within regions and populations (Lemmen et al. 2008, 14). Differences also exist in adaptive capacity among rural and urban communities. Both urban and rural centres have characteristics that enhance or limit their adaptive capacity (Seguin and Berry, 2008). For example, Northern Canada, with its sparse, widely distributed population, evolving governance and institutions, and significant subsistence economy, has unique limitations to adaptive capacity. However, urban centres such as

Toronto or Montreal tend to be places of greater wealth, higher education, skill sets, with easier access to technology and institutions and thus higher adaptive capacity (Furgal et al. 2008, 105). Although, urban centres tend to have greater reliance on critical energy, transportation and water infrastructure, they also experience more severe heat stress and air quality problems than rural communities (Borque et al. 2008, 176; Chotti et al. 2008, 231). A study (Haque, 2002) comparing rural and urban communities identified the following key challenges facing rural communities in their efforts to improve preparedness and adaptation to climate change: lack of economic resources to cope with hazards; an underestimation of the frequency of hazards events because of lack of knowledge; low level of risk assessment and reliance on volunteers as emergency personnel who are often inadequately trained or organized.

4. **Canada and Policy Approaches to Vulnerability**

In general, reducing vulnerability requires the rigorous pursuit of a combination of climate mitigation and adaptation measures, where both are considered as complementary rather than alternative strategies (UNICEF, 2008). There have been few proactive climate mitigation measures at the federal level in Canada. No overarching federal legislative framework has been put in place to regulate the emission of greenhouse gases, while the proposed 'cap and trade' market regulatory mechanism is yet to be in force. The 'cap and trade' mechanism is in itself flawed because once a cap has been set, the work and responsibility of the government is obscured by activities and vacillations of the carbon market, which is then "responsible" for climate protection, hence if the rate of emission reduction required is not achieved, government can easily point to the permit market as being at fault for lagging behind in implementation of carbon emission reductions.

The Harper government insists on following suit on whatever plan the United States chooses.

To date, apart from passing into law the American Clean-energy and Security Act 2009 (otherwise known as the Waxman-Markey bill), the U.S. has not done an excellent job on climate mitigation. The current toughest action by Canada on climate mitigation is investment in carbon capture and storage technologies, which only addresses a tip of the iceberg. Canada has failed to take firm actions and introduce regulatory policies to control emissions, or invest in alternative technologies that allow people to consume and maintain the status quo. This is unacceptable. What is at stake is too high for any country to hide behind the curtains of tranquilizing alternatives.

Canada is failing its Kyoto multi-lateral commitment. Canada signed and ratified²⁰ the Kyoto Protocol, which requires it to reduce greenhouse gas emissions to 6% below 1990 levels during the 2008-2012 commitment period, instead, the country's greenhouse emissions have continued to rise such that in 2007 they were 33.8% above the accepted Kyoto target (Environment Canada, 2008). Compared to other G8 countries,²¹ Canada's emission level per capita is very high and still increasing as there has been no significant policy improvement since 2007, while the expansion of carbon-intensive non-conventional oil (tar sands) has continued. Sadly, inaction or slow momentum towards mitigation at the global and national level does come at a great cost as more emissions now will lead to greater and more rapid warming of the earth and therefore greater adaptation cost later on.²²

Adaptation action and planning, on the other hand, has caught on strongly in Canada, particularly at the provincial level. A great deal of knowledge in this area is held by government agencies, universities, think-tanks, professionals and NGOs (Hodgson, 2007; Lemmen et al. 2008; Mehdi, 2006; Nickels et al., 2005; Bruce et al., 2006; Chiotti, & Lavender, 2008; Hebb, & Mortsch, 2007; C-CIARN, 2006; Environment Canada, 2006; Health Canada, 2008). Many of the federal government

20. Canada ratified UNFCCC on 04 December 1992, signed Kyoto in 1997 and ratified it 17 December, 2002.

21. Canada ranks bottom in the G8 2009 Climate Scorecard
http://knowledge.allianz.com/en/globalissues/climate_change/top_climate_stories/climate_scorecards_09.html?g8_climatescorecards_2009_flash
(accessed August 3, 2009).

22. CO₂ stays in the atmosphere for at least 100 years, even if the world could go to zero greenhouse gas emissions tomorrow, adaptation will still be needed to cushion the blows from environmental damage that will be caused by climate change in the next decades. Synthesis Report, Climate Change, Global Risk, Challenges & Decisions – Copenhagen 2009; 10-21 March, <http://climatecongress.ku.dk/pdf/synthesisreport> (accessed, July 10, 2009).

departments have taken steps, to varying degrees, to integrate adaptation planning or analysis into policy and program development. These include Agriculture and Agri-food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada, Indian and Northern Affairs Canada (INAC), Natural Resources Canada, Public Safety and Emergency Preparedness Canada (PSEPC) and Transport Canada. Through these government departments, some measures have been taken to aid adaptation and build the resilience of Canadians against climate change, although the various strategies to date have generally been fragmented, and there has been little collaboration among departments (Policy Research Initiative, 2009).

The NRCan 2008 report defines adaptation as “making adjustments in decisions, activities and thinking because of observed or expected changes in the climate, in order to moderate harm or take advantage of new opportunities.” Designing effective adaptation policy for climate change requires: understanding the vulnerability of people to current impacts, consideration for future impacts to climate change and related risks and opportunities, identifying adaptation options; and evaluating the costs and consequences of the options (Policy Research Initiative, 2009). There are at least four facets to adaptation that governments consider: 1) protecting interests and well-being of people within their jurisdiction (local and provincial); 2) regulating minimum standards or actions for others within their jurisdiction (industrial sectors, businesses and people); 3) facilitating adaptation by others within their jurisdiction; 4) making the public aware of adaptation issues and options.

Often cited as a limitation to formulating appropriate adaptation policy and plan, are uncertainties about climate prediction and projected impacts, and the need to prioritize other immediate needs given the limited availability of resources. Dessai, Pielke et al (2009) point out that uncertainty about future prediction is not peculiar to climate prediction, and epistemological limits to climate prediction should not be interpreted

as a limit to adaptation, as successful adaptation strategies can be developed in the face of deep uncertainties. Analysts can use multiple runs of one or more simulation models to systematically explore vulnerability and the implications of a wide range of assumptions to make policy arguments whose prospects for achieving desired end are unaffected by the uncertainties²³ (Bankes 1993, 436; Dessai, Pielke et al. 2009, 73). Such approach Dessai et al. (2009, 76) argues generally fall under the heading of robust decision-making and can be found in other public policy areas (such as, earthquake risk, national security and public health). Robust decision-making in this sense translates to embracing a no-regret adaptation strategy that may provide benefits to communities and sectors whether anticipated climate changes materialize or not. It can also help avoid cumulative and sudden impacts of climate change (C-CIARN, 2004). Accurate climate prediction, however, will inform effective decision-making only if it is helpful in discriminating among alternative courses of action in terms of their expected outcome.

Substantive investment in adaptation is required at all levels of government. Canada’s federal government has shown some political will in planning and implementing proactive adaptation programs. In 2008, a budget of \$86 million over five years was earmarked to help increase the capacity of Canadians to adapt to climate change (Policy Research Initiative, 2009). “Environment Canada is taking the lead in the implementation of several new adaptation programs in collaboration with Natural Resource Canada, Indian and Northern Affairs Canada, Health Canada, and the Public Health Agency of Canada. Notably, part of this funding (\$35 million) will be allocated to help Natural Resources Canada develop regional adaptation work programs and risk management tools (guidelines, analytical models, etc.) that will guide stakeholders through a series of steps to examine the implications of climate change impacts on their policies, plans, and operations to determine the most appropriate response options” (Policy Research Initiative, 2009). Nonetheless, critical gaps still exist in many of the government

23. For instance, Dessai (2005) uses information from climate models to identify potential weakness in strategies that water agencies in the UK have put in place to address future climate change. This analysis does not require accurate prediction of future climate change. Rather it only requires a range of plausible representations of the future climate change scenario that can be used to help water agencies better understand where their vulnerabilities may lie.

adaptation actions in Canada as noted in these reports: 2006 Report of the Commissioner for the Environment and Sustainable Development (CESD), March 2006 report of the Conference Board of Canada, and NRCan 2007 report, *From Impacts to Adaptation*.

The gaps identified include:

- The government has not clarified how it intends to manage its own adaptation efforts and has not developed a federal strategy to indicate the expected results and time lines, and which department would assume what responsibilities (Policy Research Initiative, Canada, 2009).
- The Federal government has not yet recognized its adaptation activities in a manner that could ensure Canadians obtain the information needed to take appropriate action in adapting to a changing climate (Policy Research Initiative Canada, 2009).
- The number of adaptation initiatives in Canada is small compared to the scope of adaptation needs (NRCan, 2007).
- Adaptation action to date has been achieved through informal actions and strategies in response to specific events or circumstances at the local, regional, or provincial levels. No effort has yet been undertaken to integrate climate change considerations into ongoing federal development planning and policy decision-making (i.e. climate change mainstreaming) (NRCan, 2007).
- There are existing specific regulations or legislation that may limit adaptation options and societal expectation (i.e. lack of policy response to maladaptation) (Conference Board of Canada, 2006).
- Decision-makers lack clarity on the estimate of financial impacts of climate change on assets, as well as the cost of implementing adaptation (Conference Board of Canada, 2006).
- Work with the provinces and territories has been limited (Policy Research Initiative Canada, 2009).

In its 2009 report, *Prioritizing Climate Change Risks and Actions on Adaptation, A Review of Selected Institutions, Tools, and Approaches* – Policy Research Initiative points out that Canada has the wealth, technology and expertise to overcome many of the barriers to action on adaptation. The 2008 budget funding of \$86 million over five years will play a critical role in this regard. Also the report drew attention to the need for further research into the impacts of climate change and for long-term perspective that considers all potential costs and benefits – the importance of developing tools, techniques and indicators that can assist in minimizing and clarifying the extent of climate risk and uncertainty. It reiterated the suggestions made by NRCan (2007) on the need for closer collaboration between industry, academia, government and local communities, and for a more anticipatory strategic approach to adaptation that could help reduce social and economic cost, increase efficiency and further reduce climate vulnerability in Canada.

A key adaptation strategy linked to climate security is the idea of integration and mainstreaming – that is “climate proofing” development plans, operations and practices. Mainstreaming adaptation at different levels of government will require careful analysis of governance architecture at different stages of the policy cycle to identify entry points where the consideration of climate change adaptation could be incorporated (OECD, 2009). A recently published report by Canada’s National Round Table on the Environment and the Economy (NREE, 2009) recommends mainstreaming adaptation into existing knowledge and future infrastructure decisions. The NREE (2009) specifically called on government (federal and provincial) to leverage the integration of climate risks in new construction and rehabilitation of infrastructure and ensure that systems are in place to monitor and report on infrastructure performance. They also called for closer collaboration between government and insurance industries in managing current and emerging climate risks. The NREE emphasized the need for governments at all levels to undertake a collaborative review of current disaster/emergency management frameworks as mechanisms to enable adaptation to climate change on a preventive basis.

Incorporating climate change adaptation measures into various sectors such as, water resources management, forestry and soil conservation, food and agriculture industry, public and private infrastructure, and so on, can create opportunities of reducing vulnerability while developing local communities' capacities to cope and adapt to climate change. According to Gaye (2008):

It is therefore imperative for the world to place ecological concerns at the centre of development. A radical new approach to adaptation which includes mobilization of resources not just for environmental climate proofing, but also for social protection programmes aimed at building the resilience of vulnerable groups and empowering people to manage climate risks is required. These programmes should include employment guarantee measures in drought prone areas and a range of social transfer to help vulnerable people create and manage their own schemes for coping with potentially catastrophic risks.

While adaptation at all level of governments (federal, provincial, municipal) is essential, it is not just a government issue or activity, but also an issue for all citizens, businesses, civil society and non-governmental organizations, individually and collectively. The importance of having specific information to support combined top-down and bottom-up approaches to adaptation has been emphasized in the Policy Research Initiative document (2009). One way of giving teeth to a bottom-up adaptation approach is by creating enabling legislation or a regulatory framework at provincial and local levels to address the vulnerability of critical infrastructure, industries, sectors and populations.

4.1 Building Adaptive Capacity at the Community level

Given that the *situs* of climate-induced hazards is at the local level, preparation and action on adaptation must also begin early at that level

with keen focus on increasing knowledge about climate risks and impacts, building resilient infrastructures, enhancing response institutions through fiscal support and expertise, and strengthening the adaptive capacity of vulnerable groups. Capacity building and empowerment strategies are invaluable to the goal of effective adaptation. To proactively adapt, the following elements are required at all tiers of government, particularly at the community level:

Information sharing: Access to vital information about effective adaptation programs (such as disaster preparedness techniques, early-warning systems, behavioural change (such as convincing individuals to reduce their exposure to harmful ultraviolet rays) must be provided to citizens alongside institutional support and skills required to cope with current and emerging impacts of climate change. Information is more likely to be used if it is easy to locate, easy to understand and relevant to the user.²⁴ This condition should be met when providing resource materials, toolkits or information guides to community users. City to city networks and discussion forums, such as, the Alliance for Resilient Cities (ARC) webinar forum (<http://www.cleanairpartnership.org/arc>), can aid cities and communities in timely sharing of experiences and information.

Stakeholder Engagement: Climate change adaptation needs to be mainstreamed into an overall development agenda of municipalities, provinces and the federal government. Relevant stakeholders, including policy makers, civil society groups, private organizations, NGOs, community representatives, utility providers and everyday Canadians, should be actively engaged in the planning and implementation of adaptation. The process should be structured in ways that allow for full participation and feedbacks from community members, particularly those at high risk. The Halifax ClimateSMART initiative illustrates how such collaborative partnerships between multiple orders of government, private sector and community can be done.²⁵ The principal focus of the

24. The Intergovernmental Climate Change Impacts and Adaptation Working Group, 2005.

25. ClimateSMART (Sustainable Mitigation & Adaptation Risk Toolkit) is an innovative project officially launched in March 2004 and developed to mainstream climate change mitigation and adaptation into municipal planning and decision-making. It is collaboration between the public and private sectors. Partners include: the Federation of Canadian Municipalities' Green Municipal funds; Natural Resources Canada; Environment Canada; Nova Scotia Department of Energy; Nova Scotia Department of Environment and Labour; Nova Scotia Environmental Industries Association; select members of ClimAdapt; Several community groups and local business, and HRM (Halifax Regional Municipality).

Climate SMART project includes: vulnerability assessments and sustainability analyses; cost-benefit assessments, emission management and mitigation tools; climate change risk management plan; emission management and adaptation methodology, including methodologies for each sector of the community; communications and outreach.

Education and local knowledge: Community-level responses to climate change are most effective when they are a blend of local knowledge, experience and expertise with solutions and information about conventional climate change adaptation. Such a synthesized body of knowledge can be distributed through community outreach and education programs.

Safety net: The provision of well-funded adaptation and emergency response programs for vulnerable groups is of great importance. Emergency management organizations in various provinces in Canada have been vocal in calling for investment in disaster risk reduction measures. Their knowledge and skills will be increasingly vital in implementing proactive long-term adaptation programs. Conducting due diligence examination on critical infrastructure such as electricity units, transportation, water systems, telecommunications, and fire safety units, and the level of preparation for emergencies will go a long way in undercutting unexpected climate effects. Key principles to be followed when designing safety nets for communities are inclusion, representation, participation, non-discrimination and elimination of mal-adaptation policies.

Removal of Mal-adaptation: Mal-adaptation and unintended consequence can occur in many different ways. Hence, those designated with adaptation planning should consider the multiple political, social, economic, technological and other human factors in determining whether adaptation strategies, policies, and measures will be effective (Kristie, Smith et al. 2006, 611). Making these connections helps ensure that friction on one end does not undermine adaptation effort on another.

Reparation/Compensation for climate-victims: Since not all climate hazards can be easily or effectively managed, there may occasionally be casualties or loss of properties, hence, an important consideration to bear in mind is compensation for

those affected by unavoidable climate disaster. The compensation could be financial, social, institutional, or other forms of assistance to support victims.

Transparency and accountability: Those assigned with specific adaptation responsibility and funding must clearly reflect a deep sense of accountability and transparency in their operation and relations with the public.

5. Conclusion

Security implications of climate change are multiple and complex – as effects of a changing climate pose fundamental threats not only to fragile states but even to a more stable society like Canada. Climate change impacts may impose severe strain on the Canadian economy, infrastructure, industries, social structure and foreign relations with other Arctic countries. Aboriginal communities, the elderly, the poor, infants, single mothers, and chronically ill are likely to experience double impacts, as their health and livelihood options, become threatened by climate extremes of droughts, heat waves, floods, storms, and sea level rise. A window of relief lies in the fact that there is a growing body of knowledge and expertise about climate adaptation and capacity building in Canada, particularly, among government department and agencies. Leveraging this knowledge by strengthening collaboration ties with other groups such as, community organizations, NGOs, insurance companies, risk-management practitioners, think-tanks, and academia, will prove useful in addressing individual and societal vulnerability. Three issues are crucial to a coordinated long-term response to vulnerability: one, designing a no-regret adaptation policy and improving on climate-related observation networks and co-ordination across various jurisdictions; two, adopting existing tools and methodologies developed through fields such as disaster risk reduction, and working with partners to develop tools not already available; and finally promoting ‘tested and proven’ adaptation practices across provinces in Canada.

Acknowledgements

Many people have helped develop and refine the ideas expressed here through stimulating discussions and meticulous critiques on various drafts, including, Andrew Dawe, Mike Brklacich,

Gordon McBean, Burt Dowsett, and other participants at the climate security workshops held in London, Ottawa, and Toronto. The author takes sole responsibility for any errors or omissions. 🍁

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CHAPTER TWO

Canadian Water Security in the 21st Century

THE
Security
Canada
AND Canadians

Christopher J. Popovich, M.A

1. INTRODUCTION

“Clean, safe, secure and available water is essential to Canadians” (Environment Canada 2004, v). Yet when considered in the context of climate change, these necessities are significantly challenged. For instance, water-related extremes such as floods and droughts are likely to intensify and increase in frequency, threatening critical infrastructure and human lives; in some areas, more intense precipitation may increase erosion and runoff containing sediments and nutrients, posing threats to water quality; areas with change in timing and amount of precipitation and evapotranspiration pose a risk to groundwater re-charge; saltwater intrusion into groundwater aquifers raise concerns over future groundwater quality; and while Canadian people and industries are among the highest per capita users of water, demand for water continues to rise at unsustainable rates. Ranging from socio-economic to biophysical impacts, climate change confronts policymakers with a diverse set of challenges with respect to water.

While climate change is a global issue, its effects will be felt differently among regions. Moreover, it can be viewed as a *threat multiplier*. That is, climate change will likely interact with, and exacerbate a wide range of existing stresses, such as population growth in vulnerable areas, land use change, growing gaps between the rich and poor, and aging infrastructure. It will also have the potential to introduce its own stresses, ultimately resulting in higher overall vulnerability and impacts (Brown 2008, 16). A major challenge therefore, is projecting the specific impacts that will result from a change in climate.

While the negative impacts of climate change have been viewed as a *global threat*, some countries have moved toward framing the climate change issue specifically as a threat to *national security*. In a recent national report, the United Kingdom concluded that climate change is “potentially the greatest challenge to global stability and security,

and therefore to national security” (United Kingdom, 2008). Joshua Busby takes it further in stating, “like armed attacks, some of the effects of climate change could swiftly kill or endanger large numbers of people and cause such large-scale disruption that local public health, law enforcement and emergency response units would not be able to contain the threat” (Busby 2007, 5).

This knowledge synthesis aims to identify the effects of climate change as they relate to water security. The scope will be limited to freshwater resources and will take on a distinctively Canadian perspective. Section two will discuss background information and associated uncertainties. Section three will define key concepts related to climate change, water and security. Section four will highlight key domestic issues. Section five will explore the water-energy nexus. Section six will highlight only a selection of transboundary issues. The paper will conclude with a summary of the key concepts and highlight the regions of Canada that are most at risk.

This background paper explores the extensive literature on the subject of climate change and water resources in order to demonstrate the scope of potential impacts for Canada. Moreover, it will develop the case that while Canada’s water resources are vulnerable to climate change, it is within Canada’s capacity to respond and emerge ‘water secure.’

2. Background and Uncertainty *Canada’s Freshwater*

Freshwater is fundamental to the survival of all living things. It is also one of Canada’s most valuable natural resources, playing a vital role in several economic activities and sectors (O’Neill 2004, xi).

Canada has 20 per cent of the world’s *total* freshwater supply (Government of Canada 2003, 1) but only 6.5 per cent of the world’s *renewable* freshwater supply (World Resources Institute,

2005 in Sprague 2007, 25). Whereas *total* freshwater refers broadly to the volume contained in various water bodies, *renewable* freshwater refers specifically to the “salt-free water that is fully replaced in any given year through rain and snow that falls on continents and islands and flows through rivers and streams to the sea” (World Resources Institute, 2003 in Sprague 2007, 23). Misunderstanding of these key concepts can lead to misconceptions of the availability of water, with associated effects on management and allocation of this valuable resource. For example, the Great Lakes are typically considered a vast reserve of water yet only one per cent of the volume is renewed annually (Morris et al. 2007, 11). This renewable supply is available for sustainable use, but over-allocation and overuse can diminish the resource.

While approximately two-thirds of Canada’s freshwater flows northward toward the Arctic Ocean and Hudson Bay, the majority of the population is located in the more southern regions and in coastal areas (Government of Canada 2003, 1). In fact, water shortages have occurred in 25 per cent of Canadian communities during the latter half of the 1990’s (Bakker 2009, 16). In other words, “water tends to be where most of the people aren’t” (Pollution Probe 2007, 5).

In a global context, Brazil and Russia possess the greatest renewable water supply, respectively, with Canada in a tie for third place with Indonesia, the United States and China (World Resources Institute, 2005 in Sprague 2007, 25). Thus while there is a large supply of water in Canada, it is only in relative terms.

These points highlight the myth of water abundance in Canada. It will therefore be crucial for policymakers to consider the location, amount, and the renewable portion of Canada’s water supply in devising adaptation and management strategies with respect to climate change.

2.1 Climate Change Impacts on Freshwater

Due to its interconnectedness with socio-economic and biophysical issues, water is increasingly becoming recognized as a key priority

in the context of climate change. The following briefly outlines some of the projected impacts on water resources from a continental and Canadian perspective. More in-depth discussion of some of the issues and implications will follow in the next section.

According to the Intergovernmental Panel on Climate Change (IPCC) 2008 technical report on Climate Change and Water (IPCC 2008, 130), climate change will impact North America’s water resources in the following ways:¹

- *“Projected warming in the western mountains by the mid-21st century is very likely to cause large decreases in snowpack, earlier snowmelt, more winter rain events, increased peak winter flows and flooding, and reduced summer flows”*
- *“Reduced water supplies coupled with increases in demand are likely to exacerbate competition for over-allocated water resources”*
- *“Moderate climate change in the early decades of the century is projected to increase aggregate yields of rainfed agriculture by 5-20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources”*

Also of concern to Canada, are the impacts on water resources in the Polar region, including (IPCC 2008, 130):

- *“Northern Hemisphere permafrost extent is likely to decrease by 20-35% by 2050. The depth of seasonal thawing is projected to increase by 15-25% in most areas by 2050, and 50% or more in the northernmost locations under the full range of SRES scenarios. In the Arctic, disruption of ecosystems is projected as a result”*
- *“Further reductions in lake and river ice cover are expected, affecting thermal structures, the quality/quantity of under-ice habitats and, in the Arctic, the timing*

1. The following probabilities and descriptions are assumed in the italicized IPCC language: virtually certain > 99%; extremely likely > 95%; very likely > 90%; likely > 66%; more likely than not > 50%; about as likely as not 33% to 66%; unlikely < 33%; very unlikely < 10%; extremely unlikely < 5%; exceptionally unlikely < 1% (IPCC, 2008, 11)

and severity of ice jamming and related flooding. Freshwater warming is expected to influence the productivity and distribution of aquatic species, especially fish, leading to changes in fish stock, and reductions in those species that prefer colder waters”

permafrost threaten Arctic communities, industrial infrastructure and water supply”

More detailed impacts of climate change on water resources in the Canadian regional context have been adapted from *Climate Change Impacts and Adaptation*:

- “Increases in the frequency and severity of flooding, erosion and destruction of

Potential impacts of climate change on water resources in Canada

Region	Potential changes	Associated concerns
Yukon and coastal British Columbia	Increased spring flood risks (BC), impacts on river flows caused by glacier retreat and disappearance	Reduced hydroelectric potential, ecological impacts (including fisheries), damage to infrastructure, water apportionment
Rocky Mountains	Rise in winter snowline in winter-spring, possible increase in snowfall, more frequent rain-on-snow events	Increased risk of flooding and avalanches
	Decrease in summer streamflow and other changes in seasonal streamflow	Ecological impacts, impacts on tourism and recreation
Prairies	Changes in annual streamflow, possible large declines in summer streamflow	Implications for agriculture, hydroelectric generation, ecosystems and water apportionment
	Increased likelihood of severe drought, increasing aridity in semiarid zones	Losses in agricultural production, changes in land use
	Increases or decreases in irrigation demand and water availability	Uncertain impacts on farm sector incomes, groundwater, streamflow and water quality
Great Lakes basin	Possible precipitation increases, coupled with increased evaporation leading to reduced runoff and declines in lake levels	Impacts on hydroelectric generation, shoreline infrastructure, shipping and recreation
	Decreased lake-ice extent, including some years without ice cover	Ecological impacts, increased water loss through evaporation and impacts on navigation
Atlantic	Decreased amount and duration of snow cover	Smaller spring floods, lower summer flows
	Changes in the magnitude and timing of ice freeze-up and break-up	Implications for spring flooding and coastal erosion
	Possible large reductions in streamflow	Ecological impacts, water apportionment issues, hydroelectric potential
	Saline intrusion into coastal aquifers	Loss of potable water and increased water conflicts
Arctic and Subarctic	Thinner ice cover, 1- to 3-month increase in ice-free season, increased extent of open water	Ecological impacts, impacts on traditional ways of life, improved navigation, changes in viable road networks
	Increased variability in lake levels, complete drying of some delta lakes	Impacts on ecosystems and communities

Table 1

The projected impacts of climate change on freshwater resources are diverse, varying among regions and seasonality, and cut across socio-economic and biophysical domains. This makes climate change a dynamic and complex public policy issue.

2.2 Uncertainty

Significant uncertainties remain regarding climate change impacts on water resources and include issues with respect to greenhouse gas emissions rates (Doll et al., 2003; Arnell, 2004 in IPCC 2008, 47), climate sensitivities (Prudhomme et al., 2003 in IPCC 2008, 48), and hydrological models (Kaspar, 2003 in IPCC 2008, 48). The critical uncertainties relate to projections of precipitation increase or decrease and changes in evapotranspiration (IPCC 2008, 47).

In terms of social systems, uncertainty surrounds the various human actions (i.e. land use planning, water use, immigration and population control, etc.) and adaptation measures that may be taken to respond to climate change (IPCC 2008, 48). Feedbacks from such actions and adaptation are not easily captured in modeling efforts nor are they predictable.

Uncertainty in both natural and human systems is greater towards the end of the century, as the climate will adapt and change in unpredictable ways. When combining such uncertainties in natural and human systems, policymakers are faced with a significant challenge. However, uncertainty is not a justified reason for delaying action as much can still be done with the knowledge we have and sustainable practices that are available to us.

3. Definition of Key Concepts

Security and Climate

Governments are increasingly bringing 'security' to the forefront of their policy considerations. According to Dimitrov (2002, 679), understanding security is important because:

...*what* security is taken to mean leads one to look in certain directions for the sources of threats, that is, for sites *where* danger lurks. Further, this very act of identifying the threats gives a general idea of *how* one is to

guard against these threats. Finally, this trail of thought brings us to the question of *who* is responsible for maintaining security.

While the concept of *environmental* security in particular has not only had many definitions, it has also had much criticism and caused controversy within the field of security studies due to its ambiguity. As Ajibade clarifies in "Climate Security and Vulnerable Populations in Canada," this knowledge synthesis will take a different approach, highlighting 'climate' (and the associated impacts of climate change) as a significant *threat* to security.² That is, it views climate change as an 'umbrella threat,' intensifying some pre-existing issues and introducing new stresses of its own.

3.1 Water Security Defined

Water is a prominent issue in numerous contexts such as public policy, economic development, environmental scarcity, migration and environmental refugees, food security, human security, and human rights (Dimitrov 2002, 677). Many have proposed definitions for 'water security,' with a plethora of interpretations and consequently, a lack of clarity as to what it really means to have 'secure water.' For instance, there are those in the United States that have linked fears of terrorism to vulnerabilities in drinking water systems (de Loe et al. 2007, 1); some have viewed water security in a context of scarcity and violent conflict (Homer-Dixon, 1991; 1999); and still others have viewed it generally as "access to adequate quantities of water, of acceptable quality, for human and environmental uses" (Global Water Partnership, 2000 in de Loe et al. 2007, 1). This paper will employ the definition of water security as per Shultz and Uhlenbrook (2007, 3) of UNESCO, which states:

Water security involves the sustainable use and protection of water systems, the protection against water related hazards (floods and droughts), the sustainable development of water resources and the safeguarding of (access to) water functions and services for humans and the environment.

This definition allows for the broad investigation of issues concerning water quality

2. See Ajibade's preceding paper on "Climate Security and Vulnerable Populations in Canada," for a more extensive definition of 'security.'

and water quantity, issues that are biophysical and socio-economic in nature and issues that include climate change impacts and adaptation. Bridging such dimensions within this definition is admittedly ambitious, but allows for a macro view of the challenges facing Canada's water security. This approach also importantly demonstrates the connection of 'humans *within* the environment,' rather than dichotomizing it as 'humans *and* the environment.' Thus a general systems analysis is important to draw various linkages between domains, for the effects of climate change will have consequent challenges for the future planning of water management and water security. As one makes their way through this report, the aforementioned questions pertaining to the 'what, where, how, and who' of water security must be posed.

3.2 Vulnerability and Adaptation

Achieving water security in Canada is challenging because in a country as large and diverse as Canada, vulnerabilities vary significantly across the regions (Gleick, 1998; Kempton, 2005; and Soussan, 2006 in de Loe et al. 2007, 1). Although Canada possesses a relatively high adaptive capacity when compared internationally, there are significant regional variances that leave some people more at risk than others. For example, more than 1600 Canadian communities obtain at least 30 per cent of their employment income from highly climate-sensitive sectors, such as agricultural, forestry, fishing and hunting (IPCC 2008, 130; Lemmen et al. 2008, 14). In addition, Aboriginal and rural communities retain strong cultural connections to the land, in some cases relying on a subsistence economy that constitutes up to 50 per cent of total income. In response to numerous climate change-induced stresses, their adaptive capacity is being eroded (IPCC 2008, 130; Lemmen et al. 2008, 14). These vulnerabilities and diminishing adaptive capacity are intensified in northern communities, as Arctic regions are experiencing the greatest rates of warming in the world (IPCC 2008, 130; Lemmen et al. 2008, 14).³

Two definitions are particularly important when understanding 'vulnerability':

Vulnerability to climate change "is the degree to which a 'system' [quotations added] is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (Schneider et al. 2007, 21).

This definition considers the vulnerability of a given 'system' in terms of susceptibility and resilience. To better understand where susceptibilities and resiliencies lie, an integrated approach can be useful, viewing the 'system' as both biophysical and social environments that are interrelated, and interdependent (Dolan and Walker 2003, 3). While both interact and co-evolve with changes in the other, this approach gives a more holistic understanding of a system's vulnerability, and also where opportunities exist for increasing adaptive capacity.

The second definition states that,

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 (Lemmen et al. 2008, 14).

This definition considers vulnerability in terms of impacts and adaptive capacity, specifically within the social environment. It asserts that by increasing a population's adaptive capacity, its vulnerability will be reduced. For such capacity-building to occur in the context of water security, a complex interaction between multiple levels of government and different water users is required.

3.3 Violent Conflict

There is a large body of literature on the link between water and violent conflict, where some depict a strong link and others refute the link. Several points must be noted, however. First, a simple dichotomy cannot be drawn between peace and violent conflict. Disputes can occur at several levels: between villages, national political subdivisions, nations sharing borders, and even between nations that are geographically

3. See Ajibade's preceding paper entitled "Climate Security and Vulnerable Populations in Canada."

isolated (Gleick 1993, 83). At each level, conflicts and resolutions can take on unique dynamics, ultimately creating a ‘grey area’ with regards to causal factors in conflict. Second, not all security threats lead to conflict that is violent in nature (Gleick 1993, 82). That is, while conflicts sometime culminate in violence, many have been completely peaceful in their resolution. Finally, while water (and its associated concerns) exacerbates tensions, it is rarely the *direct* cause of conflict (Wolf et al. 2005, 81).

It is therefore important to exercise caution when attributing water to ‘conflict’ (especially that which is violent in nature), and be clear as to what role water plays in ‘security’ concerns. Such clarity is crucial in order to avoid unintended tensions and hostilities, and to ultimately avoid unintended security dilemmas.

While Canada’s water security concerns are unlikely to result in direct violent conflict, it is nonetheless important to consider the indirect consequences within the context of international stability⁴ (Wolf et al. 2005, 81).

4. Domestic Security Issues

4.1 Water-related Hazards

Natural hazards such as floods and droughts pose several threats to Canadians, including the potential to disrupt economic and social activities, cause property damage, and even death (McBean and Henstra 2008, 1). Defined as a ‘triggering event,’ a hazard has the potential to become a *disaster* when it interacts with a population’s vulnerability (McBean and Henstra 2008, 3). Many hazards are directly affected by weather and weather-related systems, and they are likely to increase as the climate changes, posing a major security threat. Already, there is an increase in weather-related hazards from approximately 2-4 per year in past decades to the approximately 12 per year more recently (McBean and Henstra 2003, 2).

Floods

Floods are the most frequent natural hazard in Canada (Government of Canada, 2008), and are likely to pose a major water security threat

as the climate continues to change. Despite the widespread occurrence of floods across various regions of Canada, the Red River Basin, coastal areas, and major urban centres remain at the highest risk.

While floods can occur at any time of the year, the primary causes are often due to excess snowmelt-runoff, rain, rain on snow, ice-jams, or natural dams (Simonovic 2008, 7). Moreover, the timing and amount of precipitation plays a key role in the onset and severity of floods. The following figure shows the observed changes in precipitation since 1950, by season. While noting seasonal variance, many of Canada’s major population centres fall within the areas of significant increases in precipitation.

Changes in precipitation since 1950, by season⁵

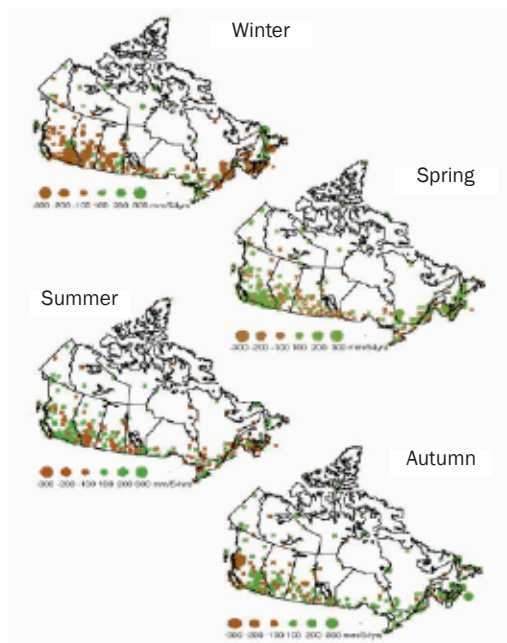


Figure 1. Warren and Egginton 2008, 46

Yet the IPCC states that as the climate continues to warm, “increases in precipitation in Canada are projected to be in the range of +20% for the annual mean and +30% for winter, under the A1B scenario. Some studies project widespread increases in

4. See Rodgers “International Stability Concerns” in this report.

5. The magnitude of change is indicated by the size of the circle, with green indicating an increase and brown indicating a decrease. The crosses denote areas where trends are not statistically significant.

extreme precipitation...” (IPCC 2008, 102). The following figure links the *projected* changes in temperature and precipitation in the continental context. Noteworthy is the seasonal variation in

precipitation, in which summers are projected to be warmer and drier, with major increases in precipitation projected for the winter months.

Projected Temperature and Precipitation Changes Over North America from the MMD-A1B Simulations⁶

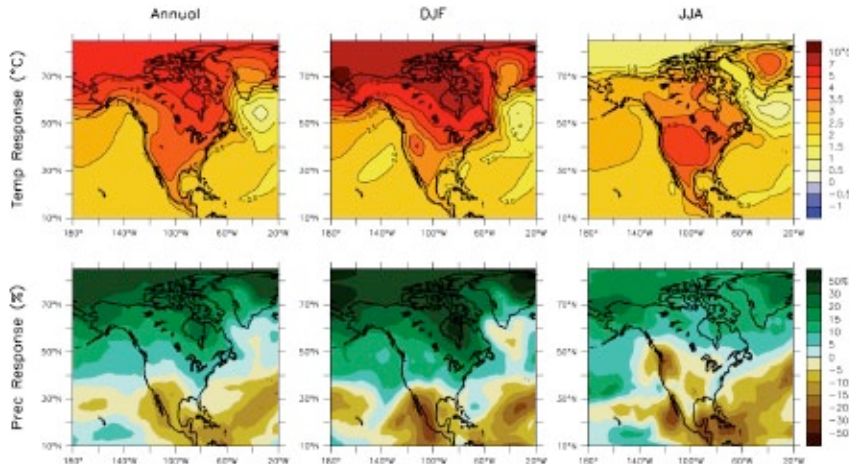


Figure 2 Christensen et al. 2007, 890

Changes in the form, timing, and amount of precipitation will therefore raise the potential of flooding. Depending on factors such as geographic location, degree of urbanization, age of infrastructure and overall capacity to cope, floods in Canada will vary in the cause of onset and severity. Such widespread vulnerability is evidenced by the Saguenay, Red River and Toronto floods. The Saguenay Region of Quebec experienced major flooding in 1996 due to abnormally heavy rainfall; 15,000 people had to be evacuated and over \$1.5 billion of damage resulted (McBean and Henstra 2003, 2). Only one year later, the Red River Basin in Manitoba also experienced major flooding, induced by heavy snowfall and an unusually fast spring thaw (characterized by abnormal timing, duration and extent). Declared then as the “Flood of the Century,” major parts of south Winnipeg were inundated and Grand Forks, North Dakota was left completely under water (McBean and Henstra 2003, 2). Over 25,000 Canadians were evacuated and damages reached approximately \$1 billion (McBean and

Henstra 2003, 2). More recently, the North Toronto flood of 2005 highlighted the interconnectivity of vulnerabilities when combined with a hazard. In the four-hour rainfall event, approximately 153mm of rain fell, causing a collapse of a major road, Finch Avenue, and associated damage to two high-pressure gas mains, a potable water main, and telephone, hydro, and cable services that were buried beneath the road. More than \$500 million was recorded in insured losses (Lemmen, 2008).

As the climate continues to change, there will likely be an increase in floods and flash floods, posing significant security risks to Canadians (amounting to high economic costs, human lives, health issues, etc.). Whereas areas such as the Red River Basin remain at high risk, major urban centres across Canada are also highlighted as vulnerable due to high population density (McBean and Henstra 2003, 3) and aging infrastructure (Mirza 2007, 2).

One aspect of being ‘water secure’ means reducing the impacts from floods and requires a

6. Top row: Annual mean, DJF and JJA temperature change between 1980 to 1999 and 2080 to 2099, averaged over 21 models. Middle row: same as top, but for fractional change in precipitation. Bottom row: number of models out of 21 that project increases in precipitation.

strategic combination of both structural adaptation measures (i.e. dams, dikes and diversions) and non-structural adaptation measures (i.e. floodplain regulation and flood forecasting). While improvements have been made to Geographic Information Systems, mapping technologies and simulation models, there remains a critical need for more hydrological information (Pietroniro et al. 2004, 52).

Droughts

Regions of Canada are likely to experience an increased frequency, duration and severity of drought conditions due to climate change (Warren and Egginton 2008, 49). This is a serious threat to Canada's water security, as an adequate water supply is crucial for most socio-economic activities and ecosystem health (Bonsal et al. 2004, 40). Specifically, the Prairie region of Canada will be most at risk to droughts due to its high variability of precipitation in both time and space (Bonsal et al. 2004, 40). This water security threat to the region is further magnified by its agricultural significance in global, national, and regional contexts. More generally, the major sectors that are likely to be stressed by drought are the agricultural,⁷ industrial, municipal, energy (hydroelectricity), forestry and recreational sectors. Ecological stresses include changes in water quality, fish habitat and other ecological goods and services. Hydrological stresses include depletion of soil moisture, reduced streamflows, lower lake and reservoir levels, and diminished groundwater supplies (Canadian Foundation for Climate and Atmospheric Sciences; Simonovic 2008, 6).

Many factors influence the occurrence, severity and duration of droughts. Therefore, droughts will take on different characteristics depending on the area affected, duration, intensity, antecedent conditions, and a region's capability to adapt to water shortages (Bonsal et al. 2004, 40). However, it can be said with confidence, that drought-prone areas are likely to experience recurrent water shortages due to characteristically dry environments (Bonsal et al. 2004, 40). As Bruce et al. (2000 in Mehdi et al. 2002, 6) confirm, the annual evaporation in the southern Prairie Provinces usually exceeds precipitation, leaving deficits in

soil moisture. While the Prairies are vulnerable as a region, it is more specifically the area extending from south-western Manitoba to south-western Alberta (known as the Palliser Triangle), that is at the greatest risk.

The Palliser Triangle



Figure 3 Khandekar 2004, 5

Despite the Prairies being the most susceptible to significant droughts, there is nonetheless widespread risk in Canada. For instance, in 2001 British Columbia had its driest winter on record, the Great Lakes – St. Lawrence basin experienced its driest summer in 54 years, and the Atlantic region experienced its third driest summer on record (Government of Canada 2004, 35). From 2001-2004 alone, it was estimated that Canadian GDP lost some \$5.8 billion; between 2001-2002 agricultural production dropped over \$3.6 billion; and between the same period approximately 41,000 jobs were lost (Canadian Foundation for Climate and Atmospheric Sciences).

The following figure provides the observed regional distribution of temperature trends in Canada from 1948-2003. Noteworthy is the variability in seasons and the regions most affected.

7. See Harris "Food Security in a Changing Climate" in this report for more information on the link between climate change, drought, and agricultural production.

Regional distribution of linear temperature trends observed between 1948 and 2003⁸

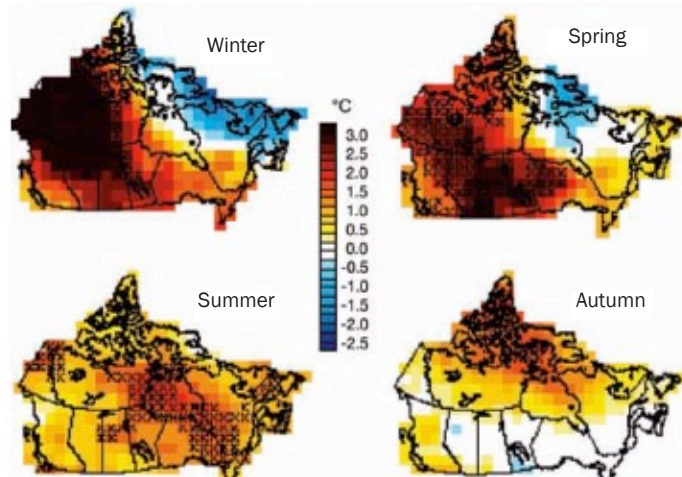


Figure 4 Warren and Egginton 2008, 45

With respect to drought, major water security concerns arise from projected warmer and drier summers. In addition, a more general security threat in the continental perspective emerges, as water shortages will significantly threaten major parts of the United States and Canada. Important decisions must therefore be made in rationalizing the use of water for various purposes. This will create tradeoffs and may provide the basis for conflict both within and across Canada's political boundary.

Adaptation actions will be crucial to cope with future ecological and socio-economic issues pertaining to drought. This will include implementing more efficient irrigation systems (de Loe et al., 2001 in Mehdi et al. 2002, 7), ensuring soil moisture conservation strategies (Mehdi et al. 2002, 7), designing new criteria for adjustable water storage structures (Mehdi et al. 2002, 7), establishing legal priorities to regulate withdrawals during times of shortage (de Loe et al., 2001 in Mehdi et al. 2002, 7) and switching to crops that require less water (de Loe et al., 2001 in Mehdi et al. 2002, 7). Adaptation strategies will vary by sector and location, and will likely be decided upon and implemented by individuals, groups, institutions, and local, provincial and federal governments (Bonsal et al. 2004, 42).

Data needs are once again identified as critical future steps in ensuring our water security. As such, it is crucial to better understand the physical causes and characteristics of *past* droughts, including their spatial and temporal variability (Bonsal et al. 2004, 45). Further, a better understanding of the occurrence of *future* droughts is important, specifically looking at areas likely to be affected, and the potential changes to their frequency, duration and severity (Bonsal et al. 2004, 45). It also necessary to understand how people coped with past droughts, what the major security issues were, and what institutional arrangements were in place so that we can build capacity and better deal with droughts in the future.

Climate change is affecting our weather and weather-related systems, making it difficult to isolate the impacts on climate, ecology and our society. Moreover, our water security is becoming ever more tied to the natural processes (and increasingly abnormal processes) that surround us, overwhelming us with either too much or too little water. How are we going to adequately protect against and adapt when one-in-one hundred-year events become one-in-twenty-year events? And how are governments going to communicate the risks to Canadians so we are all guarded with the knowledge to help prepare ourselves?

8. The X marks areas of statistical significance.

4.2 Water Quantity

The impacts of climate change on water availability are diverse and complex, involving several types of water bodies. As the climate changes, issues of water availability will pose several water security threats to Canada. Such threats are likely to vary geographically and the extent of the threat will depend on the socio-economic and biophysical dependence on the different water bodies. The first sub-section will focus specifically on surface water, and will examine effects on rivers, lakes and wetlands. While many water bodies will suffer from reduced water levels, the areas specifically reliant on glacier-runoff will first experience periods of high flow due to glacier melt, followed by reduced flow

rates and lower overall water levels as glaciers permanently retreat. The second sub-section will examine groundwater and will underscore critical knowledge gaps.

Surface Water Availability

A watershed or drainage basin is defined as a “geographic area of land in which precipitation drains to a common point on a stream, river, pond, lake or any other body of water. All urban, rural and industrial land uses can potentially affect or be affected by surface and groundwater water quality and quantity in a watershed” (Agriculture and Agri-Food Canada, 2007). There are five major watersheds in Canada, represented in the following map:

Major Watersheds/Drainage Basins in Canada

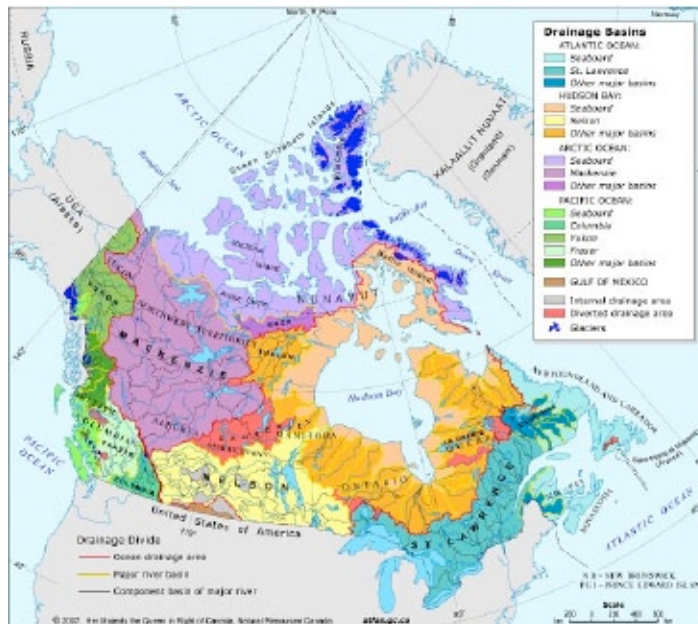


Figure 5 Natural Resources Canada, 2007

According to a new report by the World Wildlife Foundation (WWF), it is important to consider the impacts of climate change on rivers at the ‘watershed scale,’ and specifically consider the impacts to *flow*, including the amount and timing (WWF 2009, 4). This analysis focuses the dialogue on “how much water the river can give” as opposed to “how much water we can use” (WWF 2009, 4).

Flows in rivers can be susceptible to small changes in temperature and precipitation as they influence evapotranspiration and can result in relatively large changes in the magnitude and timing of flow (WWF 2009, 7). Moreover, it is a combination of form, timing, and amount of precipitation that also influence the impacts. Specifically, the snowmelt-dominated watersheds

and mountain snowmelt-dominated watersheds are likely to see earlier snowmelt runoff, increases in winter and early spring flows and decreases in summer flows, more winter rain instead of snow and less snow accumulation at low levels (Field et al., 2007 in Simonovic 2008, 14; Whitfield et al. 2004, 106; WWF 2009, 7). As the climate continues to change, these impacts will likely intensify, challenging water availability in Canadian rivers in various complex ways.

While the WWF identifies ten Canadian rivers currently at risk with respect to environmental flow, the South Saskatchewan River is highlighted as Canada’s most threatened river (WWF 2004, 23).⁹ With a changing climate and increasing socio-economic pressures, the threats to this river are likely to intensify. Current changes in climate have contributed to warmer average air temperatures, drier conditions, and a 50% reduction in source glaciers between 1975 and 1998 (for which it relies for water recharge). Indeed, some parts of this river are now running dry. Containing 13 large hydropower dams and hundreds of smaller ones, water use for energy purposes has also produced considerable stress by altering the timing and amount of flow. Intensive human use looms large as its water

is significantly over-allocated, supporting most of Canada’s irrigated agriculture and a growing dependent population (WWF 2009, 23). Finally, crossing political jurisdictions between Alberta and Saskatchewan, the decision-making and management of the river is highly complex.

Although most of Canada’s major rivers remain in ‘fair,’ ‘good,’ or ‘natural’ condition, some are ranked as ‘poor’ with worsening conditions projected for the future. Recall that one aspect of water security is the ‘sustainable use and protection’ of water systems; yet our continuing practices of allocating, diverting, consuming and demanding more of our rivers, that when added to simultaneous stresses from climate change, will push our rivers past their natural thresholds. This will in turn, significantly affect the way we continue to use and depend on water. The South Saskatchewan River can serve as an appropriate example of the interconnectedness of such socio-economic and climate change impacts to water security.

Canada’s small and large lakes are also highly sensitive to climatic changes, and are likely to experience impacts in water availability as warming continues. The following is a map of Canada’s largest lakes and the drainage basins they are located in:

Canada’s Largest Lakes and Drainage Basins

Selected Lakes

1. Superior
2. Huron
3. Great Bear
4. Great Slave
5. Erie
6. Winnipeg
7. Ontario
8. Athabasca
9. Reindeer
10. Smallwood
11. Nettling
12. Winnipegosis
13. Nipigon
14. Manitoba
15. Lake of Woods
16. Dubawnt
17. Amadjuak
18. Melville
19. Mistassini
20. St. Clair
22. Lake Michigan
(entirely in U.S.A.)



Figure 6 Schertzer et al. 2004, 92

9. See *Canada’s Rivers at Risk: Environmental Flows and Canada’s Freshwater Future* for more information.

Canada's lakes will be affected in different ways, depending on the type of lake and its geographic location. In the high Arctic, water budgets of lakes will be affected by a longer ice-free period in the summer; northern lakes may experience catastrophic drainage due to melting permafrost; water balance dynamics of glacial-fed lakes will be affected by glacial melt and runoff; and some Prairie pothole lakes may disappear with intensified drought conditions (Schertzer et al. 2004, 117). Despite uncertainty, most scenarios of climate change project reductions in lake levels (Schertzer et al. 2004, 115). The Great Lakes are of particular concern in this regard, as less available water will be problematic to the projected increases in demand for navigation, consumption, diversions, and exports (Schertzer et al. 2004, 115). For instance, the province of Ontario depends on the shipping industry for approximately \$7 billion annually (Expert Panel on Climate Change Adaptation 2009, 47). Although the shipping season could be extended as ice cover is reduced, safe navigation of shallower waters, especially between lakes, will require cargo ships to carry smaller loads (Expert Panel on Climate Change Adaptation 2009, 47).

As in the case of rivers, knowledge gaps are evident. Data regarding seasonal changes in hydrological characteristics of lakes are incomplete. To fully capture the connection between socio-economic and biophysical domains to climate change, integrated assessments of the vulnerabilities and impacts to water supply have also been noted as necessary.

Finally, The National Wetlands Working Group (1988 in van der Kamp and Marsh 2004, 101) define wetlands as, "land that has the water table at, near, or above the land surface." The term can be synonymous with swamp, marsh, bog, muskeg or slough. While shallow water wetlands are found in water less than 2m deep, other wetlands can be deeper. Canadian wetlands occupy 14 per cent of the land surface, and are vulnerable to changes in the water balance – increases in evapotranspiration, changes in precipitation, runoff and lake levels – of which will be intensified as the climate warms (van der Kamp and Marsh 2004, 123). Similar to rivers and lakes, wetlands serve many important roles. From an ecological perspective, they recharge groundwater; reduce peak flows during floods and help maintain base

flow in rivers during dry periods (van der Kamp and Marsh 2004, 122). From a socio-economic perspective, wetlands provide a resource base for hunting and fishing, and serve a recreational value through opportunities for bird watching (van der Kamp and Marsh 2004, 122).

Changes in the water balance are likely to be the primary stressor for wetlands due to climate change. As winters become warmer and summers become longer, evapotranspiration is projected to outweigh increases in precipitation. Depending on the region, however, wetlands will also be affected differently across the country. For example, cold-climate wetlands depend on underlying permafrost to prevent drainage, and mountain and Arctic wetlands depend on meltwater from long-lasting snowcover and snowpack; both will be affected as the permafrost and snow melt at accelerated rates (van der Kamp and Marsh 2004, 123). Furthermore, prairie wetlands depend on snow accumulation for recharge in the spring, and lake shoreline and river delta wetlands depend on inundation by annual or near annual flooding events or water level changes; both will be affected as shorter winters and changing precipitation patterns challenge their hydrological dynamics (van der Kamp and Marsh 2004, 123).

Surface water availability in all its forms and geographic locations is diverse and complex. Playing vital roles in both nature and human society, it is projected to be heavily impacted as the climate continues to warm. This will in turn impact our socio-economic system in areas such as commercial navigation, recreation boating and marinas, port and shipping transportation facilities, municipal water supply, hydroelectric generation, shoreline infrastructure, among others (Marchand et al., 1988; Mortsch, 1998; Changnon and Glantz, 1996; Hartmann, 1990; Lee et al., 1994; Rissling, 1996; Sanderson and Smith, 1987 in Mehdi et al. 2002, 4). It is not always the direct impact of climate change but the combination of socio-economic stressors and a rapidly changing climate that put water availability at risk. To ensure our freshwater security, it will be crucial to address critical knowledge gaps with respect to the hydrological and socio-economic effects of a changing climate, and adequately manage the socio-economic impacts that will compound climate change impacts.

Groundwater

Existing “almost everywhere underground,” groundwater is the water “...found beneath the surface and located at the water table and below. Groundwater is frequently concentrated in large subterranean areas called aquifers... An aquifer is an underground formation of permeable rock or loose material which can produce useful quantities of water when tapped by a well” (Natural Resources Canada, 2009). Moreover, groundwater is inextricably linked to surface water within the hydrological cycle, thus tightly coupling the effects of climate change on both. As affirmed by the Council of Canadian Academies (CCA), “there is really only one store of available freshwater” (CCA 2009, 12).

Groundwater is an integral part of water security, and plays many important roles such as maintaining the health of streams, lakes, wetlands and other associated ecosystems. While roughly 30 per cent of Canadians rely on groundwater as a source of drinking water, it also drives economic activity as the primary source of water for livestock watering and crop irrigation, and in manufacturing, mining and petroleum production¹⁰ (CCA 2009, 3; Rutherford 2004, 1). The following is a map of the known locations of Canada’s groundwater resources:

Canada’s Known Groundwater Resources

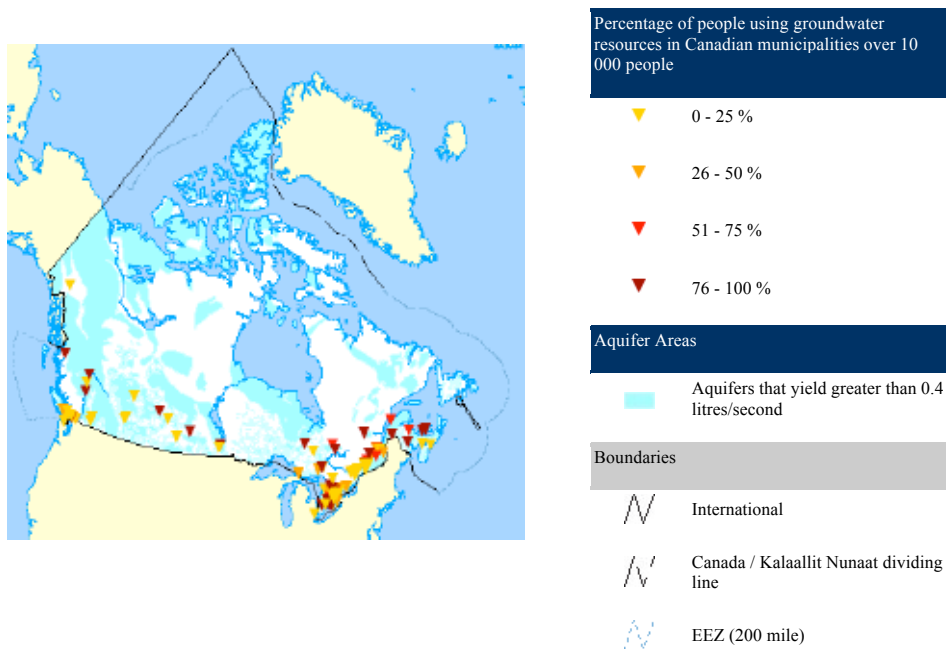


Figure 7 Natural Resources Canada, 2009

Despite real concerns over the future status of Canada’s groundwater, there remain more critical knowledge gaps than for surface water. This includes lack of data on groundwater availability, recharge of groundwater, withdrawals of groundwater, and the amount of groundwater reused (CCA 2009, 12). In fact, the Canadian Press

states that Canada is yet to fully map its stores of groundwater aquifers, making information unavailable for another two decades (Prairie Water Directive, 2009). The following figure shows the extent of such knowledge gaps regarding aquifer mapping.

10. More information on groundwater use can be found in the *Water Use* section of this paper.

Aquifer Mapping Assessments

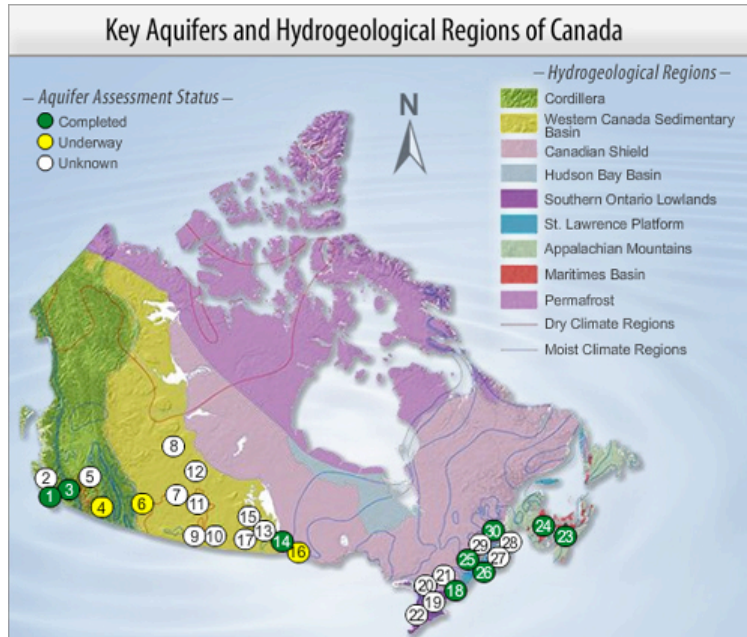


Figure 8 Natural Resources Canada, 2009b

Most significantly, little research has been done on the effects of climate change on groundwater resources, leaving us with significant constraints for effective policymaking and sustainable use practices in the context of a warming climate. In the technical report on *Climate Change and Water*, the IPCC concludes that “owing to a lack of data and the very slow reaction of groundwater systems to changing recharge conditions, climate-related changes in groundwater recharges have not been observed” (IPCC 2008, 36), and observe that “knowledge of current recharge and levels in both developed and developing countries is poor; and there has been very little research on the future impact of climate change on groundwater, or groundwater-surface water interactions” (IPCC 2008, 38). Although some inferences can be made based on surface water impacts, we remain in a critical deficit in understanding the effects of climate change on groundwater availability.

4.3 Water Quality

One aspect of water security is the “...safeguarding of water functions and services for humans and the environment.” As the climate changes, the impacts to water quality will affect both socio-economic and biophysical systems, and pose significant challenges to the ways in which we use and treat water. Whereas the impacts of climate change on water quantity have produced numerous focused reports, the impacts of water quality have not received the same attention. This section will highlight two overarching water quality issues, increasing air and water temperatures, and increased frequency of high intensity rains. Each will produce effects that will pose considerable challenges to Canada’s water security. The section will begin with a table that outlines some of the projected regional impacts to water quality in Canada.

Main water quality concerns across Canada

Region	Water quality concern
Atlantic	<ul style="list-style-type: none"> • Saltwater intrusion in groundwater aquifers • Water-borne health effects from increased flooding
Quebec	<ul style="list-style-type: none"> • Upstream shift in saltwater boundary in the Gulf of St. Lawrence • Water-borne health effects from increased flooding and sewer overflow
Ontario	<ul style="list-style-type: none"> • Degradation of stream habitat • Water-borne health effects • Volatilization of toxic chemicals
Prairies	<ul style="list-style-type: none"> • Summer taste/odour problems in municipal water supply • Stream habitat deterioration
British Columbia	<ul style="list-style-type: none"> • Saltwater intrusion due to rise in sea level and increased water demands • Water-borne health effects from increased floods • Increased water turbidity from increased landslides and surface erosion
Arctic and The North	<ul style="list-style-type: none"> • Rupture of drinking water and sewage lines from permafrost degradation • Rupture of sewage storage tanks from permafrost degradation, and seepage from sewage storage lagoons • Increased turbidity and sediment loads in drinking water

Table 2

Bruce et al., 2000

One key water quality issue is increases in air affecting water temperatures, which "... are *likely* to lower water quality in lakes through increased thermal stability and altered mixing patterns, resulting in reduced oxygen concentrations and an increased release of phosphorus from the sediments" (IPCC 2008, 43). This is likely to have several consequent effects, namely an impact on coldwater-dependent fish, increasing instances of eutrophication and risks to human health.

Longer periods of summer-like conditions and later cooling in the fall will likely cause prolonged stratification of lake waters between warm and cold layers, increasing the risk of earlier oxygen depletion in cool, lower water (Expert Panel on Climate Change Adaptation, 2009, 53). While this is the preferred zone by several different fish species, the loss of oxygen can result in "dead zones" (Expert Panel on Climate Change Adaptation, 2009, 53). For instance, the sockeye salmon in British Columbia's (BC) Fraser River is naturally a cold-water fish, and requires specific water temperatures in order to spawn and survive. The salmon's lifecycle can more specifically be described as the following:

Sockeye salmon begin their lives in spawning beds distributed throughout the [Fraser River] watershed. Eggs laid in these beds hatch in the following spring. After spending the next year in freshwater, they move into the ocean for a period of 2-3 years after which time they return to their original natal streams where they spawn and then die (Morrison et al. 2002, 231).

While the salmon is sensitive to temperature changes upon return to the Fraser River, it is suspected that temperatures specifically between 22 and 24 degrees Celsius over a period of seven days can be fatal (Servizi and Jansen, 1977 in Morrison et al. 2002, 231), and temperatures over 24 degrees can cause death within only a few hours (Bouke et al., 1975 in Morrison et al. 2002, 231).

Current temperatures in the Fraser River are estimated to have now reached about 22 degrees Celsius, and such rise is suspected to have contributed to a sharp decline in the salmon population (David Suzuki Foundation, 2009; English et al., 2008). In fact, the BC sockeye salmon decline is now subject to a national inquiry.

This becomes a significant water security issue for several reasons: British Columbia is one of Canada's largest producers of salmon, with the sockeye serving as its largest agricultural export, a multimillion dollar industry, and a source of employment for 2800 residents, including First Nations peoples (British Columbia Salmon Farmers Association, 2009). Having major socio-economic implications in global, national and regional contexts, the decline of salmon also indirectly contributes to an increase in nuisance algae blooms (Poff et al., 2002 in Mortsch, Alden and Scheraga 2003, 91), and can upset the feeding habits of dependent animals, namely bears and bald eagles (David Suzuki Foundation, 2009).

As air and water temperatures continue to rise, they are also likely to intensify the natural process of lake eutrophication. That is, the human discharge of particulate contaminants from industrial sources and municipal water treatment systems (including nutrients such as phosphorus) have long posed the risk of algae growth and lake eutrophication, even without considering the impacts of climate change (Expert Panel on Climate Change Adaptation 2009, 53). Yet with increasing risk of lower flow and lower volumes of water in some lakes, the reduction in oxygen levels intensifies the release of nutrients that contribute to the process (Expert Panel on Climate Change Adaptation 2009, 53). As a result, the natural purification process of lakes will be diminished to the point where some will no longer be able to sustain biodiversity as they once would have (Mortsch, Alden and Scheraga 2003, 91).

While many steps have been taken to combat eutrophication in lakes across Canada, signs have pointed to a deterioration of water quality in the Great Lakes Basin. Since 2000, not only has the Lake Erie basin experienced reduced oxygen levels characteristic of the 1960's, but four of the Great lakes have experienced lake stratification increases by up to 6 days per decade, with significant fish kills in Lake Michigan in 2001 and Lake Erie in 2002 (Bruce, 2009).

This in turn will impact ecosystem and human health. That is, warmer waters and reduced oxygen levels make lakes more hospitable to invasive species such as zebra mussels. When these species die, they release concentrated

amounts of phosphorus, an important stimulant in the eutrophication process. This ultimately sets the condition for positive feedbacks, with notable examples in Lakes Huron, Erie and Ontario (Expert Panel on Climate Change Adaptation 2009, 47). Furthermore, there are major risks to elements of human health such as increasing potential for waterborne diseases (IPCC 2008, 43), and deteriorated drinking water quality from low oxygen concentrations of water that is drawn from deep intake pipes (Expert Panel on Climate Change Adaptation 2009, 53).

The second major water quality issue arises from high flow events and flooding, resulting in more instances of increased turbidity and erosion, and the entrainment of nutrients, sediments and other pollutants into water supplies (Government of Canada 2004, 40). Such high flow events pose a major water security threat to Canada, as the potential for water-borne contaminants and diseases to spread is significantly increased. In fact, while poor drinking water quality in Canada is often perceived to have the greatest impact on First Nations communities, it has also been widely observed throughout different regions of Canada, demonstrating a serious national concern (Eggertson 2008, 1261). As of March 31, 2008, there were 1766 boil-water advisories across Canada in small towns, cities and townships, or in neighbourhoods, trailer parks and business sites (Eggertson 2008, 1261). Of particular note, Ontario has 679 boil-water advisories; British Columbia has 530; Newfoundland and Labrador has 228; and Saskatchewan has 126 (this excludes 93 advisories in First Nations communities; Eggertson 2008, 1261).

Specific points of risk include existing wells and sewage treatment systems, designed to operate within expected levels of precipitation, ambient temperature, snow cover, snow melt, water levels, sea level, and coastal dynamics (Charron et al. 2004, 1668). With a changing climate, these dynamics are going to be affected, rendering existing practices incapable to cope with high flow events. As Canada's most tragic case of groundwater contamination, the city of Walkerton, Ontario experienced an outbreak of pathogenic *E. Coli* due to an overflow of contaminants into the cities wells, poisoning the municipal tap water. Seven people died and more than 2,300 more suffered

from severe gastrointestinal illness (O'Connor, 2002a; O'Connor, 2002b in CCA 2009, 3). Despite other involved factors, the heavy rainfall event on May 12 was believed to play a significant role in the transport of pathogens and pollutants from surface to groundwater supplies.

In addition, more frequent and intense rainfall events have the potential to exceed the conveyance capacity of storm and sewer systems as well as wastewater treatment plants (IPCC 2008, 43). In July of 1988, an extreme precipitation event led to the washing of waste from the streets, overflows of sewage plants, and the closing of almost every beach in Toronto, Hamilton, St. Catharines, Peterborough, Kingston, and Ottawa (Gabriel et al. 1993, 124; Mortsch, Alden and Scheraga 2003, 90). Thus as precipitation events become more frequent, they will continue to strain our water systems. To ensure our water supplies are safe and secure, public health professionals and water managers need to understand the required changes to water infrastructure in order to cope with changing conditions under climate change.

Climate change has the potential to make it more difficult to attain water quality goals. For example, the Great Lakes Water Quality Agreement (GLWQA) commits Canadian and U.S. governments to improve the water quality of the Great Lakes. For over 40 'Areas of Concern' (AOC's) have been identified in the GLWQA, because "... a geographic area...fails to meet the General or Specific Objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life" (Mortsch, Alden and Scheraga 2003, 80). For each AOC, a Remedial Action Plan (RAP) has been developed and they are in the process of being implemented to restore and protect the beneficial uses. Some biophysical effects related to climate change are likely to affect the rehabilitation of beneficial uses. For open lake waters, Lakewide Management Plans (LaMPs) are developed to distinguish pollutants that could affect humans or aquatic life and to restore beneficial uses that were impaired (Mortsch, Alden and Scheraga 2003, 80).

Despite progress in some areas, there remain significant uncertainties and knowledge gaps. The effects of land and water use on surface and groundwater increase the complexity of climate

change (Murdoch, Baron and Miller 2000, 348). While some climatic changes may exacerbate water quality issues, some may in fact reduce the overall impacts. One aspect of water security is to maintain the functions of water for humans and the environment. To do so, building on past institutional agreements will be important in maintaining positive steps already taken. Yet to build adaptive capacity and resilience into both systems, a better understanding of how climate change will positively and negatively affect water quality is required. This will better outline where opportunities lie, and where more resilience and remedial action is needed.

4.4 Water Use

This sub-section reviews the different uses of water across Canada, highlighting the significant variance by regions and sectors. It also discusses issues of over-use, waste, increasing demand and water pricing as they relate to the sustainability of Canadian water resources. It will conclude with recommendations for water conservation, a demand-side management policy that aims at reducing the human use of water.

Water security involves 'the sustainable use... of water systems.' While no Canadian federal government law/legislation mentions groundwater sustainability, both federal and provincial water laws more generally refer to the concept. For example, the Federal Water Framework states that to achieve "clean, safe, and secure water for people and ecosystems," we must have "sustainable development through integrated water-resources management within the federal government and within national and international contexts" (Government of Canada, 2004 in CCA 2009, 15). Of several provincial strategies, the *Ontario Water Resources Act* states that "the purpose of this Act is to provide for the conservation, protection and management of Ontario's waters and for their efficient and sustainable use, in order to promote Ontario's long-term environmental, social, and economic well-being" (Government of Ontario, 1990 in CCA 2009, 15). Despite these commitments, Canadian water use has been intensive and unsustainable, even showing increasing demands. When overlaying the projected reduction in water availability due to changes in climate, sustainability is further threatened.

Total annual freshwater use in Canada is roughly 1,500 cubic metres per capita (CCA 2009, 6). Ranked as the second largest consumer of urban domestic water in the world, Canada uses 65 per cent more water than the Organization for Economic Cooperation and Development average (OECD; Brandes et al., 2005 in Morris et al. 2007, 5; Forum for Leadership on Water). In fact, overall residential water use increased by 21

per cent during the 1990's, despite the efforts of some municipalities in reducing water use levels (Brandes, 2005 in Thirlwell et al. 2007, 5). Such high use is not surprising, however, for there are several contributing factors. First, the average Canadian municipal water prices in 1999 were the lowest in the OECD at US\$0.70/1000 litres, and are only one quarter of European water prices (Forum for Leadership on Water).

Water Pricing vs. Consumption in Canada and the World

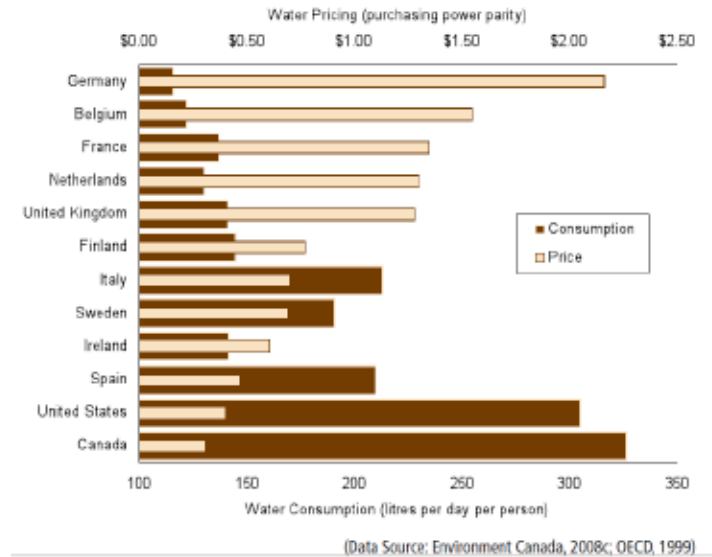


Figure 9 CCA 2009, 115

Second, some municipalities charge less per cubic metre of water as consumption rates increase (Thirlwell et al. 2007, 6). Finally, some municipalities do not even require water metering at all, essentially detaching consumers from the excessive use of water (Thirlwell et al. 2007, 6). When the average Dane consumes 8 times less water than a Canadian while still enjoying a high standard of living (OECD, 2000 in Thirlwell et al. 2007, 5), serious questions arise as to whether water is priced effectively to encourage sustainable use of water in Canada. Indeed a controversial issue, it is nonetheless important for a water-pricing dialogue to begin in Canada.

Despite accounting for only 4 per cent of total freshwater used in Canada, groundwater use has

doubled between 1980 and 1990, suggesting the potential for future increases (OECD, 1995 in CCA 2009, 12). Groundwater is depended on and used in various degrees across the country, highlighting a strong regional dimension. While roughly 30 per cent of the Canadian population depends on groundwater as a source of drinking water, more than 80 per cent of rural Canadians depend on groundwater for their entire supply (Nowlan, 2005 in CCA 2009, 3). In fact, groundwater is 100 per cent relied upon for domestic use in Prince Edward Island, yet only 23 per cent in Alberta (Rutherford 2004, 6; CCA 2009, 7). More specifically, groundwater supports municipal use in Ontario, Prince Edward Island, New Brunswick, and the Yukon; is used for livestock watering in Alberta, Saskatchewan and Manitoba; is used mainly for

industrial purposes in British Columbia, Quebec and the North West Territories; and is used for domestic wells in Newfoundland and Nova Scotia (CCA 2009, 7).

Management policies in the context of Canadian freshwater security need to consider these strong regional differences because vulnerabilities will

vary in type and extent. While some provinces will experience shortages, their resilience and capacity to adapt will also vary. Despite regional contexts, however, the need for a national water framework is needed to address Canada's water challenges. More generally, Canadian water use per sector is described in Figure 10 below:

Canadian Water Use Per Sector

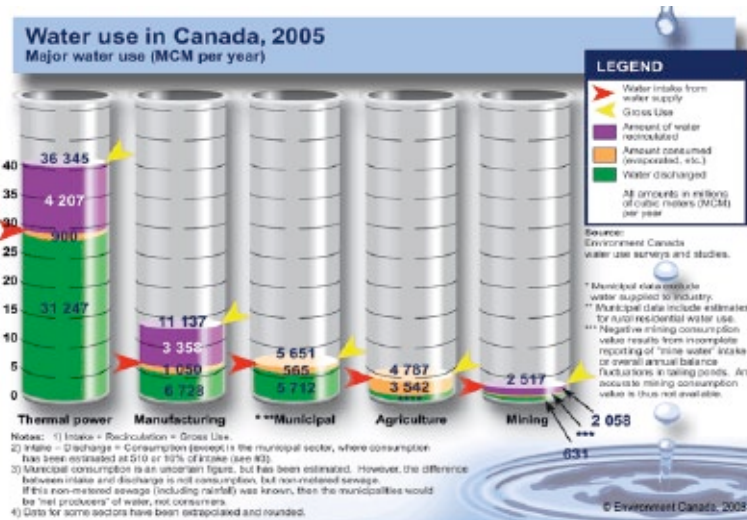


Figure 10 Environment Canada, 2008

Figure 10 makes important distinctions between water *used* (returned) and *consumed* (not returned), generally highlighting more environmentally friendly vs. wasteful practices. That is, while thermal power generation accounts for roughly 60 per cent of water use, almost all is returned to its source without degradation (Shinnan, 2008 in CCA 2009, 6). Conversely, agriculture returns less than 30 per cent to its source, therefore ranking as a high consumer of water. In fact, of all agricultural withdrawals of water, 75 per cent occur in the semi-arid Prairies (Chambers et al. 2001, 60). Alberta in particular represents an extreme case, in which more than 60 per cent of surface water consumed is directed at irrigation (Kienholz et al. 2000, 18). The region is already prone to droughts and with climate change, water scarcity is likely to increase. Such high levels of water consumption in Canada's West increases vulnerability to climate change and raises concerns

over long-term sustainability and the security of future water supply.

Thus while water demand grows in most sectors, the impact of climate change on water quantity and quality will likely intensify the competition over water, ultimately raising the potential for conflict among the various water users. Important questions must be raised as to how to effectively manage water use and allocation to achieve the stated federal and provincial objectives of sustainability.

Reducing Water Use

A key adaptation to projected changes in water availability is reducing the *demand* for water. If demand is reduced, less energy will be required to pump water; if wastewater is reduced, less energy will be required to treat it. Ultimately, using less water will benefit aquatic ecosystems and help ensure the long-term sustainability and protection

of water systems, and importantly, reduce the impacts of climate change. However, such a strategy will need to diverge with the emphasis on *supply*-side management policies of the past. To achieve this, the onus is not only on government to form policy and incite change, but on the individual to make a change in behaviour. All sectors must also play a role.

For instance, 65 per cent of municipal water is comprised of residential use and leakages (Thirlwell et al. 2007, 10). Targeting residential use has the potential to make the biggest difference as it alone accounts for 52 per cent of municipal water use. Strategies include adopting new model toilets that use only 1.6 gallons per flush or composting toilets that do not even require flushing, as opposed to old model toilets that use 6 gallons per flush. As well, low-flow shower heads and faucet aerators, and efficient appliances can also play a role in reducing water use. All of these strategies are low-cost and have been developed within the past two decades (Brandes, 2005 in Thirlwell et al. 2007, 10).

To improve the efficiency of and reduce consumption in the agricultural sector, the Prairie Farm Rehabilitation Administration has encouraged changes to irrigation practices. These include improving timing of irrigation, changing to low pressure sprinklers and using drip irrigation techniques, among others (Prairie Farm Rehabilitation Administration, 2003 in Thirlwell et al. 2007, 12). Making such changes will also lower energy prices, since many irrigation systems are energy intensive (Thirlwell et al. 2007, 12).

The California Energy Commission (CEC) noted that urban water conservation measures “achieve[d] 95 per cent of the savings expected from the 2006-2008 energy efficiency programs, at 58 per cent of the cost” (Klein et al., 2005 in Maas 2009, 4). The International Development Research Centre (IDRC) highlighted conservation from a different perspective, as an effective adaptive strategy for increasing social resilience and preparedness for climate change (IDRC, 2008 in Maas 2009, 4). Ultimately, water conservation as a demand-side management strategy has many benefits and can be widely implemented by sectors, individuals and governments and can play a large role in ensuring Canada’s water is secure.

5. Water-Energy Nexus

This sub-section will bring to the fore the intimate connection between water and energy, showing that the interdependent relationship will be heavily impacted as climate change intensifies impacts on water resources. Three major water security threats will be addressed, examining different angles of the water-energy nexus. These include the potentially higher energy costs associated with supplying water from further distances and treating water of lower quality; the potential negative impact on Canada’s hydroelectric power industry; and the harmful effects of Alberta’s oil sands production.

Water and energy use are co-dependent and inextricably tied to the other. That is, energy is used to pump, treat and transport water, while water is in turn used to power turbines, wash inputs, and cool equipment (Thirlwell et al. 2007, 3). As the climate continues to change, this dynamic will be altered with serious consequences. Affirmed by a group of water experts:

it is anticipated that as the climate changes, water resources will be altered; potentially reducing their quality, quantity, and accessibility. This in turn will require increased energy inputs to purify water of lower quality or pump water from greater depths or distances. Additionally, Canada’s hydroelectricity sector could be affected forcing Canada to turn to other energy sources with higher emissions. All of this would ultimately reinforce climate change and create a vicious circle (Thirlwell et al. 2007, 3)

The following two figures demonstrate the two-way interaction of the water-energy nexus, in which each depends on, and is affected by the other:

Water Supply – Use – Disposal All Require Energy



Figure 11 Gleick 2009, 3

The Energy Cycle Requires Water

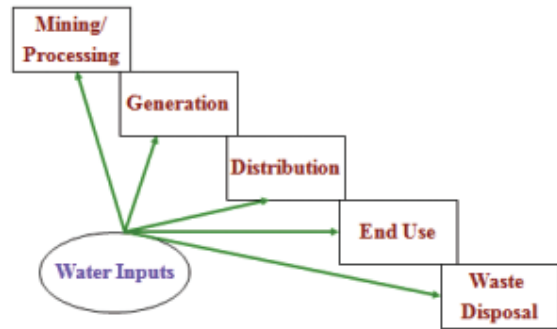


Figure 12 Gleick 2009, 5

While consuming large amounts of energy, Canada also supplies 24.2 per cent to the world's largest energy user, the United States, in the form of oil, natural gas and electricity (Nikiforuk 2007, 13). In fact, Canada and the U.S. are linked by 22 petroleum pipelines, 34 natural gas pipelines, and 91 electric transmission lines (US Department of Energy Press Release, 2006, online in Nikiforuk 2007, 13). Since water and energy are so intimately linked, there are significant policy implications for both domestic and international contexts that tightly couple concerns of energy security to water security. If water resources are increasingly scarce or become excessively expensive to treat, what will it mean for energy trade across the border? What tradeoffs will need to be made?

Energy is required in several stages of water supply, use, and disposal. As some areas become more water stressed under conditions of climate change, costs associated with meeting the demand for water have the potential to increase significantly. Evidenced from recent headlines in California such as, "How green was my valley: California's drought" (Verma, 2009) and "California's water wars: of farms, folks, and fish" (*The Economist* 2009, 28), California serves as an important example of a region that will increasingly see conflict between different water users as supplies decrease and costs to compensate increase.

Moreover, water demand in California has continued to grow alongside an increasing population. Already water stressed, municipal water is pumped from long distances in order to

meet demand. Yet the process of transporting and treating water is expensive and energy intensive because water is naturally heavy and treatment costs are considerably high (Lofman et al., 2002 in Thirlwell et al. 2007, 8). Accounting for 7 per cent of its total electricity usage, supplying water has become the most significant use of electricity in California (Lofman et al., 2002 in Thirlwell et al. 2007, 8).

As the globe continues to warm, precipitation levels in this south-western region are projected to decrease, reducing the accessibility and quality of water. As such, California will be under even greater pressure to continue to provide the needed water supply for municipal, industrial and agricultural uses – all sectors that are in significant competition for water. Highlighting the severity of the situation, Timothy Quinn, director of the Association of California's Water Agencies, commented on a recent court ruling on pumping restrictions that it was "equivalent of an earthquake...whose shock was severe enough to shake California's democracy" (*The Economist* 2009, 28).

This example holds semblance in Canada's domestic context, as the Canadian Prairies remain at high risk of increasing drought conditions. Significant water security concerns may therefore arise from the need to supply the region with water from greater distances and at greater costs. The California example also holds transboundary significance, as boundary waters between Canada and the United States may come under increasing pressure as sources of water to regions farther

away. As such, the political arrangements between California's different water users and the associated pumping restrictions will serve as an important reference case in coping with future water supply stresses in Canada.

Canada will also be affected by the role that water plays in supplying energy. For instance, thermal and nuclear power plants intensively use water to generate power, converting water into high-pressure steam in order to drive turbines, and then using water as a coolant to condense the steam back into water (Hutson et al., 2005 in Natural Resources Canada, 2009c). Of greatest

concern to Canada in the context of water security, however, is the dependence on hydroelectric power generation.

Canada's energy generation is primarily hydroelectric, producing power from more than 600 large dams, hundreds of smaller dams and involving 54 inter-basin water diversions (Bergkamp et al., 2000 in Natural Resources Canada, 2009c). Compared internationally, Canada ranks second in hydroelectric power generation, with major stations located in Quebec, Ontario, British Columbia, Labrador and Manitoba (Natural Resources Canada, 2009c).

Hydroelectric Power Generation

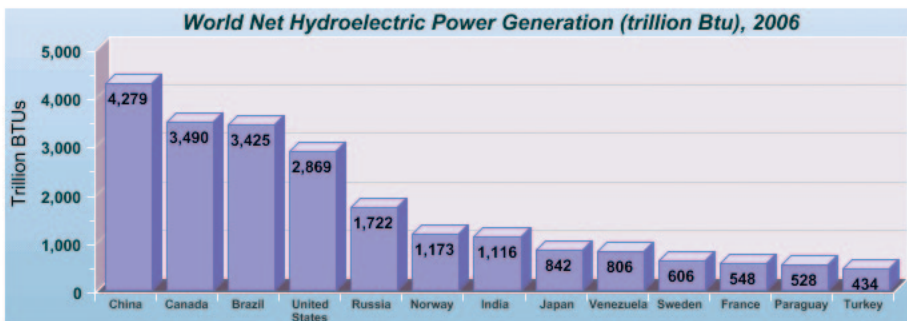


Figure 13 United States Geological Survey, 2009

In fact, while hydropower produced from the Great Lakes accounts for 80 per cent of Ontario's electricity (Expert Panel on Climate Change Adaptation 2009, 47), it accounts for 97 per cent of

the total energy produced in Quebec (Ressources Naturelles et Faune, 2004), demonstrating a strong interdependence between water and energy.

Installed Hydroelectric Capacity by Provinces (2006, in megawatts)

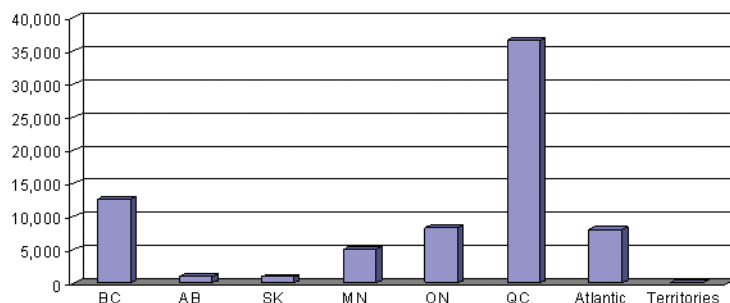


Figure 14 Natural Resources Canada, 2009d

With the effects of climate change, hydropower generation will be sensitive to total runoff, to its timing, and to reservoir levels (IPCC 2008, 103), and will exhibit different regional outcomes. For instance, while a 2-3 degree Celsius warming in the Columbia River Basin will likely cause net benefits to hydropower production, even in the worst case scenario, it is also projected to positively impact parts of Northern Quebec production due to greater precipitation and more open water conditions (IPCC 2008, 103). On the other hand, Southern Quebec and the Great Lakes Basin will likely suffer negative consequences from reduced water levels (IPCC 2008, 103). In the broader Canadian context, it is estimated that the effects of climate change would contribute to an overall reduction in hydropower production by about 15 per cent by 2050 (Forge, 2007 in National Roundtable on the Environment and Economy, 2007). Thus coupling the effects of climate extremes and weather extremes in the context of high national dependence on hydroelectricity, climate change is likely to pose significant water security threats to Canada, making proactive planning and new vulnerability assessments critical (National Roundtable on the Environment and Economy, 2007).

Particularly in the context of domestic and transboundary water-energy concerns, is the connection between water and oil, specifically with regards to the mining/processing stage of oil production in Alberta. The Alberta oil sands differ from conventional oil fields because the extraction and separation process is very energy intensive. Essentially, every grain of sand is surrounded by a layer of water and a film of bitumen. In the event that the tar sands can be recovered at the surface, the technique of open-pit mining is employed, first separating the bitumen by adding hot water to the sand, and then upgrading it to a less viscous state (Oil Shale and Tar Sands Programmatic EIS). On the other hand, if the bitumen is buried deep, the technique of in-situ production is employed, including steam injection, solvent injection, and firefloods, all requiring vast amounts of water and energy for heating and pumping (Oil Shale and Tar Sands Programmatic EIS). In fact, to produce one barrel of oil, about two tons of tar sands are required (Oil Shale and Tar Sands Programmatic EIS). For the same barrel of oil, roughly three

barrels of water are required (Natural Resources Canada, 2009e in Nikiforuk 2007, 14). Where does all this water then come from?

Most of the water used in the production of the Alberta oil sands comes from the Athabasca River, which feeds the world's largest boreal wetland (the Peace Athabasca Delta), and that is identified by the WWF's latest report to be in 'good' but 'declining' condition (WWF 2009, 15). The intensive process of the oil sands mining accounts for the largest consumptive use of water from the Athabasca River; that is, the water that is used is not returned to its source (Schindler et al. 2007, 2). Furthermore, oil sands mining accounted for 76 per cent of the licensed water use in 2005, demonstrating an excessive concentration of use (Schindler et al. 2007, 2).

Climate change alone has contributed to a rise in local temperatures by approximately 2 degrees Celsius (Schindler et al. 2007, 6). This has impacted summer flow rates in the Athabasca River, recording a decline by 29 per cent between 1971 and 2003 (Schindler et al. 2007, 6). Yet when compounding the effects of climate change on the many environmental impacts, they are significantly exacerbated; droughts, decreasing water supplies, increasing water demand, and above all, unrestrained development, are just some of the factors that are raising concerns over future quantity and quality of the water in this region. A Calgary oil consultant has even mentioned that due to future constraints on development from decreasing water availability, "considerable social conflicts" are likely (Peachey, 2005 in Nikiforuk 2007, 15).

The Alberta oil sands also raise significant concerns over current waste disposal practices from open-pit mines. That is, 90 per cent of the water processed in this mining stage "ends up as ketchup-thick tailings" that are stored in silos along the Athabasca River (Woynillowicz, 2005 in Nikiforuk 2007, 15). Some of these tailings range over a 50km square area, and contain salts, heavy metals and toxic hydrocarbons; some in fact, have been found to be leaking (Woynillowicz, 2005 in Nikiforuk 2007, 15). Not only are aquatic ecosystems at risk, but so are the 360,000 aboriginals that live in the Mackenzie River Basin (Woynillowicz, 2005 in Nikiforuk 2007, 15).

The connection between water and energy is mutually reinforcing, and compounded further by the impacts of climate change. While water supply, hydroelectric production and oil production are only three examples of the water-energy nexus, they demonstrate the interconnectedness of issues with significant domestic and transboundary implications.

6. **Transboundary/External Security Issues**

Canada and the United States foster a unique and complex transboundary relationship. Of the 8,800 km southern border, approximately 40 per cent of it is water (International Joint Commission 2009, 1). In addition, the U.S. is Canada's largest trading partner, with the Great Lakes-St. Lawrence River alone sustaining half of that trade and totaling approximately \$80 billion worth of goods per year (Schindler and Hurley 2004, 4). Given that such an important bi-national relationship is partly based and dependent on shared water, there is a critical need for sustainable and equitable management.

Map of Canada-U.S. Transboundary Drainage Basins



Figure 15 International Joint Commission, 2009b

While the Canada-U.S. relationship has been mostly characterized by cooperation, climate change will undoubtedly add significant pressures to water management and institution building. IPCC assessments plainly state, “negative impacts of future climate change on freshwater systems are expected to outweigh the benefits” (IPCC 2008, 3). It goes on to highlight affected areas, including food availability, stability, access and utilization (IPCC 2008, 3). As such, Canada and the U.S. will be affected differently and thus may be inclined towards conflicting reactive and adaptive measures. From a water security perspective, the

potential of breakdown or failure of institutions that govern transboundary waters, especially in the context of climate change, has provided the basis of rising tensions between Canada and the U.S. (de Loe et al. 2007, 36; Morris et al. 2007, 42).

This section will lay out two of the most prominent issues in the Great Lakes basin, water diversions and water withdrawals. In the case of diversions, it will argue that the agreements put in place are indicative of positive cooperation and sustainable management. In the case of withdrawals, however, it will argue that ambiguities

and loopholes exist within the agreements that raise significant concerns. The section will end with the discussion of a more nation-wide concern, bulk water exports. It will highlight past flirtations with proposals in federal and provincial contexts, and will underscore the uncertain policy realm that governs it. Ultimately, this section will argue that many of the threats to Canada's freshwater security will require both a national approach, and a bi-national approach. While these matters are surely complex, there have been signs of optimism and significant concern.¹¹

6.1 Water Diversions in the Great Lakes Basin

As previously mentioned, water in Canada tends to flow north while the majority of people mainly live along the southern border and on coasts. It is not surprising then, that Canada (and the U.S.)

have gone to great lengths to dam and divert water for means of storage and redistribution (Quinn 2007, 2). A diversion can be defined as "any transfer of water across watershed boundaries through a man-made pipeline or canal" (Great Lakes Water Institute, 2008). Mainly used for irrigation and municipal water supply in the United States, diversions are overwhelming used for provincial hydroelectric commissions in Canada (Quinn 2007, 2). While hydroelectricity that is generated from diversions supplies energy markets across the border, it is important to note that the diversions themselves have customarily taken place within and not across political boundaries (Quinn 2007, 2). The following image, taken from the Great Lakes Water Institute report, provides a sample of the water diversions that currently exist in the Great Lakes basin:

Existing Diversions of Great Lakes Water

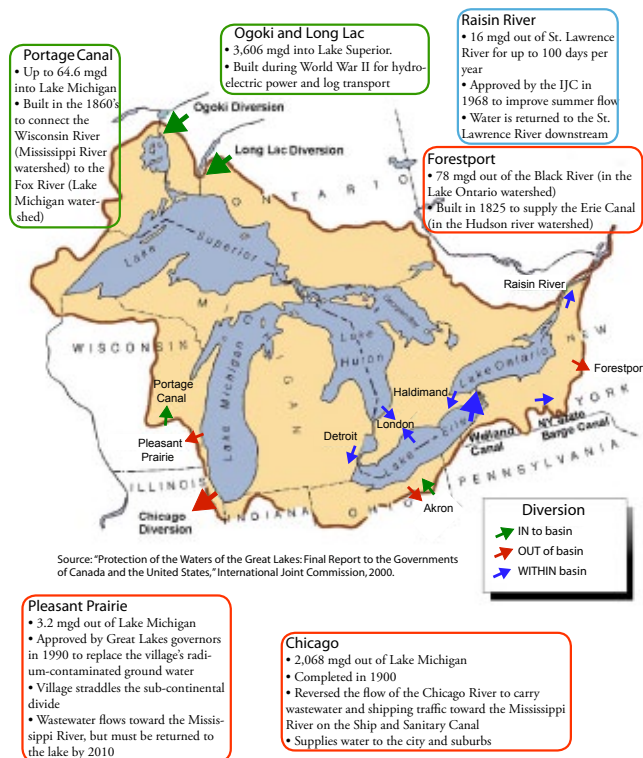


Figure 16 Great Lakes Water Institute 2008, 2

11. See <http://ijc.org/> for a comprehensive and complete list of the transboundary issues between Canada and the U.S., reports on various topics, and further references.

The largest and best-known diversion of the Great Lakes is the Chicago diversion on the southern part of Lake Michigan, dating back to 1848 (see above image for details). Originally used for navigational purposes between Lake Michigan and the Mississippi River, it later became used for supplying municipal water and carrying away wastewater (Great Lakes Water Institute, 2008). Changes to the permitted rate of diverted water were common, ranging from 8,500 cubic feet per second in 1925, to 1,500 cubic feet per second in 1938 (United States Army Corps of Engineers (USACE), 2009). Due to repeated concerns from Great Lakes states and Canadian provinces, however, the U.S. Supreme Court decreed in 1967 that the diversion rate not exceed 3,200 cubic feet per second (USACE, 2009). It has since remained at that rate. Nevertheless, periodic pressures to increase the rate of the diversion have continued to surface, only to confront fierce and continuing opposition by Canada and the Great Lakes states.

Among many arguments from the opponents, are that diversions alter the natural flow of the Great Lakes and return water of different quality than when it was initially withdrawn (Great Lakes Water Institute, 2008). These effects, in turn, have additional ecological and socio-economic impacts, including on wetlands and near-shore ecosystems, tourism, recreation, shoreline property values, hydroelectric power generation and commercial shipping (Great Lakes Water Institute, 2008). The Chicago diversion and others represented a serious concern for Canada and the Great Lakes states, but a series of progressive agreements have shown signs of positive cooperation.

Institutions, Policies and Agreements

Several levels of governance protect and manage the Great Lakes Basin, including federal, state, provincial and municipal governments in Canada and the U.S., as well as the International Joint Commission (IJC). Established by the 1909 *Boundary Waters Treaty* and run jointly by Canada and the U.S., the IJC has set in place a series of institutional innovations that arguably are models for the rest of the world (IJC, 2009c). Considered to be bi-national, independent and impartial, the IJC is comprised of six Commissioners, three from

Canada (appointed by Cabinet) and three from the U.S. (appointed by the President). When referred by both governments, the Commission undertakes investigations of transboundary issues and reaches decisions by consensus (IJC, 2009c).

The *Boundary Waters Treaty* sets the context of institutional agreements specifically with regards to diversions. That is, only when diversions affect the level or flow of shared waters, is approval under the *Boundary Waters Treaty* required. Encompassing the Great Lakes under its authority, it makes no mention of the lakes and rivers that flow into them, or groundwater (Ontario MNR, 2008).

The 1985 *Great Lakes Charter*, signed by the eight Great Lakes states and provinces of Ontario and Quebec, took significant steps in further protecting and managing the waters. While it is not legally enforceable,¹² it obligated the signatories to information sharing strategies and consultation among all parties for proposals regarding major water use (Ontario MNR, 2008; Petrash, 2007, 154). The good-faith agreement also importantly distinguishes between existing diversions and new or increased diversions, targeting stringent regulation of only the latter (Ontario MNR, 2008).

In 2001, the process progressed with the signing of the *Great Lakes Charter Annex* between the same ten parties. Although no specific guidelines were established, the *Annex* set out a series of directives that would serve as a framework for enacting future binding agreements over water exports and diversions. Like the *Charter*, the *Annex* only applies to new or increased withdrawals and diversions (Great Lakes Water Institute, 2008; Ontario MNR, 2008; Petrash 2007, 155).

Negotiations culminated in 2005 with the signing of two historic agreements: first, the *Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement*, was a good-faith agreement between the ten parties. The second, *Great Lakes-St. Lawrence River Basin Water Resources Compact*, was a binding agreement between only the eight Great Lakes states. Together, they serve as the implementation agreements of the 2001 Annex directives, prohibiting most new diversions and

12. Only federal governments can negotiate legally binding international treaties.

exports of water out of the Great Lakes basin (Great Lakes Water Institute, 2008; Ontario MNR, 2008; Petrash 2007, 155). Among several stated objectives, the Compact “ban[s] diversions of water out of the Great Lakes-St. Lawrence River Basin with rare, strictly regulated exceptions and prohibit[s] new or increased transfers of water from one Great Lake watershed to another unless strictly regulated criteria are met” (Ontario MNR, 2008). Though to ensure enforceability in all jurisdictions, the terms of the agreement had to be passed into separate state and provincial laws. In 2007 the government of Ontario fulfilled its commitments by passing the *Safeguarding and Sustaining Ontario’s Water Act*; the eight Great Lakes states followed suit in 2008 with state ratification, Congressional approval and Presidential signing; and in 2009, Quebec completed its legislative process and brought the agreement into full acceptance (Ontario MNR, 2008).

From a water security perspective, weakly regulated diversions of transboundary waters pose a serious threat to the sustainable use and protection of water resources on both sides of the border. Different from the domestic issues raised above, water diversions are affected by actions on both sides of the border, and are crucially dependent on effective transboundary management. This includes reconciling a host of different challenges to managing threats, by information sharing, resource sharing, collaboration among stakeholders and decision-makers, and above all, compromise when certain interests cannot be met.

Moreover, the stakes are high. The Great Lakes do not only provide the basis of a bi-national relationship, but are important in a purely domestic context. Ninety-eight per cent of Ontarians live in the basin, of which three quarters get their drinking water from the Great Lakes. Supporting more than half of Canada’s manufacturing output and a quarter of Canada’s agriculture, their economic importance cannot be overstated (Ontario MNR, 2008). In such a context, the Canadian provinces and U.S. states demonstrated considerable stewardship for the long-term protection of the Great Lakes waters. Averting the potential for future conflict, the parties partook in effective institution building and set in place a series of agreements that would protect against new or increased diversions.

6.2 Water Withdrawals in the Great Lakes Basin

Whereas ‘diversion’ refers to “transfer of water from the basin to another watershed,” a ‘withdrawal’ refers to “any taking of surface or groundwater, including...water withdrawn or withheld...and incorporated into products, or other processes” (Petrash 2007, 157).

Institutions, Policies and Agreements

Despite being governed under the same agreements as diversions, the mention of water withdrawals in the Great Lakes basin contains significant loopholes. Falling under such weak regulation, are concerns over bottled water, a product in rising demand. While the Great Lakes region actually imports more water than it loses from the bottled water industry, it nonetheless has significant local impacts, and is symbolic of a greater international concern.

Under the Great Lakes agreements, a product is defined as “something produced in the Basin by human or mechanical effort...and used in manufacturing, commercial or other processes or intended for immediate or end use by consumers” (Council of Great Lakes Governors, 2005a and Council of Great Lakes Governors, 2005b in Petrash 2007, 159). Since ‘products’ are regulated by the ‘withdrawal/consumptive uses’ category and not ‘diversions,’ different regulations apply. That is, if removed in containers holding less than 5.7 gallons, water withdrawal is actually legally permitted (Petrash 2007, 159). Thus while new or increased ‘diversions’ are banned (with minor exceptions), the treatment of bottled water leaves uncertainty and concern over withdrawals that could collectively amount to significant removal of water from the basin over the long-term.

Weak regulation over bottled water is particularly concerning when considering the add-on effects of climate change on the basin. For instance, due to the coupled effects of lower precipitation and higher air temperatures, Lake Huron, Lake Michigan, and Lake Erie have all been found to be experiencing their lowest water levels in 35 years (Petrash 2007, 148). As climate change impacts continue to intensify, so too does the threat of decreasing average lake levels. When only a mere 1 per cent of the Great Lakes waters are recharged per year, the potential of an intensive

water bottling industry significantly challenges the sustainable use of the resource, overlaying concerns of the security of Great Lakes water.

6.3 Water Export as a National Concern

As water shortages become more apparent in the context of climate change, there will undoubtedly be calls to transfer water from water-rich regions to water-scarce regions. Coupled with economic growth and growing populations, the potential for the development of water export markets looms large. While such proposals raise considerable fears over the sovereignty and potential commodification of Canadian water resources, Canada continues to have a significant policy gap.

In North America, proposals have taken the form of large-scale megaprojects to small-scale entrepreneurial projects. For instance, in 1959, a private sector company and Quebec Premier Bourassa entered in to negotiations over the Grand Recycling and Northern Development Canal (GRAND Canal), a proposal estimated at \$100 billion in 1984, that planned to dyke James Bay and transport fresh water to the U.S. through the Great Lakes (Anderson and Landry 2001, 62; Quinn 2007, 7). Due to widespread resistance, however, the project did not get off the ground. In 1964, there was another major proposal, called the North American Water and Power Alliance (NAWPA), aimed at diverting 308 billion cubic meters of Canadian and Alaskan waters per year, through Canada to the U.S. and Mexico (Anderson and Landry 2001, 61). Estimated between \$80 billion and \$100 billion, this project also did not materialize.

While the above cases mainly highlight major Canada-wide exports, there have also been several cases of provincial interest in water export. British Columbia, Newfoundland, Quebec and Ontario all at one point from 1986 to 1998 had proposals that would either transfer water to places such as California, or even ship water overseas to Asia (Quinn 2007, 11). Tensions were eventually brought to a peak in 1998, when the Ontario Ministry of Environment unilaterally granted a permit to a Canadian company, the Nova Group.

The proposal would have seen the removal of 10 million litres of water per day for up to 60 days a year from Lake Superior (Quinn 2007, 11). Not only did opposition rise in Canada, but the neglect to consult the eight U.S. Great Lakes states induced major transboundary tensions and protests (Quinn 2007, 11). In the end, the Ontario provincial government and the Canadian federal government intervened to revoke the permit and fortunately sidestepped trade discrimination charges (Quinn 2007, 11).

Institutions, Agreements, and Water Export

While some proposals came close to materializing, it is important to note that Canada has not engaged in water export to date.¹³ However, several issues raise fears over the potential of approval should more schemes be proposed. For instance, under the Canadian Constitution, there is a clear division of jurisdiction between federal and provincial governments. Whereas the provinces have the authority and powers to govern natural resources that lie within their jurisdiction, the federal government has responsibility for international trade and foreign policy matters (Clarke 2008, 16). Thus while water exports falls under federal jurisdiction, the resource to be exported falls under provincial jurisdiction; any exporting of water requires a significant degree of multi-level cooperation.

The first major attempt at a national policy came by the Mulroney government. While the GRAND Canal and NAWPA proposals induced fears among the public, the drought-stricken summer of 1988 initiated several southern U.S. senators to strongly advocate for a tripling in the diversion rate from the Great Lakes at Chicago. The government responded with the introduction of the *Canada Water Preservation Bill*, which if passed, would prohibit without exception, “any export, or diversion into boundary waters for the purpose of export, of water above the average daily rate of one cubic metre per second or annual volume of 20,000 cubic decameters, a very conservative allowance for most parts of Canada” (Quinn 2007, 9; Schindler and Hurley 2004, 9). While this policy would have taken positive steps to

13. Two pairs of neighbouring boundary communities actually share treated water. This is not of concern, however, because the volume is negligible and the purpose is only a matter of local accommodation. The cities are Coumts, Alberta with Sweetgrass, Montana; and Vancouver, B.C. with Point Roberts, Washington (Quinn, 2007, 2).

protect Canada's water even before the NAFTA negotiations were completed, the government soon called an election and the legislation was not passed; neither was it later re-introduced.

In 1999, the Chretien federal government made another attempt to push for a national policy that would ban bulk water removals from all major Canadian water basins, in negotiating a *Canada-Wide Water Accord* with the provinces and territories (Clarke 2008, 19). Two points serve as caveats, however: first, as discussed above, export is under federal authority. Second, while the Accord was not legally binding on provinces, it also permitted them to develop their own approach (Clarke 2008, 20). Even if all provinces committed to the Accord (which Nova Scotia did not end up passing into provincial legislation), there was no legally binding measure that would uphold the agreement through a change of government. As such, Quebec and Newfoundland have continued to express interest in the potential for future bulk water export schemes (Clarke 2008, 20).

NAFTA raises a different set of fears, that once a legal permit has been issued, Canada may not deny similar permits to other parties regardless of quantity (Baumann 2001, 116). Furthermore, once Canada begins to export water, the 'proportionality clause' (Article 315), legally obligates us not to reduce exports below the average of the previous three years (Clarke 2008, 18). Thus if a water export scheme is approved, even if by a provincial government, it may begin an unstoppable process of dwindling control over our water resources.

A final set of concerns arise over the Security and Prosperity Partnership (SPP), a regional-level dialogue initiated in 2005 between Canada, the U.S. and Mexico, and aimed at enhancing North American integration (Nikiforuk, 2007; Anderson and Sands, 2007). Intended to inform the governments, separate research projects are undertaken by business and academic representatives regarding a series of priorities. One such project called *The Future of North America 2025*,¹⁴ is funded by U.S. Center for Strategic and International Studies (U.S.-based), the Conference Board of Canada (Canada-based) and Centro de Investigacion y Docencia

Economicas (Mexican-based), and makes a series of controversial statements with regards to water.

For instance, in leaked documents to the Council of Canadians, the project quotes: "Juxtaposed to the relative scarcity of water in the United States and Mexico, Canada possesses about 20 per cent of the earth's fresh water" (Council of Canadians, 2009). This statement is highly problematic because as previously discussed, Canada in fact possesses only 6.5 per cent of the *renewable* water – and is in fact tied with the U.S. in terms of overall supply. If that sustainable level is exceeded, significant damage will extend to the ecosystem and a host of socio-economic issues (see sections above). The document goes on to recommend "...regional agreements between Canada, the United States, and Mexico on issues such as water consumption, water transfers (and) artificial diversions of fresh water..." (Council of Canadians, 2009). Yet not only are the Great Lakes highly allocated, but most of the rivers in Canada flow north (see sections above). And as clarified in this section, any trade deal over water would lead to a relinquishing of control to NAFTA. When such a document sanctioned by the three governments makes highly controversial statements and recommendations, it raises significant fear as to the future plans over North American integration and the involvement of freshwater.

Canada's water security in the transboundary context is highly complex, involving a diversity of issues (many of which are not discussed in this section) and requiring a significant degree of multi-level governance. Quinn (2007, 12) has emphatically argued that the government of Canada has "drifted into irrelevance on the water file, sitting on the sidelines as each province plays its own cards and the public waits in vain for any sign of leadership at the national level." This raises an important point, the need for federal leadership. As Morris et al. (2007, 41) lay out, the federal government is an important player because it possesses constitutional powers to negotiate international treaties and manage international boundary waters; it is responsible for implementing the Boundary Waters Treaty of 1909 and for conducting and managing

14. See the *Future North America 2025* project at http://www.canadians.org/water/documents/NA_Future_2025.pdf

international relations; and because tensions over transboundary waters impact on other issues that fall under federal jurisdiction. Ultimately, the onus will fall on a national approach (federal, provincial and municipal), setting the context for being able to effectively respond and co-manage the many challenging transboundary issues.

7. Conclusion

Freshwater is fundamental to the survival of all living things, and plays a significant role in our socio-economic and biophysical systems. Moreover, freshwater is the lifeblood of the planet. While Canada possesses only 0.5 per cent of the world's population (Government of Canada 2003, 1), it is endowed with a significant supply of this valuable resource. At the same time, it remains significantly challenged. As the climate continues to warm, the impact on Canadian water resources will be intensified in complex and dynamic ways, threatening the way we use and depend on it. That is, issues of water quantity relate to quality; issues of supply relate to demand; issues that are socio-economic relate to those that are biophysical. Complicating the issues further, is the strong regional dimension that exists throughout the country. Some regions are more vulnerable than others due to the location of water relative to human settlements; others are more vulnerable due to lower adaptive capacity and resilience within the social system. Ubiquitous in numerous contexts, water security is a key concern for Canadian citizens and policymakers for the 21st century.

This report has identified the major water security threats to Canada and outlined specific geographic areas that will be at risk. Underpinning these threats, however, is Canada's long-held myth of water abundance; a belief that we have more available water than reality proves, thus detaching us from the severity of the issues. In dealing with Canada's water security threats, it will be critical to understand the difference between total and renewable water supply; that Canada in fact only possesses 6.5 per cent of the world's renewable supply; that Canada ranks third, behind Brazil and Russia in total supply; and that while most of our population resides on the southern border of the country and on coasts, about 2/3 of the water flows northward toward the Arctic and Hudson Bay.

While some security threats pertain specifically to the domestic context, others involve transboundary implications, thus bringing a wide range of concerns to the fore. Moreover, the effects of some issues will be more pronounced than others, at times requiring different types and disproportionate responses. As such, Canada's major security threats can be grouped into three categories: biophysical threats, institutional threats, and knowledge gap threats.

Biophysical threats likely to be at the greatest risk include increased frequency and severity of floods and droughts, reduced water levels in heavily utilized lakes and rivers, and deterioration in water quality in major water bodies. These issues will extend major impacts on human lives, economic industries, energy, and ecosystem and human health. Major hotspots include the Great Lakes Basin, Red River Basin, the Prairie region, as well as major urban centres and coastal areas.

The major institutional threat concerns Canada's lack of a national water policy. While certain institutional arrangements are currently in place, they do not have the ability to set national standards. Nor do they have the capacity to protect Canada's waters in the event of extreme climate change scenarios. Canada's water security in the transboundary context is highly complex, involving a diversity of issues (only some of which were discussed in this review). Yet if any province were to commit to a water exporting scheme, it would essentially set the course for an irreversible process that relinquishes national control over our water resources. Especially in the context of high-level international discussions of potential water sharing, Canada must develop the capacity to address these issues.

Finally, knowledge gap threats are sometimes equally as dangerous as those we are informed about. In many contexts, significant amounts of hydrological information and level analysis is required to better understand the hydrological process and interactions of the many issues in the context of a changing climate. Enhancing our knowledge will better inform policy.

While seeking to highlight the severity of some issues, several strategies and recommendations have been made that demonstrate it is within

Canada's capacity to emerge water secure. To achieve this, multiple levels of government must provide leadership, and citizens will need to be engaged and committed to making fundamental changes in how we use and treat water. Further, constraining knowledge gaps must be closed.

Viewing climate change as a threat multiplier to water security demonstrates the pervasiveness of climate change impacts in a plethora of water concerns. As a country, it is our responsibility to understand the links between us and our environment, yet refrain from dichotomizing the two. As a country, it is within our capacity to emerge water secure. 🍁

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CHAPTER THREE

Canadian Food Security in a Changing Climate

Melissa L. Harris, M.A.

1. INTRODUCTION

Climate change is a significant issue with pervasive and widespread implications. With a global increase in temperature, scientists anticipate an increase in coastal flooding, in the frequency and duration of extreme weather events and in resource scarcity, among other negative consequences (IPCC, 2012). Given the expected nature and severity of these effects, it is important to examine the human security implications of climate change. Climate change is often considered a threat multiplier because it exacerbates existing conditions that create insecurity. Other papers in this report examine the effects of climate change on human health, migration and conflict, water security and vulnerable populations. This chapter will examine the link between climate change and food security as it relates to Canada. Food insecurity caused by climate change constitutes a significant threat to the well-being of people in many countries, including Canada. Currently, there are more than one billion undernourished people worldwide and food insecurity is expected to increase as a result of climate change (FAO, 2009; Schubert et al., 2008).

Food security is achieved when people “at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1996, 9). There are four main aspects of food security: food availability, food accessibility, food utilization and food system stability (FAO 2008, iii). Food security is jeopardized when any of these elements are challenged. This chapter will outline key findings from the literature on climate change and the various aspects of food security. First, some global implications for food security will be examined. Next, the current state of knowledge on the effects

of climate change on Canadian food production, accessibility and utilization will be investigated. Then, the key issues, including economic implications and knowledge gaps involving food security and climate change will be explored. Finally, some recommendations for increasing the resiliency of Canadians to improve food security will be presented.

2. The Effects of Climate Change on Global Food Production

Climate models used in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) project that total average agricultural yields are likely¹ to increase with a temperature change between 1 and 3°C, but yields in some countries may experience up to 50 per cent reductions by 2020. Furthermore, any increase in temperature above 3°C is expected to result in significant global average yield reductions with disastrous implications for food security worldwide (Parry et al. 2007, 11-13). As climate zones shift and droughts worsen, crops that were previously grown and relied on for local consumption or export may no longer thrive. With climate change will come an increase in atmospheric levels of CO₂ and, according to the CO₂ fertilization effect, photosynthesis will increase as a result. However, there is debate and uncertainty about how yields will be affected (Smith, et al., 2009; Bellamy et al., 2005; Stafford, 2007). There is also concern that the nutritional value of crops could suffer² in a high-production environment and could result in significant soil degradation and loss of soil fertility (Stafford 2007, 526).

Elevated CO₂ levels will also affect fish stocks. Currently, more than 2.6 billion people rely on fish for at least 20 per cent of their protein needs. As CO₂ in the atmosphere increases, the ocean will also absorb higher levels of this gas to a certain

1. The IPCC uses the following language when describing the likelihood of situations or events to occur: virtually certain is used to describe something more than 99% likely to occur; extremely likely > 95%; very likely > 90%; likely > 66%; more likely than not > 50%; about as likely as not 33% to 66%; unlikely < 33%; very unlikely < 10%; extremely unlikely < 5%; exceptionally unlikely < 1% (IPCC, 2008, 11).

2. When soybeans were grown in test fields with high CO₂ levels, drops in calcium and zinc levels of 10 to 20 per cent and drops in sugars and starches of 50 per cent were recorded. The drop in calcium is especially important given that soybeans are used to make substitute dairy products (Stafford 2007, 528).

threshold, causing more ocean acidification with detrimental effects on fish growth and development (Carius et al. 2008, 27; Stern 2006, 56). The IPCC AR4³ expresses high confidence that with continued warming, local extinctions of certain fish species, especially freshwater species, will occur (Easterling et al. 2007, 300). These issues will be compounded both by the current over-fishing practices in numerous countries and the increasing demand for food. Furthermore, it is predicted that warming of even 1°C over this century will increase concentration of mercury methylation in marine species with risks for increased human exposure (Booth and Zeller, 2005).

It is projected that population growth combined with higher living standards will result in a 55 per cent increase in global food demand by 2030 and 80 per cent by 2050 (Carius et al. 2008, 28). Consequently, more agricultural land and water will be required at a time when both are increasingly scarce.⁴ Higher living standards and food demand are expected to result in an increase in livestock production. Livestock is one of the most energy- and water-intensive food sources. At the same time meat consumption continues to rise, climate change will exacerbate livestock production issues (Garratt 2008, 12; Schreier 2009, 52). Drought will limit water available for animal consumption and will degrade pasture land. Warmer temperatures

will have some benefits such as longer grazing times with less feed requirements, and less cold-related deaths in the winter. However, increasing average temperatures are also expected to cause more heat stress and heat-related deaths for livestock, less milk production, and reduced appetites causing less weight gain (Lemmen et al. 2008). Furthermore, cases of infectious animal diseases are expected to increase due to climate change (McIntyre et al. 2009, 49). These benefits and drawbacks will manifest differently across regions and will lead to net gains in some places and net losses in others.

In addition to warmer temperatures and higher CO₂ levels, heavy precipitation, flooding and other extreme weather events are expected to increase, which may degrade prime agricultural land, destroy entire harvests, lower yields, increase food prices and cause famines⁵ (Carius et al. 2008, 27). For example, in India, Pakistan and Bangladesh the water supply that is required for agricultural production is expected to decline due to glacial retreat in the Himalayas, sea-level rise is expected to claim thousands of hectares of farmland, and changes in cyclones and monsoon seasons are expected to damage crops (Schubert 2008, 3). These outcomes would be highly detrimental for agricultural production and may increase food insecurity in regions with burgeoning populations.

Expected Impacts of Climate Change Worldwide by 2050

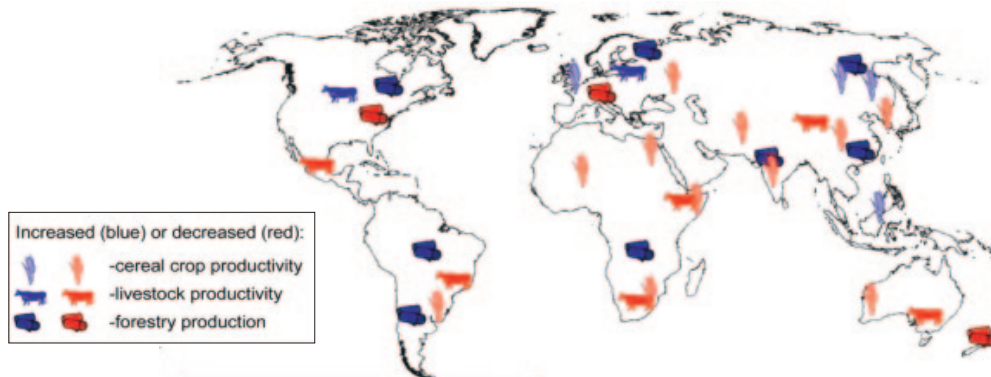


Figure 1 Easterling et al. 2007, 302⁶

3. Many of the projections of the IPCC AR4 are now appearing to be quite modest. See *Climate Diagnosis* for an analysis of the implications of these modest findings as well as an update on expected outcomes of climate change based on more recent research. Available online at www.copenhagendiagnosis.org
4. See the Lawrence National Centre for Policy and Management *Water Innovation Forum: Towards a Competitive and Innovative Agriculture Sector* (2011) for more information on water availability and the role of innovation in agricultural production. Available at www.lawrencecentre.ca
5. See Rodgers in this report for further discussion of climate change, desertification and famine.
6. This map outlines the expected impacts of climate change on crop and livestock yields, and forestry production by 2050 based on temperature increase scenarios between 2-4 degrees Celsius, without adaptive measures.

The Food and Agricultural Organization (FAO) and the IPCC, among others, identify sub-Saharan Africa and south Asia as future hotspots for food insecurity exacerbated by climate change (FAO, 2006; Easterling et al. 2007, 297). Although drought is not uncommon in many parts of Africa, climate change will act as a threat multiplier by worsening drought conditions and creating challenges for food production. It is expected that grain yields across Africa may decrease substantially while crops such as maize may no longer grow at all in some areas. Livestock production is also expected to decline as water shortages and desertification worsen (Easterling et al. 2007, 281). In the Asian mega deltas and in south Asia, rice and wheat production is expected to decrease due to sea-level rise associated with climate change, however some of these losses may be offset with improvements and transfers in farming technology (FAO, 2005). Smallholder and subsistence⁷ farmers in Asia and Africa will suffer disproportionately from the impacts of climate change due to their high vulnerability to extreme weather events and their limited resources to adapt (Easterling et al. 2007, 275).

In 2009, the Government of Canada identified twenty countries to become the focus for Canadian bilateral aid. These countries include Bolivia, Caribbean Region, Colombia, Haiti, Honduras, Peru, Afghanistan, Bangladesh, Indonesia, Pakistan,

Vietnam, Ukraine, West Bank and Gaza, Ethiopia, Ghana, Mali, Mozambique, Senegal, Sudan and Tanzania. Although the regions were chosen based on their current needs and their anticipated capacity to use aid effectively, the majority of these countries are also expected to experience the worst effects of climate change (CIDA, 2009b; Parry et al., 2007). Some of these countries are trading partners, while others are important sources of Canada's immigrants; consequently the impact of climate change on their food security, stability and well-being is of strategic interest to Canada (Statistics Canada, 2004; CIDA, 2009a).

While developed countries in the northern hemisphere are not expected to experience food production challenges to the same extent as developing countries in the southern hemisphere, the IPCC AR4 expresses high confidence that yields in North America will decrease with a temperature increase above 3°C (Parry et al. 2007, 13). In *Climate Wars*, Gwynne Dyer cautions that "the lucky countries in the northern tier that can still feed themselves- but have little or no food to spare- must be able to turn back hordes of hungry refugees, quite probably by force" (Dyer 2008, 4). While his warning may appear extreme, he effectively emphasizes that adequate food supplies are vital for human security and all countries will be increasingly affected by food shortages.

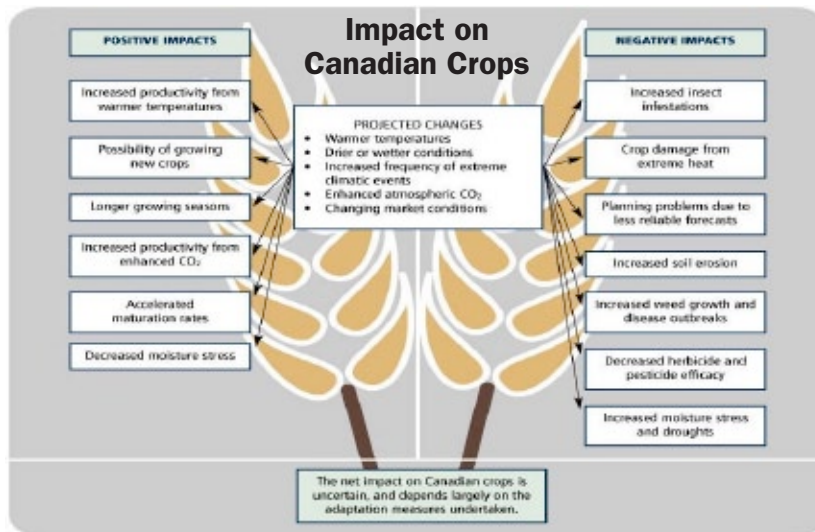


Figure 2 Lemmen, Warren, and Bush, 2008⁸

7. 'Subsistence and smallholder' can be defined as "rural producers, predominantly in developing countries, who farm using mainly family labour and for whom the farm provides the principal source of income" (Cornish, 1998; Easterling et al. 2007, 281).
 8. This image is a reproduction of an official work published by the Government of Canada and has not been produced in affiliation with, or with the endorsement of the Government of Canada.

3. **The Effects of Climate Change on Canadian Food Production**

It is expected that, overall, Canada will experience greater warming than most other countries and certain areas, especially in the North, will warm more than others. Given the significant geographical, ecological and socio-demographic diversity within Canada, there will be considerable regional variation in the impacts of climate change. It is anticipated that because of the Prairies' mid-latitude continental climate, which is highly variable, the region will experience more change during this century than the rest of southern Canada (Wall et al. 2007, 68). Several simulations indicate that, for the next century, an overall increase in temperature between 1 and 3°C will lengthen growing seasons (Cox et al., 2000; Berthelot et al., 2002; Fung et al., 2005; Field et al. 2007, 629). However, it is important to keep in mind that high yields are reliant on more than the length of the growing season (see Figure 2). For example, longer and earlier growing seasons that are cool and wet, followed by extremely hot summers are highly detrimental for both grape and apple yields (Wall et al. 2007, 161-162). Additionally, rising temperatures cause earlier bud-breaks that increase the risk of frost damage (Wall et al. 2007, 170).

Climate change is also expected to increase the occurrence of extreme weather events such as droughts, floods, extreme precipitation, hurricanes and heat waves (ICLR, 2012; McBean and Henstra, 2003, 2). This will be detrimental to crop growth and could impact food security in Canada. A report by Natural Resources Canada explains that, "a single extreme event (later frost, extended drought, excessive rainfall during harvest period) can eliminate any benefits from improved 'average' conditions" (Lemmen et al. 2008, 149). A hailstorm in Alberta or a wildfire in British Columbia can destroy hundreds of acres of crops, regardless of longer growing seasons.

For food production in Canada, drought is one of the most damaging hazards expected to increase due to climate change. While some drought is to be expected, especially in the Prairies, most climate models predict drought conditions to worsen and,

when combined with other expected hazards, may exceed the ability of many farming communities to cope (Wheaton et al. 2005, 10). Populations at risk of water shortages could experience a higher degree of food insecurity due to the costs of purchasing water and increased costs of agricultural goods if irrigation water must be imported from other provinces (Gosselin et al. 2008, 228).

Drought causes many other problems for food production. Weeds have a high tolerance for drought, and pests such as grasshoppers, which can destroy crops, thrive in drought conditions (Wheaton et al. 2005, 16). Changes to climate conditions are expected to increase the migration, reproduction, feeding activity and population dynamics of insects and mites, which are harmful to crops and food production (Wall et al. 2007, 22). In addition to improving conditions for weeds and pests, climate change is expected to increase plant diseases by creating conditions that support the survival of pathogens, accelerate the rate of disease progress and extend the duration of epidemics (Wall et al. 2007, 22). An increase in plant diseases, pests and weeds will threaten yields for farmers and challenge food security in Canada.

While some important farming regions will experience increased drought conditions, many other areas are expected to see an annual increase in precipitation.⁹ However, this increase in precipitation is projected to come in the form of more frequent heavy precipitation events, more precipitation in the winter months and less during the growing season when it is most beneficial (Lemmen et al., 2008). Furthermore, as the climate warms there will be a decrease in snow cover. When this is coupled with more winter rain, it is likely to result in more erosion of nutrient-rich soil while also increasing the potential for water quality impacts in agricultural areas (Atkinson et al., 1999; Walker, 2001; Soil and Water Conservation Society, 2003; Field et al. 2007, 629). When precipitation is sporadic, and comes more often in the form of extreme weather events, with longer drought periods in between, it is detrimental to soil integrity, crop growth and overall food security (Wall et al. 2007, 18).

9. See Popovich in this report for further discussion of the effects of climate change on water security.

Ultimately food production, both globally and within Canada, will be affected in numerous ways by climate change. While areas in Africa and Asia are projected to experience yield reductions and North America may see yield increases, the effects will vary widely and will be contingent upon the extent of global warming. Much of the climate change-food security research focuses narrowly on assessing the sensitivity of crop systems to changes in climate (Gregory et al. 2005, 2143). However, food security involves more than food production. The following sections will examine the existing research on the effects of climate change on food accessibility and food utilization.

4. **Climate Change, Food Accessibility and Food Utilization in Canada**

The FAO reports that, “food security depends more on socio-economic conditions than on agroclimatic ones, and on access to food rather than the production or physical availability of food” (FAO 2008, 3). In order to fully understand the relationship between climate change and food accessibility, it is necessary to identify the populations that are currently vulnerable to food insecurity.

Almost 2.5 million Canadians lack adequate access to food (Food Secure Canada, 2011). It has been found that food insecurity rates are highest in households with certain socio-economic traits. More than 30 per cent of single-parent families and 20 per cent of Aboriginal families are food insecure (Statistics Canada, 2005). Approximately 60 per cent of households that relied on social assistance, and 30 per cent of households that relied on employment insurance had experienced food insecurity in 2008 (AAFC 2008, 4). As of 2003, the rate of Canadians using food banks more than doubled since 1989, with more than 750 000 people per month relying on them (Redway 2003, 3). This has increased by 25% since January 2009 as a result of the economic recession (Monsebraaten, 2009). Many food banks do not have sufficient supplies to meet the ever-growing demand. These patterns of food inaccessibility for single-parent, Aboriginal and unemployed Canadians will increase if climate change deteriorates food production conditions,

increases food costs and widens the gap between socio-economic classes.

Climate change is expected to have numerous effects on food accessibility, especially in northern regions of Canada. In the future, warmer summer temperatures may enhance opportunities for small-scale agriculture, providing a more affordable local food source (Furgal 2008, 333). Growing conditions for fruit and vegetables are expected to be more favourable thus decreasing the reliance on imports (Lemmen et al. 2008, 399). Greater growing capacity is important because sea-level rise, coastal erosion, and permafrost melting will make the ground less stable. This will have negative implications for roads, airstrips and other important infrastructure, making food transportation difficult and goods more expensive in remote communities (Furgal 2008, 333-36; Industry Canada, 2006). Residents in northern communities are the most likely to experience food insecurity, with the rate in Nunavut being four times higher than the Canadian average (Statistics Canada, 2005; Furgal, 2008). With temperatures rising, the sea ice has already become less reliable, interfering with travelling, hunting and fishing. Changing sea ice conditions are also disruptive to the reproductive, migratory and feeding patterns of certain species’ such as the ringed seal and caribou, which are important traditional food sources (Field et al. 2007, 625). As animal availability decreases and human access to wildlife becomes more unpredictable, food security for Aboriginal communities in the North is jeopardized (ACIA, 2005; Field et al. 2007, 625).

Additionally, there is a risk that as climate conditions change but traditional food utilization and preparation techniques remain the same, there will be an increase in food-related illnesses. Wildlife will be exposed to new diseases and raw consumption and inadequate storage, which are more typical in remote communities, will bring new health risks (Furgal 2008, 353). Although more research is required about the role of climate change in food utilization, there are some studies that show negative effects of increasing temperature on food poisoning cases, such as salmonellosis (D’Souza et al. 2004; Kovats et

10. See Ajibade in this report for a detailed discussion of populations that are vulnerable to the effects of climate change.

al. 2004; Fleury et al. 2006; Schmidhuber and Tubiello 2007). Climate change is expected to affect food safety conditions and alter disease vectors¹¹ for food- and water-borne diseases (Schmidhuber and Tubiello 2007, 19704). Clearly there will be numerous challenges in reducing food insecurity as the climate changes. Conditions for vulnerable populations will be exacerbated, northern populations will face transportation and supply issues and traditional food practices will become more risky. While current information on food accessibility and utilization provides some insights, more research is required in order to fully understand the threats to food security that climate change poses. A 2009 report for Indian and Northern Affairs Canada argues that, “the Arctic, being on the frontlines of climate change, will be forced to address food security sooner than other regions of Canada and many other areas of the world. How the Arctic responds to this crisis may well provide valuable directions to others” (UNEP et al. 2009, 5).

5. **Key Issues: Aid, Energy and Emissions**

It is important to keep in mind that security in Canada is dependent on security abroad. Changing ecosystems and weather patterns, an increase in sea-level and extreme weather events, and the subsequent impact on food security will create significant challenges in the future. As food production becomes more difficult, there may be an influx in migration from rural areas to major cities and an increase in competition for scarce resources, which in turn may increase tension and political instability (Carius et al. 2008, 28).¹² The problem of food insecurity is compounded by the link between scarcity and violence. UN Secretary-General Ban Ki-moon explains that “when resources are scarce – whether energy, water or arable land – our fragile ecosystems become strained, as do the coping mechanisms of groups and individuals. This can lead to a breakdown of established codes of conduct, and even outright conflict” (as cited in Schubert et al. 2008). Food is necessary for survival and as starvation and desperation increase, people may turn to violence to meet their needs. There is

some evidence that food shortages have already triggered riots in Egypt, Ethiopia, Haiti, Indonesia, Mexico and the Philippines (Ehrhart et al. 2008, 16). Climate change will continue to worsen the conditions necessary to achieve food security, which will increase the likelihood of famine, health problems and social unrest (Ehrhart et al. 2008, 16).

In 2008, the Canadian International Development Agency (CIDA) spent more than \$152 million on international aid for agricultural initiatives alone (CIDA 2009a, 13). However, funding for agriculture in developing countries has decreased significantly in recent years; in 1979, support for agriculture comprised 18% of total Official Development Assistance (ODA) but was only 3.5% of total ODA in 2004 (FSPG 2008, 1). As climate change poses challenges for growing conditions in some developing countries, more support from Canada for food aid will be required. On October 16, 2009 CIDA announced its new Food Security Strategy to address the food crisis, climate change and the global economic recession. Under this initiative, the Canadian International Food Security Research Fund of \$62 million was created to develop further research technologies and strategies to improve food security worldwide. The Government of Canada has also committed \$75 million over three years to the International Fund for Agricultural Development (CIDA, 2009b). These are significant steps in recognizing the threats that climate change will continue to pose to food security and the importance of research in overcoming these challenges.

When providing food aid, Canada and the U.S. are frequently criticized for sending local food instead of financial support. It is argued that instead of improving the local agricultural capacity of developing countries in need, aid that is provided in the form of food benefits the donor countries, increases dependency, distorts local markets and detracts from the overall value of the aid (Garratt 2008, 8). In 2008 more than 40 per cent of all food aid spent was attributable to shipping¹³ and distribution costs (Garratt 2008, 5). In recognition of this inefficiency of the food aid

11. See Harris et al. in this report for information on climate change and changing disease vectors.

12. See Rodgers in this report for a detailed analysis of the link between climate change, resource scarcity and international instability.

13. U.S. law dictates that up to 75 per cent of their food aid should be grown domestically and must be transported in U.S. ships and vehicles (Garratt 2008, 4-5).

system, Canada has committed to sending 100 per cent of the food aid funding directly to multilateral organizations such as the World Food Programme to procure food within developing countries, instead of transporting food from Canada (CIDA, 2009b). In addition to untying food aid, Canada has committed to untie all of its development assistance by 2012-2013 (CIDA, 2009b). As changing climate conditions exacerbate food security issues worldwide and challenge development in many countries, more support of this nature will be required to strengthen local capabilities and improve resiliency.

Another key issue for food security and climate change is the growing bioenergy market. The use of biofuels and biomass in the place of fossil fuels has some benefits, but it also has implications for food security. Much of the recent literature raises the concern that bioenergy crops occupy land that could be used to grow food or support livestock; these food supplies must then be grown in other areas at higher costs, thus raising food prices (FAO 2008, 25; Garratt, 2008; MacIntyre, 2009; Funk et al. 2008, 581).

An increase in the cost of food creates serious issues for food accessibility. Rising food prices, coupled with reduced agricultural production, will increase significantly the populations that are vulnerable to food insecurity. However, rising food prices are attributable to many causes. An increase in oil prices and production costs, rising per-capita consumption, population growth and the increasing demand for biomass, among others, play a role in higher food prices (Funk et al. 2008, 581). The food versus fuel debate remains relevant because the implications are significant and they differ for each country.¹⁴ In Canada, where different classes of agricultural land are abundantly available, reducing the reliance on fossil fuels is important, and there is support for green energy policy and technology, conditions exist for a healthy and successful bioenergy market.¹⁵ However, a shift is required from energy-intensive first generation biofuels such as corn ethanol grown on prime land to next generation biofuels occupying marginal land such as cellulosic ethanol (switchgrass, miscanthus) and agricultural residues (see Figure 3). This shift would mark an improvement in food security, economic viability and GHG emission reductions for Canada (MacIntyre 2009, 6).

Next Generation Biofuels Occupying Marginal Land

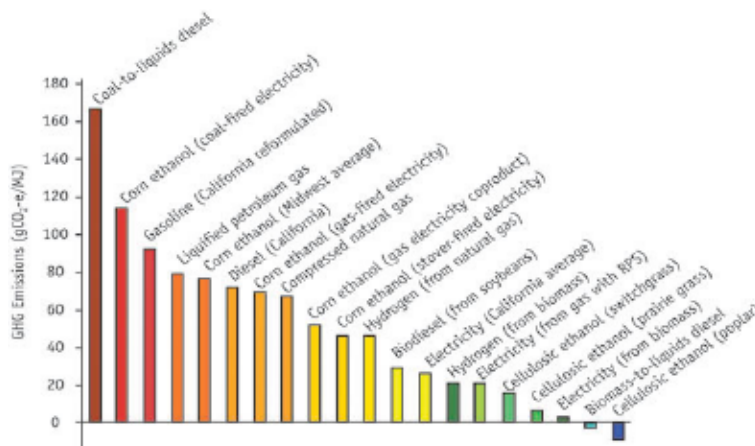


Figure 3 Kammen, 2008

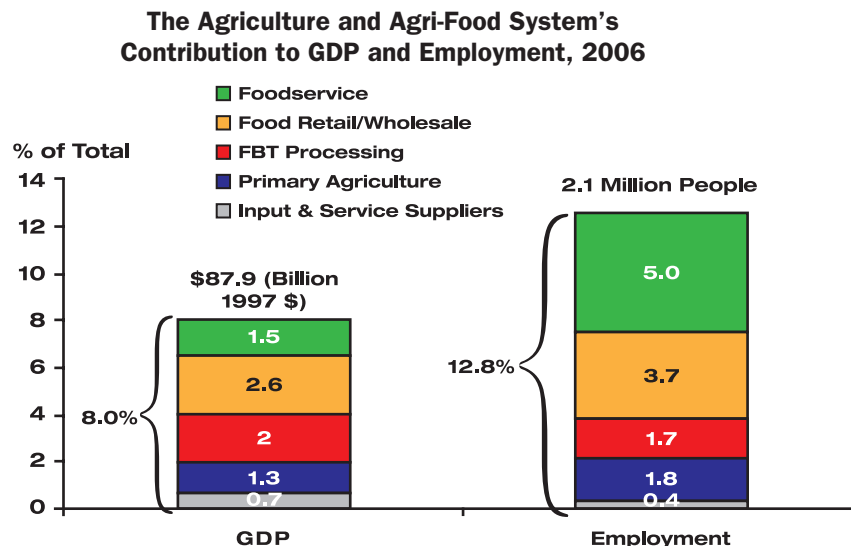
11. See Harris et al. in this report for information on climate change and changing disease vectors.
12. See Rogers in this report for a detailed analysis of the link between climate change, resource scarcity and international instability.
13. U.S. law dictates that up to 75 per cent of their food aid should be grown domestically and must be transported in U.S. ships and vehicles (Garratt 2008, 4-5).
14. In many developing countries, the use of traditional bioenergy can have detrimental effects. Wood fuels are often used because they are affordable and accessible but there are associated negative environmental, health and economic issues. Furthermore, when biofuel crops are planted in areas with limited growing capacity because of their higher retail value, food security is jeopardized (MacIntyre 2009, 6; FAO, 2008).
15. For more information on the green energy market in Canada, see the report by the Lawrence National Centre for Policy and Management entitled *Making Green Energy Happen: Policy and Priorities* report available at http://www.ivey.uwo.ca/lawrencecentre/green/green_conference_report.pdf

Clearly climate change has a significant impact on food security; however, it is important to keep in mind that while agriculture is dependent upon climate, climate change is also affected by agriculture and food production. Currently agriculture is responsible for approximately 10% of Canada's total GHG emissions (Environment Canada, 2011). Of this 10%, fertilizer overuse makes up a significant share of agricultural emissions. Nitrous oxide (N₂O) emissions from fertilizers and soils, and methane (CH₄) from enteric fermentation of cattle comprise 38% and 32% of total global non-CO₂ GHG emissions respectively (Bellarby et al. 2008, 6). Livestock production is very energy-intensive and is one of the largest users of land globally, especially as the use of livestock feed crops increases and grazing practices decline (Bellarby et al. 2008, 8; Zhang et al., 2008; Khan et al. 2009, 141). Improving energy efficiency in food production will be critical to increasing food security in a changing climate. GHG emissions can be reduced or offset by using no-till practices, avoiding excessive fertilizer application, rotating agricultural crops with legume crops to improve soil fertility, reducing

enteric fermentation, reusing agricultural residues for biofuels, improving forest management to prevent soil erosion and increasing reforestation to capture carbon (McIntyre et al. 2009, 51; Bellarby et al. 2008, 9). These practices, among others, will reduce costs in addition to reducing overall GHG emissions.

6. Economic Implications: Industry, Trade and Infrastructure

Much of the food that Canadians consume and export is grown in Canada, creating an important link between agricultural production, food security and climate change. However, it must be remembered that "agriculture is not only a source of food but, equally important, also a source of income, less income means less food security" (Schmidhuber and Tubiello 2007, 19703). Agriculture is an important industry in Canada; when considering the entire supply chain, the agriculture and agri-food system contributed more than \$8.5 billion to the country's GDP and employed 2 million Canadians in 2011 (AAFC, 2012).



Source: Statistics Canada and AAFC calculations.

Figure 4 AAFC, 2008¹⁶

16. This image is a reproduction and does not appear here in affiliation with, or with the endorsement of Agriculture and Agri-Food Canada.

Agriculture is also the economic sector most sensitive to climate change as crop development is directly dependent on weather patterns and climate (Almaraz 2008, 188; Lemmen et al. 2008, 14). While it is known that sea-level rise, increased salinity of rivers and groundwater, extreme precipitation, floods, droughts and other extreme weather events will create significant problems for water and food availability, there are almost no studies providing quantifiable information about the economic implications of climate change on food security in Canada. There is a knowledge gap in terms of the expected costs and benefits to Canadian economic sectors resulting from climate change.¹⁷ Past experience reveals that an increase in natural hazards will cause significant threats to the economic growth of the Canadian agriculture and agri-food sectors. For example, the 2001–2002 drought in the Canadian Prairies led to the loss of more than 41,000 jobs and economic losses amounted to \$3.2 billion (Wheaton et al., 2005). There is also a general understanding that the food we consume is often exported from distant countries and as fuel costs increase for various reasons, food prices, and thus food insecurity, will increase (Pretty et al., 2005; FAO 2008, 25). Studies have been conducted to model changes in international food prices due to climate change. The results are mixed but on average, food prices are expected to rise moderately until 2050 with temperature increases between 2 to 3 degrees Celsius; more drastic price increases are expected after 2050 (Field et al. 2007). However, some studies found that commodities like rice and sugar are expected to increase in price by as much as 80 per cent regardless of climate change, and on average changes in socio-economic development paths within countries are predicted to influence food prices more than climate change (Reilly et al. 1996; Schmidhuber and Tubiello 2007, 19706).

Canadian food imports and exports will be affected by climate change. Although Canada's exports of processed food products exceed imports by approximately 30 per cent, imports have steadily increased to more than \$12.6 billion (Statistics Canada, 2004). Imports have increased

from Brazil by \$201 million, China by \$183 million and Thailand by \$139 million between 1995 and 2002 (Statistics Canada, 2004). These countries are expected to experience some of the worst effects of climate change which may be harmful to their food production capacity, thus disrupting trade with Canada. Since Canada relies on numerous countries for many of our food staples, the international effects of climate change on trade and food production will be important to our economy. More studies are required to identify the specific implications for Canada.

Trade will create both opportunities and challenges in a changing climate. If conditions change such that some products are no longer available in certain countries, trade may be able to compensate for the differences in supply and demand (Tamiotti et al. 2009, 62). However, some countries may become more vulnerable to the effects of climate change if they focus primarily on a few specialized goods for export and do not diversify their crops. If climate change makes it difficult to grow these specialized goods, or interrupts the transport of imports and exports, then these dependent countries will face serious challenges (Tamiotti et al. 2009, 62).

Canada's transportation system, which is crucial to food distribution, is vulnerable to climate change in many ways. With warmer temperatures, roads and runways built on permafrost are already becoming less reliable; coastal infrastructure will be at risk due to flooding; Great Lakes shipping will be threatened by lower water levels; and roads across the country will be at risk due to an increase in extreme weather events (Industry Canada 2006, 11). Disruptions in these supply and transportation chains will raise the costs of goods (Tamiotti et al. 2009, 64).

Other infrastructure will also be threatened by climate change. Infrastructure in Canada is aging and often outdated, making it vulnerable to hazards, especially given the expected increase in extreme weather events (McBean, 2007). A 2003 study revealed that the cost of updating all infrastructure in Canada to an acceptable level is

17. While it does not specifically discuss economic implications for agriculture, the National Roundtable on the Environment and the Economy has launched a research program called Climate Prosperity, conducting valuable research on the economic risks and opportunities of climate change for Canada. See <http://nrtee-trnee.ca/climate/climate-prosperity> for more information.

more than \$100 billion (Mirza and Haider, 2003). Infrastructure such as bridges, seaports, rail, dams and water pipe lines are intended to last many decades with major reconstruction approximately every 50 years (Industry Canada 2006, 6). Most of this infrastructure, which is important for food security, is built based on historical climate information. For example, in 1997-1998 the Manitoba government was forced to airlift supplies into northern communities at a cost of more than \$15 million because, with warmer temperatures, the 2 000 km network of ice roads that they had relied on for decades was no longer usable (Industry Canada 2006, 13). Infrastructure based on historical climate data will become exceedingly vulnerable as the climate changes. According to a report by Industry Canada, “current longstanding gaps and deficiencies in the determination of climatic design values prevent optimum decisions from being made on infrastructure reliability and safety” (Industry Canada 2006, 18). Consequently investments in infrastructure must be made, taking into account the effects of climate change, to ensure the continued stability of trade and food distribution systems.

7. Summary of Recommendations and Findings

Given the immediate and inevitable impacts of a warming climate, it is important to address how Canadians should improve their food systems to be resilient to climate change. Both short- and long-term strategies are necessary, involving action from government, industry and local stakeholders.

Federal, provincial/territorial and municipal governments can play a vital role in improving the adaptive capacity of the agriculture and agri-food sectors. In 2003 the Agricultural Policy Framework (APF) was created to help industry adapt to changing consumer needs and demands. APF was replaced by *Growing Forward*, Canada’s 2008 to 2012 agricultural policy framework, with a budget of \$1.3 billion for programs and services to support the agricultural sector (AAFC 2008, 10-11). Many of the programs involve business risk management initiatives, such as AgriInsurance and

AgriRecovery, to assist farmers who experience extensive loss.¹⁸ These initiatives are a step in the right direction to increase the resiliency of the agriculture and agri-food sectors; however, it would also be beneficial to create a National Food Strategy. This strategy should be developed in consultation with key stakeholders in industry, NGOs, government, academia and consumers, and should outline a vision for the future of food in Canada.¹⁹

In addition to policy measures, all levels of government should invest more in climate-conscious infrastructure. At a time when so much of the infrastructure in Canada requires replacement, it would be highly beneficial to incorporate changing climate conditions and adaptive measures into infrastructure design. The design of the Confederation Bridge is an example of successful consideration of the effects of climate change. The bridge is constructed such that it can withstand up to one metre of sea-level rise (Industry Canada 2006, 12). Employing this same logic, building codes, road and bridge design, water pipe construction and other infrastructure could be updated based on current research about the expected impacts of climate change in order to increase the resiliency and longevity of infrastructure in Canada.

Government could further improve adaptive capacity by supporting research and development programs to provide necessary data about climate change and adaptation. For example, it would be useful for comprehensive drought assessments to be conducted for each major drought in order for changes in sensitivity and resiliency to be determined, to help communities learn from their experiences (Wheaton et al. 2005, 24). Furthermore, an early warning system and a monitoring system for food insecurity, implemented at the municipal level but standardized at the national level, would increase resiliency. Creating a comprehensive set of indicators to determine the extent and progression of food insecurity would allow government and civil society to develop responses and monitor their effectiveness (AAFC 1998; Funk et al. 2008, 581).

18. See <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1173969168670&lang=eng> for more information.

19. See *Food and Health: Advancing the Policy Agenda* (2010) for a discussion about the importance of a National Food Strategy for Canada and steps to advance this recommendation. Available online at www.ivey.uwo.ca/lawrencecentre/events/PDFs/food_and_health_finalreport.pdf. For an example of an effective National Food Strategy from the United Kingdom, see *Food 2030*. Available online at www.defra.gov.uk/foodfarm/food/pdf/food2030strategy-summary.pdf

There are numerous adaptation strategies that can be taken at the farm-level and local level to increase food security. To maximize the utility of precipitation events, on-farm water storage systems²⁰ can be built to collect water, which will facilitate irrigation during drought periods (Lemmen et al. 2008, 151). To protect against extreme weather events, improving drainage systems and planting trees will act as erosion control. Also creating wetlands will reduce the damage from flooding while helping to retain nutrients and sediment in water (Lemmen et al. 2008, 151). Shifting planting dates and increasing crop variety and biodiversity will also help to increase agricultural resiliency (Lobell et al. 2008, 607; Greenpeace 2008, 2; FAO 2008, xi). It is argued that “the larger the number of different species or varieties present in one field or in an ecosystem, the greater the probability that at least some of them can cope with changing conditions. Species diversity also reduces the probability of pests and diseases by diluting the availability of their hosts” (Chapin et al. 2000; Greenpeace 2008, 3). These farm-level initiatives, with support from government and industry can increase the resiliency of food production systems in Canada.

Ultimately, a system-wide approach must be taken to improve food security in the face of climate change. Production measures are integral to food security, but they must be examined in conjunction with measures to increase the stability of the food systems, the accessibility of food and improve the way food is utilized in order to fully achieve food security in Canada (McIntyre et al. 2009, 5).

8. Conclusion

The effects of climate change such as temperature increase, extreme weather events, changes in precipitation and snow cover impact soil integrity, diseases and pests, water flow and ultimately agricultural production and food security. While there are both positive and negative changes expected, “without adaptations and adjustments, all yields are projected to decline” (Wall 2007, 6). Both short- and long-term strategies are necessary involving action from all levels of government, industry and individual farms. Through government support programs, research, development and educational programs, crop insurance, and accurate market prices, the agriculture and agri-food sectors can become more resilient. The focus in climate change policy discussions has focused largely on mitigation and while agriculture can play a role in this, more emphasis is needed on adaptation to improve food security. It is important to recognize that the capacity to adapt is not equal among provinces or within provinces and some regions will require additional support (Lemmen et al. 2008, 7). However, with a comprehensive adaptation strategy, driven by accurate and up-to-date information, the Canadian agricultural and agri-food sectors can thrive in a changing climate. 🍁

20. There are numerous forms of water storage that can be implemented on farms. For small-scale irrigation needs, rain barrels can be used to capture runoff from roofs and large water reservoirs can also collect and store rainwater. On a larger scale, farm ponds, dams and dugouts can effectively collect water for irrigation use (BC Ministry of Agriculture, Food and Fisheries, 2004).

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CHAPTER FOUR

The Effects of Climate Change on Health Security

Melissa Harris, Benjamin Brisbois, Rob Lannigan

1. INTRODUCTION

The life of all species, including humans, is only possible within an ecosystem capable of carrying out the processes and functions that provide the necessary services to sustain such life. The availability and adequacy of these services determines the state of health and well-being of all living things within an ecosystem, a country or a community (World Resources Institute, 2009; McMichael, 2003). Due to the rate of current climate change and the breadth of current ecosystem impacts, a wide range of effects on the health of people living around the world is expected (Richardson et al., 2009; Ebi et al., 2008; EEA et al., 2008; IPCC, 2007a). The impacts will be particularly severe for people living in developing countries that are less able to adapt (Ahmed et al., 2009), those in northern communities that are experiencing the most severe climatic changes (ACIA, 2005) and those living in small island states which are critically vulnerable to sea level rise (IPCC, 2007a).¹ The impacts of climate change on safe physical environments that support health, the accessibility and quality of health and social services, the supply of adequate food and water and on the economic vitality of countries and communities, is also expected to threaten the health security of people in all countries, including Canada.

This chapter examines the implications of climate change for health security and how it might alter the ability of people to enjoy sustained health and well-being. The chapter begins with information on the current rate of climate change and on observed changes to key climate variables. The next section identifies key requirements of health security and those factors which are climate sensitive. This is followed by a discussion of how climate change is expected to increase risks to health security by impacting physical environments and increasing exposure to natural hazards, pathogens

and climate sensitive diseases. Information is then provided on the potential impact of climate change on the delivery of health services which are vitally important to the maintenance of a healthy population. The impacts of recent natural disasters such as the European heat wave (2003), Hurricane Katrina that affected southeastern United States (2005) and Hurricane Juan that struck Atlantic Canada (2003) are highlighted for the analysis. The chapter concludes with the identification of research needs that would help public health and emergency management officials in Canada better prepare for the potential threats to health security posed by climate change, thereby safeguarding the health of Canadians.

2. Climate Change

Over the last few centuries, human activities have dramatically increased global atmospheric concentrations of greenhouse gases (GHGs). According to the Intergovernmental Panel on Climate Change (IPCC), there is incontrovertible evidence that this increase has enhanced the naturally-occurring greenhouse effect and caused various climatic changes (IPCC, 2007b). These include increases in temperatures, increases in the frequencies of both droughts and heavy precipitation events, and related geophysical phenomena like sea-level rise and the loss of Arctic sea-ice (Allison et al., 2009). A growing body of research has assessed the health, and other impacts of historical climate trends, and made projections for the future based on scenarios produced by general circulation models (GCMs) (Séguin and Berry, 2008; McMichael, 2009; Lancet and UCI, 2009).

Based on the various scenarios and GCMs in existence, the IPCC has stated that global average temperature will increase in the short and long terms (IPCC, 2007b). The best temperature increase estimates to the year 2100 range from

1. See Ajibade in this report for a discussion of Canadian populations vulnerable to climate change.

1.8 to 4.0°C, while “likely”² values range from 1.1 to 6.4°C, depending on the emissions scenario. This expected warming is greatest over land (as opposed to over the ocean) and over most of the high northern latitude regions, reflecting considerable regional variability. These changes are projected to be accompanied by a contraction of snow cover, receding of permafrost, and a shrinking of the area covered by sea ice (IPCC, 2007b). Health-relevant projections include more intense and frequent heat waves, and a reduced incidence of extremely cold days (Lemmen et al., 2008; Séguin and Berry, 2008).

3. **Climate Change Implications for Health Security**

Other papers in this report detail how the breadth of the expected impacts from climate change on health, economies and societies poses a threat to the human security of populations around the world, but particularly those in developing countries. Fundamental to the achievement of human security is the realization of a high level of health security within a population. Chen and Narasimhan report that “good health and human survival are ultimate goals of any human security agenda” (2002, 1). A variety of definitions of health security have been presented in the literature but core components are often referred to include the following (Rockenschaub et al., 2007; Chen and Narasimhan, 2002):

- Living in a safe environment
- Access to quality health and social services (physical and economic)
- Access to housing: shelter from natural elements
- Access to safe water and food
- Limited exposure to illegal drugs
- Accessibility to safe and affordable family planning
- Prevention of HIV/AIDS and other diseases
- Basic awareness and knowledge of healthy lifestyles

The World Health Organization (WHO) reports that climate change will place additional stresses on international health security (WHO, 2007). Some requirements of health security are more greatly influenced by a changing climate and the resultant ecosystem impacts than are others. For example, the projected increase in extreme weather events and associated hazards including hurricanes, cyclones, heat waves, droughts, floods and forest fires make the physical environments in which people live more dangerous while potentially impacting the delivery of health and social services. Such events are also responsible for large numbers of evacuations and general dislocation of populations every year. In addition, as chapters on food security and water security in this Knowledge Synthesis report suggest, the availability of safe food and water will be of growing concern in many countries, including Canada, due to climate change.³

Adaptation is a necessary response to climate change to reduce risks to human health and well-being and impacts on the health security of populations (IPCC, 2007a; WHO, 2005; Gosselin, 2004). Health authorities at the national, provincial and local levels in Canada have recognized the need for public health adaptation and are taking steps to manage increased health risks already being observed from climate change (Berry, 2008; Government of Quebec, 2006; Mersereau, 2007; Ostray et al., 2008). For example, Health Canada and the Public Health Agency of Canada are working with provincial and municipal-level partners to better understand risks to health associated with extreme heat events and climate-related infectious diseases and build the capacity of decision-makers and community groups to protect vulnerable populations. Efforts are also underway to address growing threats to health and well-being faced by people living in Northern communities where some of the most severe climatic changes are being witnessed. Figure 1 highlights key pathways through which climate change can affect the health security of populations and individuals.

2. The IPCC uses the following language when describing the likelihood of situations or events to occur: virtually certain is used to describe something more than 99% likely to occur; extremely likely > 95%; very likely > 90%; likely > 66%; more likely than not > 50%; about as likely as not 33% to 66%; unlikely < 33%; very unlikely < 10%; extremely unlikely < 5%; exceptionally unlikely < 1% (IPCC 2008, 11).

3. See Popovich and Harris in this report for more broad discussions of water and food security issues associated with climate change.

Pathways through which climate change affects health security

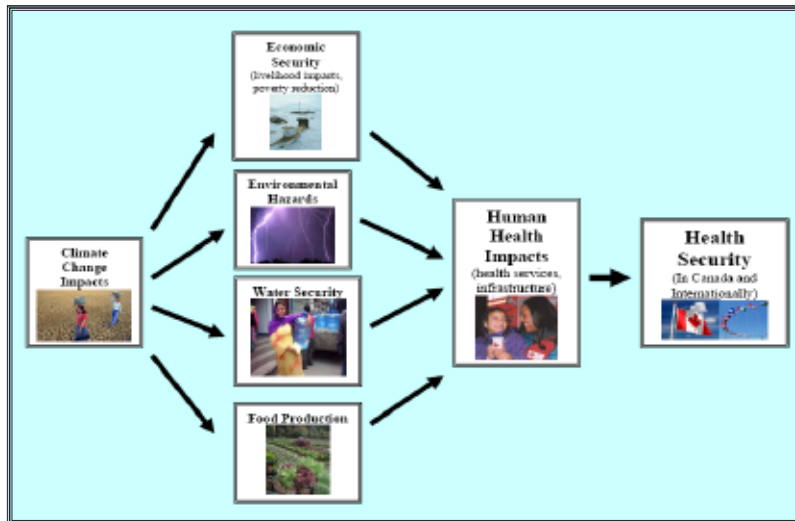


Figure 1 Peter Berry, 2009⁴

Internationally, millions of people live in countries where they lack the fundamental requirements of health security such as adequate food, shelter, drinking water, sanitation and income. For example, there are 200 million children under 5 years of age that do not fulfill their developmental potential annually. In addition, approximately 800 million people go to bed each night hungry and 1500 million do not have access to clean drinking water (Lancet and UCI, 2009). International efforts to alleviate the human suffering caused in this regard have included, among other efforts, progress towards the achievement of the Millennium Development Goals (MDGs) (United Nations, 2009). Some progress has been made in reaching these goals; however, it is now expected that most developing countries will not reach the MDG health targets by 2015 (Lancet

and UCI, 2009). There are growing concerns that climate change could delay, or in some instances, make impossible the achievement of certain MDGs. Several developing countries have limited capacity to adapt to threats to health from climate change (Grambsch and Menne, 2003). Many do not have sufficiently robust or developed health care and emergency management systems to provide services necessary to prevent, diagnose, track and treat climate-related injuries and diseases. Table 1 identifies the ways in which climate change threatens achievement of the MDGs related to improving health and well-being.

The next section of this chapter examines potential climate change impacts on health security through alterations to physical environments and related hazards.

4. Image courtesy of Peter Berry, email message to author, November 2009.

Climate change impacts on health-related Millennium Development Goal

Millennium Development Goals	Expected Climate Change Impacts
Eradicate extreme poverty and hunger (Goal 1)	<ul style="list-style-type: none"> • Impacts on requirements for sustained livelihoods (i.e. access to water, health services, shelter and infrastructure) • Impacts on economic development (i.e. individual income) due to changes in natural systems and resources, infrastructure, and labour productivity • Impacts on food security. In particular in Africa where food security is expected to worsen
Health related goals: <ul style="list-style-type: none"> • Combat major diseases (i.e., malaria) • Reduce infant mortality • Improve maternal health (Goals 4,5 & 6) 	<ul style="list-style-type: none"> • Direct impacts related to increases in heat-related mortality and illness from more frequent and severe heat waves • Indirect impacts are possible from increases in some vector-borne diseases (i.e. malaria and dengue fever), and water- and food-borne diseases (i.e. cholera) • Increased risks to children and pregnant women who are particularly susceptible to vector and water-borne diseases. Anemia – resulting from malaria – is responsible for a quarter of maternal mortality
Ensure Environmental Sustainability (Goal 7) – improve access to safe drinking water and basic sanitation	<ul style="list-style-type: none"> • Impacts on the quantity and quality of drinking water, which can exacerbate malnutrition and threaten food security, particularly in Sub-Saharan Africa • Impacts on public health infrastructure (i.e. sewage and water distribution) necessary for basic sanitation due to increased frequency of extreme weather events

Table 1

Adapted from African Development Bank et al.

4. **Climate Change Impacts on Physical Environments and Related Hazards**

Climate change is projected to modify various existing environmental health risks like poor air quality and incidence of infectious diseases, often in a manner that increases health impacts. In addition,

climate change may bring about novel health risks, such as those created by unprecedented changes to ice conditions in the Arctic, which affect rates of accidental injury and death. Some of the direct and indirect ways through which changes in climate can affect health are shown below in Figure 2.

Climate change impacts on health

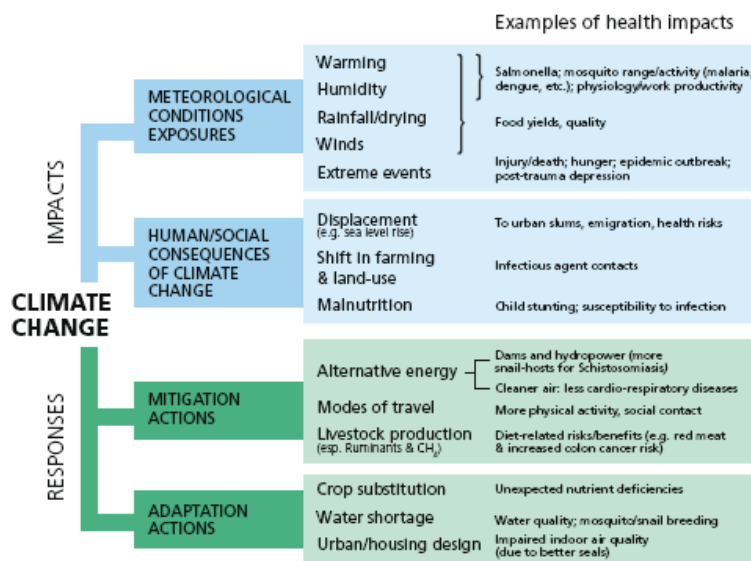


Figure 2 McMichael and Bertollini, 2009

With average temperature increases, shifting climate zones, and intensified droughts, floods and hazards associated with climate change, there is expected to be an overall increase in adverse human health outcomes. Indeed, impacts on health and well-being from a changing climate are already evident. According to Richardson et al,

One of the best indicators of the impacts of climate change on societies is human health and well-being. The observed temperature rise to date, about 0.7°C is already affecting health in many societies; the increasing number of extreme weather events, such as heat waves, floods, and storms, is leading to a growing toll of deaths and injuries from climate-related natural disasters. Beyond the direct impacts on health, climate change also affects the underlying determinants of health – quantity and quality of food, water resources, and ecological control of disease vectors (2009, 12).

4.1 Extreme Weather Events and Disasters

One major component of projected health risk due to climate change is posed by climate-related natural hazards. These natural hazards become known as natural disasters when they occur in situations characterized by certain vulnerabilities,

resulting in significant impacts (Etkin et al, 2009). Risks due to events such as heat waves and major storms have both direct, short-term effects and longer-term impacts on individuals and communities. Natural hazards that have been projected to change in frequency, geographic extent or intensity with climate change include hurricanes, heavy precipitation events, floods, wildfires, heat waves and droughts (IPCC, 2007). Climate change scenarios project an increased risk of extreme weather and other climate-related events (with the exception of extreme cold) for all regions of Canada. An increase in extreme weather events due to climate change will increase risks to the health of Canadians.

Many of the health effects of natural disasters are common to different types (i.e. floods, hurricanes and blizzards) if they stem from factors such as evacuation, stress and disruption of public health and societal infrastructure like electricity provision. For example, carbon monoxide poisoning was observed following the 1998 Ice Storm in Eastern Ontario and Western Quebec (Lecomte et al., 1998), as well as following Hurricane Rita in the southern US in 2005 (Cukor and Restuccia, 2007), largely due to activities like portable generator use during power outages.

Climate variability and weather extremes affect millions of people around the world each year through deaths, disease and injury due to heat waves, floods, storms, fires and droughts. The Global Humanitarian Forum reports that climate variability is responsible for over 300,000 deaths per year while over 300 million people are severely affected through injuries, evacuation, loss of income and livelihood or dislocation. Such impacts are responsible for over \$100 billion (US) in losses per year (Annan et al., 2009). The destruction caused by extreme weather events and disasters which are exacerbated by climate change is increasing rapidly around the world (Economics of Climate Adaptation Working Group, 2009). In the absence of effective adaptation measures, it is expected that the impacts on health on the most vulnerable populations and regions of the world (i.e., developing countries) will continue to rise.

4.2 Severe Storms

The acute and long-term impacts of hurricanes on health have been examined in an international context (David et al., 1996; Hutton, 2005), but not in-depth for Canada. Significant morbidity and mortality typically occurs following the storm as affected individuals attempt to clean up and resume normal life. Consistent with this is the large number of injuries observed in the U.S. that were caused by chain saws and portable generators (Bourque et al., 2007). Recent projections, based on scenarios taken from the IPCC fourth assessment report, suggest that climate change may increase the severity, but decrease the frequency, of hurricanes (Emanuel, 2008). Box 1 highlights some of the impacts on health that resulted from Hurricane Katrina.

Box 1

The health impacts of Hurricane Katrina

The Hurricane Katrina disaster demonstrates many of the adverse health impacts of displacement and the interruption of daily life common to different types of natural disasters. The hurricane, which hit New Orleans and nearby areas of the Southeastern U.S. in 2005, resulted in over 1800 deaths (Louisiana Department of Health and Hospitals, 2006). Large numbers of evacuees became “internally displaced”, and lived for significant periods of time in trailer parks. One survey conducted among this group found a decrease in average household yearly income from \$24,000 to \$18,000. Forty-seven per cent of respondents reported a significant change in their diet following the hurricane, and 20% reported not having enough drinking water. Other impacts observed in this internally displaced population included increased substance use, risk of major depression, and rates of intimate partner violence (Larrance et al., 2007). The disruption of daily life caused by major natural disasters can also have dental health implications. This was demonstrated by Hurricane Katrina, when dental offices and services were disrupted and had to be provided on an emergency basis among evacuated populations (Mosca et al., 2007). While Hurricane Katrina was a larger-scale disaster than Canada has experienced, it serves to illustrate some of the long-term effects that can ensue when evacuations are required and the destruction of infrastructure inhibits the resumption of normal life.

Hurricanes and typhoons have had health impacts in Canada. Most recently, Hurricane Juan in 2003 caused significant economic damage and disruption of daily life in Halifax and Charlottetown, and resulted in the deaths of 8 people (Canadian

Disaster Database,⁵ 2009). In addition, five fishermen died in a storm related to Typhoon Ogden off the British Columbia coast in 1984 and 7 people in British Columbia died as a result of Typhoon Freda in 1962. Other significant tropical storm disasters

5. The Canadian Disaster Database provides information on both tropical and non-tropical storms that have affected Canada, with the latter category including thunderstorms, tornadoes, and hail and winter storms.

in Canada include a 1959 hurricane that resulted in 33 deaths in the Maritimes, mostly among lobster fishermen, and Hurricane Hazel, which caused 81 deaths in Toronto in 1954 (Canadian Disaster Database, 2009).

A major rain and hail-storm in 2004 prompted the evacuation of 30,000 people from the West Edmonton Mall. Other hailstorms have had mortality impacts, with 5 deaths observed in the 1985 hailstorm in Windsor-Leamington, Ontario, and 2 deaths observed following a 15-minute hailstorm on July 28, 1981, in Calgary, Alberta. Major tornado disasters in Canada include the Pine Lake, Alberta tornado of July 14, 2000, in which 12 people died, the 1987 Edmonton tornado (27 deaths) and the 1985 Barrie tornado (12 deaths).

Winter storms routinely cause health impacts, including mortality in motor vehicle accidents. The 1998 Ice Storm caused 28 deaths in Eastern Ontario and Western Quebec, mostly due to injuries stemming from the indoor use of open flames, carbon monoxide poisoning or fire. Only four deaths were due to hypothermia (Lecomte et al., 1998). According to the Canadian Disaster Database, these deaths were accompanied by 945 people injured and 600,000 evacuated (Canadian Disaster Database, 2009).

4.3 Floods

Floods have a number of negative effects on health (Menne et al., 1999). Immediate health effects of flooding include drowning, electrocution due to submerged power sources, and head and other injuries due to trauma caused by debris carried in flood waters and to other causes. In addition, contact with flood waters can sometimes result in shock, hypothermia or cardiac arrest, wound infections, ear, nose and throat infections, or other infectious disease threats like leptospirosis. Indirect effects include contamination of drinking water, increasing the risk of exposure to chemical or biological hazards (Menne et al., 1999).

Flooding also causes increased risk of some longer-term health impacts. Populations evacuated to shelters can be at increased risk of respiratory infectious diseases. Mould growth can increase following flooding, with longer-term impacts on respiratory health. Vector-borne diseases can flourish if flooding leaves behind suitable

breeding sites for mosquitoes. Rodent ecology can be affected by flooding, creating increased risk of rodent-borne diseases. Flooding can lead to loss of property and long-term psychosocial effects like depression (Menne et al., 1999).

Climate change is thought to increase the risk of flooding through heavy rain, rapid melting of snow or ice, blocked watercourses, storm surges in coastal areas, dam failure and land subsidence. Projected changes such as sea-level rise in coastal areas, enhanced permafrost melting in the North, reductions in the extent of sea-ice which protects the littoral and increased storm frequency and severity due to changes in large-scale atmospheric circulation patterns can all increase flood risk (Berry et al., 2008; Gosselin et al., 2008). In the absence of adaptive actions, an increase in the frequency and severity of flooding due to climate change may result in more incidents of “drowning, injuries, respiratory diseases, shock, hypothermia, cardiac arrest, wound infections, dermatitis, conjunctivitis, gastrointestinal illnesses...and water-borne diseases” (Séguin and Clarke 2008, 59).

Canada has been affected by numerous small floods and a smaller number of major floods. According to the Canadian Disaster Database, floods killed 10-15 Canadians per decade in the 70s, 80s and 90s, although this number likely does not include all Canadians who died in storm-related flooding. Major flood disasters included the 1996 Saguenay flood, in which 10 people died and 15,825 were evacuated, and the 1997 flooding in Southern Manitoba, to which no fatalities were attributed, but which led to the evacuation of 25,447 people (Canadian Disaster Database, 2009).

Physical health effects are more widely researched and published but mental health issues such as post-traumatic stress disorder and depression in survivors of extreme weather events have been recognized as an important health concern (Hutton, 2005). The mental health effects of flooding have also been studied as a disruption of the relationship between people and their environments (or “sense of place”) (Tapsell and Tunstall, 2008). Flooding can sometimes cause such radical changes that rebuilding is impossible, and can transgress fiercely-defended boundaries based on the strong emotional attachments people develop to their homes.

4.4 Drought

With an increase in drought frequency projected by many Global Climate Models, drought-related health impacts may become more problematic in the future (Jaykus et al., no date; Nelson et al., 2009). Farmers and ranchers are affected by droughts through crop yield reductions and reduced livestock production, which results in economic losses (Herrington et al., 1997; Wheaton et al., 2005). While droughts in developing countries directly affect levels of malnutrition, their effects on health in developed countries largely operate through the impacts on economic well-being and poverty levels (Cook et al., 2008).

Health impacts from drought are related to stress from financial pressures due to crop and livestock losses. More direct impacts may arise from environmental impacts associated with dust storms and wildfire smoke, which can cause adverse health impacts, such as respiratory illnesses, exhaustion, depression or even suicide (Walker et al., 1986; Deary et al., 1997; Malmberg et al., 1997; Smoyer-Tomic et al., 2004; Soskolne et al., 2004). Lower water levels caused by surface evaporation during droughts causes suspended and dissolved matter to become more concentrated which may pose drinking water risks. In addition, during periods of drought communities often need to cutback on water use including hydroelectric production and recreation and tourism related duties.

Over the last 60 years, Canada experienced 37 major droughts. Most occurred in the Prairie provinces but drought has impacted all regions of Canada (PSEPC, 2005). No deaths have been directly linked to drought on the Canadian Disaster Database. However, it is expected that increased morbidity and mortality during periods of drought has occurred due to the effects of economic damage and dust (Berry et al., 2008).

During the 2001-2002 drought, 32 incidents of blowing dust associated with traffic incidents were reported in Saskatchewan between April and September, 2001, involving two fatalities (Wheaton et al., 2008). In the same drought, wild fire incidence in Alberta increased to five times the average rate of the preceding ten years.

4.5 Extreme Heat

Morbidity and mortality due to extreme heat represent a potentially major health impact of climate change. Over a span of several weeks, people can gradually become acclimatized to heat stress by reducing their basal metabolic rate, increasing their capacity to perspire and increasing skin blood flow (Koppe et al., 2004). Nevertheless, sudden temperature increases followed by prolonged exposure to temperatures to above 30°C (i.e. heat waves) can have serious health consequences (Campbell and Norman, 2000), especially when accompanied by high humidity and severe air pollution. Extreme heat can cause skin rashes, cramps, unconsciousness, exhaustion and heat stroke (Health Canada, 2009). Numerous studies have also investigated possible relationships between temperature and suicide rates, with variable and often contradictory results (Dixon et al., 2007).

Extreme heat events pose significant risks to individuals in Canada and can be especially dangerous for seniors, children and infants, the socially disadvantaged and people in frail health, particularly those taking certain medications (Smoyer-Tomic et al., 2003; CEC, 2008; Gosselin et al., 2008b; Kenny et al., 2008). In populations with cooler climates, or during heat waves occurring early in the season, people are particularly vulnerable as they are unacclimatized to heat stress (Keatinge et al., 2000; Curriero et al., 2003; Curriero et al., 2002). The health impacts of the heat wave that struck Europe in 2003 are highlighted in Box 2.

Box 2

Health impacts of the European heat wave: 2003

Probably the most famous heat wave in memory affected Europe in the summer of 2003. This heat wave caused significant mortality increases, with final numbers difficult to assess. A recent European Union study compared excess mortality during this period to that expected based on historical data, and concluded that the entire summer saw an excess heat mortality of over 70,000 deaths (Robine et al., 2008). This study found no evidence of harvesting, or mortality among individuals who were likely near death and is also likely an underestimate because data was unavailable for Bosnia-Herzegovina, Serbia, Bulgaria, Greece and Romania. A novel result of this study was the presence of a peak in mortality in Southern Europe at the start of the summer, which went largely unnoticed. The hardest-hit countries over the whole summer were Italy and France, both of which had approximately 20,000 excess deaths. Following the 2003 heat wave in France, researchers followed patients admitted to hospital with heatstroke over time. Sixty-five per cent of this population had died within 28 days; after one year, 22% of the remaining survivors had entered long-term care facilities because of functional limitations, with significant increases in functional impairment observed over the year.

The IPCC (2007b) indicated that the rate of climate warming will increase over the coming decades, and that it is very likely that extreme heat events will become more frequent. As the temperature increases, the number of hot days exceeding 30°C will increase and by 2050 it is

predicted that some communities in southern Canada will experience as many as four times more hot days during the summer months than they do today (Séguin 2008, 11). This is illustrated in Figure 3, which shows the projected number of hot days per year for selected cities in Canada.

Current and projected number of hot days above 30°C for selected cities in Canada

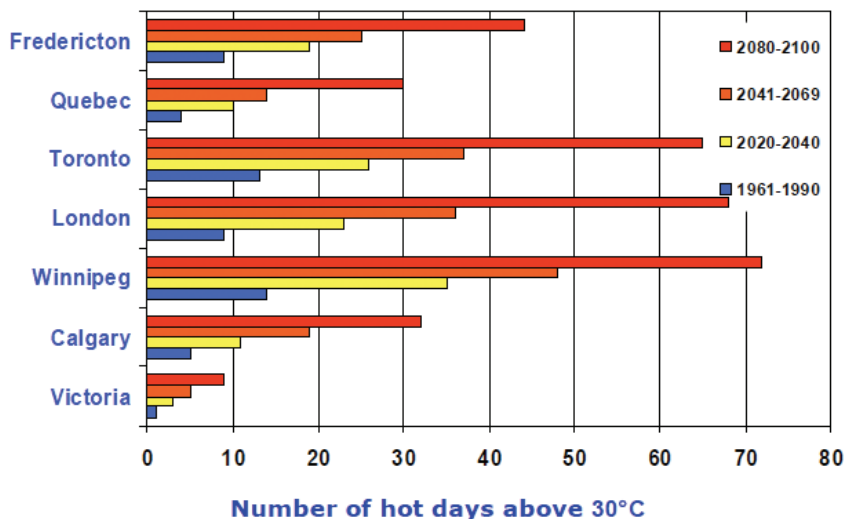


Figure 3 Kharin and Zwiers, 2000

The precise number of persons with heat-related illnesses seeking medical treatment in a given year in Canada or the U.S. is unknown because reliable statistics are unavailable. Only a small number of deaths are certified as due to heat stroke in Canada (Koutsavlis and Kosatsky, 2003). Some deaths have been classified as due to heat waves using medical records and other sources. For example, between 1900 and 2005, five major heat waves occurred in Canada (1912, 1936, 1953, 1963, 1988) causing over 1,900 deaths (Canadian Disaster Database, 2009). The 1995 heat wave in Chicago resulted in over 700 excess deaths and 33,000 emergency room visits (Klinenberg, 2002).

Researchers have estimated that between 1954 and 2000, about 120 people died each year due to heat-related causes in Toronto, 121 in Montreal, 41 in Ottawa, and 37 in Windsor (Cheng et al., 2005). A paper published based on the same larger research project used synoptic typing to classify air masses into 1 of 10 weather types, each of which was associated with a particular risk of mortality related to extreme heat and air pollution (Pengelly et al., 2007). This study found a strong association in Toronto between excess mortality and the annual number of days characterized by a hot weather-type air mass, with episode length being correlated with increased risk of daily mortality.

If effective adaptation measures are not widely adopted, this increase in the number of hot days, when combined with humidity and increased air pollution, could result in a significant increase in heat-related illnesses and deaths, especially among infants, seniors and people in poor health. Gosselin et al., (2008) using a mid-range climate scenario projected the annual excess number of deaths from extreme heat in the province of Quebec and estimated that by 2020 there would be 150 excess deaths, by 2050, 550 and by 2080, over 800 deaths.

Climate change is projected to reduce the number of extremely cold days. Currently Canada experiences some morbidity and mortality due to cold, and projections have been made that climate change could improve health by reducing these effects of extreme cold (Stern, 2006). Some evidence suggests, however, that there will be smaller-than-expected reductions in cold-related morbidity and mortality, because many Canadians are currently well-adapted to cold (Gosselin et al., 2008).

In Canada, due to better infrastructures, weather warning systems and improved public health services fatalities from all extreme weather events have fallen over the past century. However, the number of people affected, whether injured or made homeless, has dramatically risen as have economic costs. Figure 4 shows the frequency of natural disasters which have occurred in Canadian communities from 1900-2006.

Frequency of natural disasters in Canada (1900-2006)

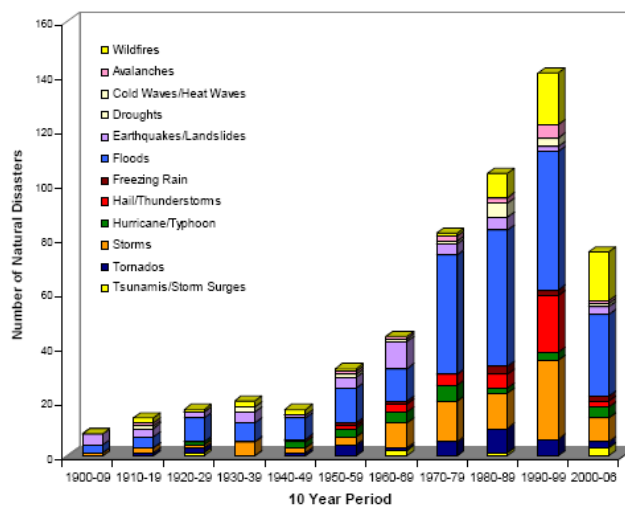


Figure 4 Canadian Disaster Database, 2006

5. Air Pollution related Health Risks

In 2008 more than 21,000 Canadians died from air pollution and the Canadian Medical Association predicts that by 2031, air pollution will cause 90,000 deaths annually (CMA 2008). Exposure to poor air quality is another major pathway through which climate change is expected to increase risks to the health of Canadians. The severity and duration of air pollution episodes are projected to increase in some areas of Canada as a result of a warming climate. Increases in temperatures in Canada will affect air quality in Canada by increasing the formation of ground-level ozone, the number and severity of wildfires, the production of aeroallergens and incidence of fungal respiratory diseases.

5.1 Ground level Ozone

Ground-level O₃ has many negative health effects. Ozone causes serious damage to the respiratory system, resulting in airway inflammation, reduced lung functioning and tissue damage. Exposure to even modest levels of ozone can lead to an increase in asthma attacks in young children and can worsen conditions for adults with asthma and other lung diseases (Field et al. 2007, 632). Ozone also has detrimental effects on the cardiovascular system (Lamy and Bouchet, 2008).

Atmospheric levels of O₃ are related to emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) from natural and anthropogenic sources. These chemicals combine atmospherically in the presence of ultraviolet (UV) radiation to form O₃. Changes to local weather patterns and higher average temperatures can affect local and regional air pollution levels by trapping pollutants and altering the rates of atmospheric chemical reactions involved in the formation of ground-level ozone (Health Canada, 2005; Lamy and Bouchet, 2008). As outlined by Bernard et al. (2001), Lloyd (2001), IPCC (2007b) and others, climate change could influence levels of ambient pollutants by modifying (1) weather and consequently local and regional air pollution levels; (2) anthropogenic emissions; and (3) natural emissions, which are strongly controlled by temperature. In North America alone, a 4.5 per cent increase in ozone-related deaths is projected to occur in the next 30 years due to climate change (IPCC, 2007a).

Lamy and Bouchet (2008) projected that a 4°C increase in average temperature in Canada (from 2002 levels), with anthropogenic emissions kept constant but biogenic emissions increasing in response to the higher temperature, would result in an expected increase in the average daily 8-hour maximum ozone concentration of over 14 parts per billion (ppb) in some parts of the country. The most affected communities would be Montréal, Toronto, Vancouver, Calgary, Edmonton, Fort McMurray and Winnipeg (Lamy and Bouchet, 2008).

Using a synoptic typing approach in which weather types (recognizable and frequently-occurring assemblages of meteorological variables) were associated with air quality conditions, Cheng et al. (2007) also projected air quality in South-Central Canada under climate conditions corresponding to a doubling and trebling of atmospheric CO₂. The synoptic typing approach was applied to meteorological conditions down-scaled from GCM projections. For Windsor, Toronto, Ottawa and Montreal, investigators estimated numbers of high-ozone days and related health impacts for the 2040-59 period (CO₂ doubling) and for the 2070-89 period (CO₂ trebling), using a number of emissions scenarios (both GHGs and air pollutants). This approach yielded warmer, moister conditions for the cities in question, with temperatures 2.2 and 3.6° C warmer by the 2050s and 2080s, respectively. In a scenario in which anthropogenic air pollutant emissions were kept constant, daily average ozone concentrations increased by 2.7 ppb by the 2050s and 4.0 ppb by the 2080s (daily average ozone concentrations were 23.0 ppb in 2008).

5.2 Wildfires

Climate influences on air quality can also occur through an increase in the frequency and severity of wild fires and forest fires. Warmer and dryer conditions, which are expected due to climate change, support the development of these fires which can lead to increased air pollution far from their locations (Séguin and Berry, 2008). Direct health impacts of wildfires include hyperthermia and dehydration, as well as eye irritation and respiratory irritation from exposure to smoke. Indirect impacts on health include physical and mental exhaustion, stress-related hypertension and post-traumatic stress syndrome experienced by fire

fighters and other emergency personnel. People who have been dislocated by wildfires through the loss of their home or through evacuation are also at risk of impacts on mental health (Mackay, 2003). In addition, wildfires have the potential to remobilize toxins previously stabilized in sediments (Cook et al., 2008). Following the 2003 wildfires in southern California, investigators found markers of fire exposure, as recalled by survey participants, to be significantly correlated with a range of health problems, including eye irritation and respiratory symptoms (Kunzli et al., 2006).

Overall, research on the human health impacts of wildfires in the Canadian context is limited, and the results have been mixed. A study in 2006 of rural residents in northern Saskatchewan did not find a link between wildfire smoke and hospitalizations (Langford et al., 2006). Nevertheless, significant data exist attesting to the magnitude of the problem. On average each year, there are more than 8,000 forest fires in Canada. Fifty-two nationally significant forest fires have occurred in all provinces and territories since 1900 resulting in the evacuation of 44 communities and more than 155,000 residents, and the deaths of at least 366 people (NRCan, 2004b; PSEPC, 2005). It is routine to see wildfires forcing the evacuation of hundreds, and sometimes thousands of people. The wildfires of 2003 in southeastern British Columbia and southwestern Alberta forced the evacuation of 50,000 people (Canadian Disaster Database, 2009).

5.3 Fungal and respiratory diseases

Fungal diseases are known to inhabit specific ecological niches, which include appropriate temperature and moisture profiles. One example of how climate change may increase risks to Canadians through this route is provided by *Cryptococcus gattii*, a fungus found in trees and soil, which can cause respiratory and neurological symptoms, and death in vulnerable individuals. While *C. gattii* was previously thought to be confined to tropical and subtropical regions (Australia, for example), it has been an endemic pathogen on Vancouver Island since approximately 1999, causing hundreds of illnesses and a handful of human deaths (with a significantly larger number of animal deaths), largely in elderly individuals (MacDougall and Fyfe, 2006). The emergence of this disease has been

described as a possible effect of climate change (Greer et al., 2008), although the organism observed on Vancouver Island is a different genotype from the tropical and subtropical strain (MacDougall and Fyfe, 2006) and therefore without a previously known climatological affiliation. Nevertheless, it is a pathogen whose dispersal and survival is affected at least in part by climate, and which could spread in the future due to climate change. It is also a uniquely-understood emergent pathogen, which could provide clues to help predict and understand future disease emergence (Kidd et al., 2007).

6. Ultraviolet Radiation

In addition to more hot days, the general warming associated with climate change may also lead to Canadians spending more time outdoors, increasing exposure to UV radiation which will increase the risk of skin cancer, cataracts and immunosuppression (Séguin and Clarke, 2008). UV radiation at certain frequencies has been shown to damage skin and eyes, causing sunburns, cancer and immune suppression, among other effects. Currently skin cancer is a serious problem in Canada, with more than 80,000 new cases emerging each year and this figure will worsen as people face more exposure to harmful UV rays (Canadian Cancer Society, 2005). Since the 1980s, ozone-depleting substances such as Chlorofluorocarbons have been restricted by international convention and deterioration of the ozone layer has been subsiding. However, climate change is projected to affect rates of recovery of the earth's ozone layer, due to temperature-related changes in atmospheric reactions at the poles.

7. Diseases transmitted by water, food, insects, ticks, and rodents

Canadians may be exposed to a variety of infectious diseases that are sensitive to climate variables. These include diseases transmitted by insects and ticks, or influenced heavily by natural reservoirs like rodent populations; food- and water-borne illnesses, often bacterial in nature; and fungal pathogens which cause respiratory diseases. Evidence suggests that many infectious diseases exhibit seasonal patterns, globally and in Canada (Grassley and Fraser, 2006). Reasons for this seasonality are not fully understood, but may include population behaviours (i.e.,

increased crowding indoors in winter); pathogen-pathogen interactions (i.e., influenza infection has been hypothesized to increase susceptibility to meningitis); environmental effects on pathogens (i.e., bacteria tend to grow more quickly in warm weather); and host susceptibility to infection (i.e., it has been hypothesized that reduced sunlight in winter reduces immune competence) (Fisman, 2007). Many of these factors can be seen as susceptible to alteration with climate change.

Chapter Two in this report details the many ways in which climate change could threaten water security in Canada. The most direct effect of climate change in this regard is on the health of people through impacts on drinking and recreational water quality. Extreme weather events have been linked to water contamination incidents in Canadian communities. In particular, heavy precipitation, snowmelt and flooding events are thought to have contributed to past water-borne outbreaks in Canada (Charron et al., 2004; Schuster et al., 2005; Bowie et al., 1997; Thomas et al., 2006). Storm water runoff can contaminate streams, rivers and lakes and drought conditions can concentrate pathogens and chemical and radiological contaminants in water due to lower water levels (Charron et al., 2008). Climate change is expected to increase the risks of water-borne disease due to projected changes in heavy rainfall events and increased temperatures.

Fleury et al., (2006) found that the occurrence of *Salmonella*, *Campylobacter* and *E. coli* O157 infection increases as ambient temperature rises. Similar findings have been documented in studies from the U.K. and Australia (Bentham and Langford, 1995, 2001; D'Souza et al., 2004; Kovats et al., 2004). While warmer temperatures and drought are projected to increase disease rates worldwide through enhanced growth of bacteria and their reservoirs, this mode of impact is likely to be prevented by Canada's water treatment systems, with some exceptions. Extreme precipitation events which enhance overland flow or flooding and overwhelm treatment systems are a greater threat to drinking water supplies.

An example of a disease that is currently rare in Canada but might become of greater concern due to climate change is leptospirosis. Outbreaks of this disease in animals have been associated with high

precipitation levels and warm wet late summer and autumn conditions (Vinetz et al., 1996). Warmer winters and increased temperature may increase the risks of transmission to swimmers in recreational waters in many parts of Canada (Jansen et al., 2005).

Water quality in Canada's North may be especially affected (Furgal et al., 2008). People living in the North may be more vulnerable to water quality-related health risks given the higher dependence on untreated water for consumption. In Nunavik, 30% of the Inuit population obtains their drinking water from rivers and lakes in the summer and melting snow or ice in the winter and spring (Martin et al., 2005). Increased rates of illness are already present in this region, compared to the rest of Quebec.

Climate change could affect the risk of food-borne disease through longer summers, which will mean exposure to pathogens is increased through higher risk behaviours (i.e. barbecues, picnics, camping). In addition, it is expected that a higher incidence of disease will result from hotter temperatures given that the survival rates of most pathogens responsible for food-borne illness are positively correlated with ambient temperature (Charron et al., 2008; Hall et al., 2002). People living in the Canadian Arctic already face a number of challenges related to food safety due to a rapidly changing climate. Concerns exist about traditional food preparation and storage practices that rely on refrigeration in permafrost (Furgal, 2008). Research has linked outbreaks of botulism poisoning in this region to changes in traditional food practices or to practices implemented in inappropriate climates (Proulx et al., 1997; Horn et al., 2001). Risks from food-borne diseases, such as gastroenteritis, paralytic shellfish poisoning and botulism may increase in the Arctic as this region continues to warm (Parkinson and Butler, 2005).

The prevalence of the most common food-borne (i.e., *Salmonella*, *Campylobacter* and *E. coli*) and water-borne (i.e., *Giardia*, *Cryptosporidium*, *Campylobacter*, *Shigella* and *E. coli*) disease hazards in humans is influenced by a wide range of factors. These include climatic conditions, risk behaviour of exposed populations, community level protection measures, and service levels for diagnosis and treatment. Research has shown that

climate change, through increased temperature and changes in precipitation, can increase risks to health from vectors that carry and transmit pathogens. Warmer temperatures may mean Canadians spend more time outdoors where they are exposed to these vectors and may also increase the tendency of vectors, such as mosquitoes and ticks, to seek out humans. Hotter summers may also expand the geographic range of mosquito vectors and lengthen the transmission season by altering mosquito life cycles (Patz and Reisen, 2001). In Canada, some mosquitoes and ticks carry diseases such as West Nile virus, Lyme disease, St. Louis encephalitis, western equine encephalitis and eastern equine encephalitis (Charron et al., 2008). For example, Saskatchewan reported 1,456 human cases of West Nile virus infection in 2007 (PHAC, 2009).

One example of an infectious disease that may expand its range in Canada due to climate change is Lyme disease, also called *Lyme borreliosis*. This is a bacterial infection that may cause a skin rash or more severe conditions such as chronic arthritis, nervous system disorders and debilitation (Charron et al., 2008). Higher temperatures associated with climate change are projected to increase health risks associated with Lyme disease as tick life cycles are shortened, the survivability of the vector increases and longer warm seasons increase the exposure of people through outdoor activities (i.e., hiking, camping etc) for host-seeking activity (Ogden et al., 2005; Ogden et al., 2004). A recent study evaluated habitat suitability for *I. scapularis* in parts of southeastern Canada north of the tick's current range. It was found that habitats are sufficiently suitable to make range expansion of the tick feasible (Ogden et al., 2006). Figure 5 shows the possible spread of *Ixodes scapularis* in Canada under climate change.

Possible spread of *Ixodes scapularis* in Canada under climate change⁶

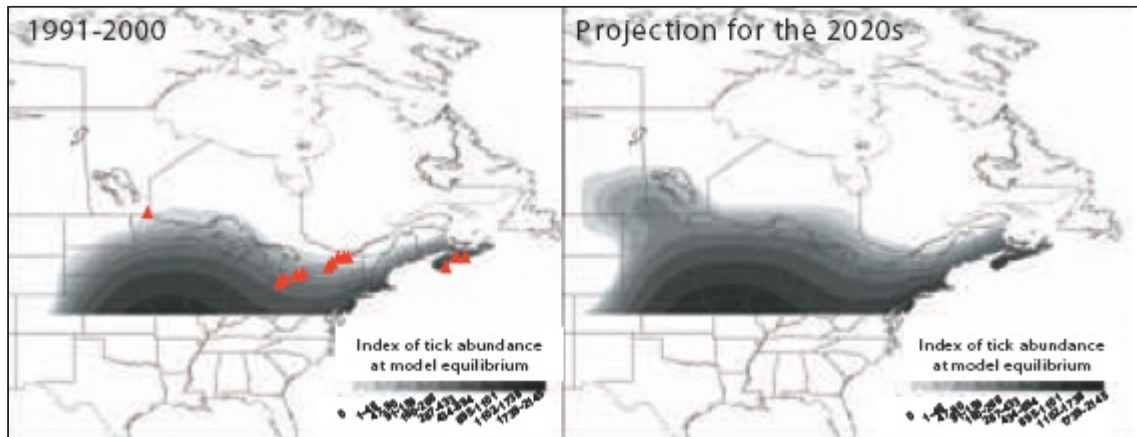


Figure 5 Ogden et al., 2006

Climate change is also projected to alter the endemic range of dengue and malaria (Rogers and Randolph, 2000; Sutherst, 2004), although there is much uncertainty about the extent of any projected expansion. Globally, malaria causes more than 250 million illnesses and at least one million deaths annually (WHO, 2009b). Health risks to Canadian

travelers may increase as climate change affects the worldwide distribution of malaria. Ultimately, “travel between Canada and endemic regions also has potential for pathogen introduction and localized transmission in areas where competent vectors are present and climate permits” (Charron et al. 2008, 184). Recent studies suggest that

6. The red triangles identify locations of known tick populations.

climate change may already be increasing risks to health from vector-borne diseases (McMichael et al., 2004; Purse et al., 2005).

8. **Populations at Higher Risk from Climate Change Health Impacts**

Climate change is expected to impact the health of certain populations more than others (Menne et al., 2008). Canadians that are at significantly greater risk include seniors, children and infants, the socially disadvantaged, people with pre-existing illnesses, the disabled, pregnant women, Aboriginal Canadians and new immigrants (Séguin and Clarke, 2008; Powell, 2009). See Box 3. For example, seniors, post-menopausal women, or those taking certain medications including

anticholinergics, diuretics, beta-blockers, estrogen replacement drugs and some antipsychotic drugs are at greater risk from extreme heat events (Lee-Chiong Jr. and Stitt, 1995; Freedman and Krell, 1999; Brooks-Asplund et al., 2000; Speizer, 2001; Gauthier et al., 2005). Infants and young children are also particularly susceptible to heat-related illnesses due to an immature thermoregulatory system (Yeo, 2004). People with depression, cardio- and cerebro-vascular conditions and diabetes need to take extra precautions during heat waves. Mortality is more sensitive to heat in urban than rural areas because of the urban heat island effect and other aspects of urban life (Kovats and Hajat, 2008).

Box 3

Canadians most vulnerable to climate change health impacts

Seniors exhibit greater vulnerability to climate-related hazards, particularly if they take certain medications, have chronic health problems, live alone, or have impaired cognition or reduced mobility. They face greater physiological limitations in their ability to cope with extreme temperatures and events.

Children and infants are more vulnerable because they are not able to protect themselves from hazards and must rely on the assistance of caregivers to reduce their exposure. Their relatively high intake of water, air and certain foods, rapid growth and development, hand-to-mouth behaviour, and immature physiology and metabolism makes them more vulnerable to climate-related hazards.

Socially disadvantaged individuals have fewer financial resources and support networks and therefore may experience greater difficulty coping with the effects of hazards. This may be exacerbated by existing chronic illnesses or health conditions.

People with pre-existing illnesses including chronic diseases such as cardiovascular disease neurological and mental illness, diabetes, asthma and other respiratory diseases and cancer can exhibit increased sensitivity to the health impacts of climate change – particularly vector-borne infectious diseases, water- and food-borne contamination, and smog and extreme heat events.

Disabled people may experience greater difficulties taking protective measure during extreme weather events and therefore be at great risk of injury or exclusion during evacuation.

Pregnant women and their fetuses may be at risk during extreme weather events due to psychosocial stress related to the fact that women often bear the burden of cleaning up after an event and bringing the family back to a state of normalcy.

Aboriginal populations are at greater risk as they experience poorer health and higher rates of some chronic diseases as well as socio-economic disparities (unemployment, education, average income).

New immigrants may face barriers related to language and social networks that decrease their awareness of climate related hazards and assistance programs. These barriers may also prevent them from understanding emergency preparedness messages and alerts.

9. **Climate Change Impacts on Health and Social Services**

Health and social services play a critical role in reducing the wide range of impacts climate change can have on individuals and on the health of their communities. As Dr. Margaret Chan, Director-General of the World Health Organization stated, “resilient health systems increase the capacity to cope with shocks to human security” (Chan 2008, 1). The ability of health institutions to protect the health of populations from the expected impacts of climate change and thereby safeguard health security is of concern to both developing and developed countries, although developing countries face the greatest challenges (Lancet and UCI, 2009). It is argued that, “climate change will strain the health resources of those countries that already face the public health challenges of poor health structure, poverty, and inequality” (Lancet and UCI 2009, 1704). The vulnerability of health system infrastructures to climate change impacts and the need to incorporate consideration of expected impacts into health facility planning, emergency preparedness planning and the training of health professionals in community health centres, hospitals and nursing homes in Canada has been recognized (Berry, 2008; C-CIARN Ontario, 2002).

Health care facilities such as hospitals may be affected by natural disasters in a variety of ways that affect the provision of services to patients (Carthey et al., 2009; Clarke, 2009; Dauphinee, 2009). Examples include:

- Influx of people not needing treatment but simply looking for air conditioned areas
- Overheating of hospital computers causing them to fail during heat waves
- Water shortages and water supply failures
- Electrical power outages causing disruption in services
- Reduced access to health care facilities for doctors and nurses during floods
- Impacts on indoor air quality due to mould growth after flooding
- Storm surges knocking down or otherwise damaging hospitals

- Heavy precipitation during hurricanes and cyclones damaging roofs and causing evacuations
- Loss of medical records and equipment due to water damage

In 2005, Hurricane Katrina affected 93 hospitals including the evacuation of 19 facilities and the closure of 18 others (Carthey et al., 2009). The storm also disrupted supplies of drugs to dependent individuals in New Orleans, and reduced the number of psychiatrists living and working in the New Orleans area by approximately three quarters (Potash and Winstead, 2008).

In Canada the relationship between extreme heat and ambulance response calls was examined for the city of Toronto (Dolney and Sheridan, 2006). Investigators found that the overall number of ambulance calls placed on weekdays increased during heat alerts (by 8 %) and during heat emergencies (by 12%). The number of calls placed on weekend days increased 14% during heat alerts, with a non-significant change observed during heat emergencies. On heat days, the greatest absolute increase in calls was observed in the Toronto urban core, with the greatest per centage increase observed in hot spots like the Toronto Island, Ashbridges Bay, and certain industrial areas. The number of weekend calls from the urban core went down significantly on heat alert or emergency days, suggesting that people tended to stay home when possible. It is likely that people went to work as usual on heat alert or emergency days during the work week, leading to the high volume of ambulance calls coming from the downtown core.

Increased stresses on health facilities and the services they provide to the public due to climate-related impacts are exacerbated by a lack of planning for emergency situations. A study by Carthey et al., (2009) revealed that most health facilities in Australia have not been built with adequate consideration of climate-related weather risks and that new design and adaptation strategies might be required to ensure that health infrastructure itself does not pose a risk to the delivery of health services to the population during extreme weather events. Hospitals that integrate climate change considerations into their design and construction and that follow rigorous

emergency management protocols contribute to the reduction of costs from natural disasters by enabling health services to treat people effectively and efficiently (Carthey et al., 2009).

New disease vectors are a challenge for health professionals who do not have the education or clinical knowledge to deal with them. Many hospital facilities in industrialized countries lack experience in managing malaria and even infections or parasitic diseases that have emerged in previously cold climates (i.e., dengue fever) are rarely well understood by practitioners (Lancet and UCI, 2009). Long-term strategies are needed to develop the clinical and management and investments will human capacity of health systems to address health risks from climate change. The need to further educate and train health professionals in Canada to prepare for increased risks to health from new or re-emerging infectious diseases due to climate change has been recognized (Charron et al., 2008).

Extreme weather events can have severe impacts on populations in developed countries. Many countries have made strides in the development and implementation of community based disaster risk reduction programs (Lancet and UCI, 2009). However, significant knowledge gaps exist about the effectiveness of such programs, the best way to coordinate activities among multiple jurisdictions and how to effect positive behavioural change among individuals to increase levels of preparedness (Lancet and UCI, 2009; Berry et al., 2009). As part of a growing recognition of the destructive effects that natural disasters can have on health systems the World Health Organization call for urgent action to protect hospitals from natural disasters during the International Day for Disaster Reduction 2009. These included safety measures to be integrated into the design, location and construction of hospitals to protect them from floods, hurricanes, cyclones, earthquakes and other hazards (WHO, 2009a). More generally, the World Health Assembly in 2008 passed a resolution which outlines five priority areas for action to prepare for the expected impacts of climate change of health (WHO, 2008):

- Documentation of the risks to health and differences in vulnerability within and between populations
- Development of health protection strategies
- Identification of health co-benefits of actions to reduce GHGs or to adapt to climate change
- Development of decision support systems to predict the effects of climate change for member states
- Estimation of the financial costs of action and inaction

Overall, Canadians enjoy very good health status, a high level of health and social services, and significant health security. Consequently, a strong foundation exists for efforts to prepare for the impacts of climate change on health. However, adaptive capacity and levels of resiliency⁷ vary greatly among individuals, from community to community and between regions; climate change and other emerging hazards are bringing new challenges to health and well-being that test our capacity to sustain robust and healthy societies. As well, concerns exist about the vulnerability of Canadians to health risks from climate variability, including those related to weather extremes (Etkin, 2009). Gaps in public health and emergency management activities have the potential to significantly affect the ability of Canadians to effectively plan for and respond to climate change in Canada and other hazards (Berry, 2008; Gosselin et al., 2008). Little information is available from a public health perspective, about when key thresholds might be crossed for different types of hazards (i.e., disease outbreaks, heat waves, hurricanes, tornados, terrorist attacks) and particularly in the face of cumulative events.⁸ Events like the 1998 Eastern Canada Ice Storm, Hurricane Katrina and the European Heat Wave demonstrate that within and outside of Canada disasters have disproportionate affects across communities and population groups. The frail elderly and people with disabilities or chronic health conditions are particularly vulnerable to these events.

7. Resiliency depends upon the ability of a community to withstand a disaster, bounce back to its pre-disaster level of functioning and to learn from the disaster experience to improve emergency management functioning (Maguire and Hagan, 2007).

8. The 2009 Global Assessment Report on Disaster Risk Reduction (ISDR, 2009) provides information on the global distribution of multiple hazards mortality risks which can be used to estimate cumulative impacts.

Resilient people and resilient communities suffer less in the face of natural disasters, public health emergencies or other challenges which threaten health and well-being and the health security of populations (IISD et al., 2003). They also “bounce back” faster as economic, transportation, energy and public health services return to normal more quickly. Public health and emergency management officials seek to understand the factors that make communities and individuals less vulnerable and more resilient to climate change hazards and health emergencies. Factors that enhance the resilience of Canadian communities to disasters include (Etkin, 2009):

- Settlement patterns in low risk areas (i.e., off flood plains)
- Well-designed and maintained infrastructures that support public health
- Economic and human resources available to reduce risks (i.e., rural communities)
- Strong public health and emergency management systems tailored to local needs
- Full voluntary sector engagement and involvement in building healthy, sustainable communities
- A knowledgeable public prepared for emergencies

Resilience to disasters also depends upon early warning systems which provide the means by which a potential danger is detected or forecast and an alert is issued. These systems have been shown to reduce the loss of life associated with natural hazards (WHO, 2005).

10. Knowledge Gaps and Research Needs

Future efforts to manage the health risks to Canadians from climate change will require local and regional level assessments of vulnerability to inform needed adaptations. These studies and ongoing efforts through adaptation to safeguard human security in the face of climate change will benefit from research to improve knowledge in the following areas:

- Assessment of the vulnerability of health facilities and services to climate change impacts

- Ability to plan for and respond to disease outbreaks and public health emergencies
- Effectiveness of current measures to adapt to the health impacts of climate change
- Factors related to the human security of Canadians that may be affected by climate change and impact health and well-being
- The resiliency of individual Canadians, and vulnerable groups to the health impacts of extreme weather events and natural disasters
- Economic costs of the projected health impacts related to climate change
- How climate-related threats to the human security of people living outside of Canada may impact the health security of Canadians.

11. Conclusion

Climate-related hazards and variables can directly and indirectly impact health through exposure to extreme weather events (i.e., hurricanes, tornadoes, extreme heat events, cold spells, floods, wildfires), through increased air pollution and through food-, water-, vector- and rodent-borne diseases. In Canada, climate change is expected to increase these risks, particularly for include seniors, children and infants, the socially disadvantaged, (i.e. homeless, low-income individuals), people with pre-existing illnesses, the disabled, pregnant women, Aboriginal Canadians and new immigrants.

Many of the basic requirements for the overall high level of health security enjoyed by Canadians are sensitive to climate impacts. The impacts of climate change on a range of physical hazards Canadians face, including possible threats to food and water security, along with effects on the delivery of health and social services could affect health security in the absence of effective adaptations. Efforts to enhance health security and improve the health in the face of climate change benefit from strengthening public health infrastructure, surveillance and monitoring, and emergency planning. Development of new technologies and innovative public health adaptations will also serve to reduce risks to health (Gosselin, 2004; Séguin, 2008; CNA, 2008).

A number of strides have been made in these areas in Canada through collaborative efforts among federal, provincial and territorial levels of government. For example, the National Framework for Health Emergency Management provides a consistent, pan-Canadian approach to health emergencies (CNA, 2008). Significant near- and long-term ancillary benefits to Canadians can be realized through well-designed adaptation strategies. These include reduced risks posed

by air and water pollution, infectious disease outbreaks and natural disasters. Some adaptation strategies (i.e. mitigation of the urban heat island effect) may also help to reduce emissions of GHGs; these measures can have significant benefits to health as well. Collaboration among all levels of government, non-governmental organizations, academia and individual Canadians will enhance Canada's capacity to reduce future threats to health security from climate change. 🍁

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CHAPTER FIVE

International Stability Concerns

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1. INTRODUCTION

In an increasingly interdependent world, Canada's security is affected by both domestic and international factors. Events that occur on the other side of the globe can affect national affairs, eliciting a political, economic or military response from our policymakers. Climate change has been recently recognized as a global threat, affecting nearly everyone in the world. Moreover, these changes can be considered a 'threat multiplier', exacerbating existing "trends, tensions and instability," and complicating mitigation or adaptation measures (Brown, Crawford and Campeau 2008; McBean, 2008; German Advisory Council, 2007; Brown and Crawford, 2009; National Security Strategy of United Kingdom, 2008; High Representative of the European Commission 2008). This label implies that current threats will be aggravated, and that the impacts of climate change will be felt differently in each state depending on their geographic location, adaptive capacity¹ and resource needs. In some regions, natural disasters will increase in intensity and frequency, causing damage to people and property (Paskal, 2010; UNISDR, 2009; Wolfe et al., 2009). In others, resource scarcity and conflict will become more prevalent (Raleigh and Urdal, 2007; Barnett and Adger, 2007; Barnett, 2003; Homer-Dixon, 1995; Homer-Dixon, 2001). The inconsistent nature of climate impacts among and within nations, adds a level of complexity to the threat of climate change, making it more difficult to address at the national and international levels.

As climate change poses a threat for states, it is important to re-examine the definition of security so that it "...explicitly incorporate(s) environmental concerns. Implicit in this argument is the notion that local or regional instability, arising from a combination of environmental, resource and political factors, may escalate to the international level and may become violent" (Gleick 1993, 81).

The review of literature undertaken herein identifies the climate related threats to international stability and the potential impacts for Canada. This chapter explores resource scarcity and changing environmental patterns as causal aspects of climate change related threats. Migration and conflict, energy related security concerns and international trade are examined in detail to determine their links to climate change and assess their impact on Canadian society. Through this process, one conclusion becomes evident: Canada must recognize climate change as a root cause of international instability and incorporate this understanding into forward-looking policies that protect the nation.

Though climate related security issues pose threats to international stability, they create several opportunities as well. Through leadership in peace building, peacekeeping and international aid campaigns, Canada can gain global influence. Moreover, there is an opportunity for Canada to acquire new trade partners, enhance Canada's economic security and drive positive environmental change in developing nations through the dissemination of new environmental technologies. The onus is on Canada to choose their response to global climate-related threats; proactively addressing direct and indirect threats, or ignoring the linkages between climate change and security, thus exacerbating the threat to Canadians.

To effectively demonstrate these linkages, this chapter first provides background information on the current status of climate change and the international commitments that have been made. Additionally, since *uncertainty* plays such a significant role in preventing governments from acting on climate related problems; the concept was extensively explored. Following this discussion, a brief look at resource scarcity was undertaken to demonstrate its destabilizing effects on the

1. Adaptive capacity is measured by examining economic, social and institutional capabilities of a community.

international system. The potential results of such instability: migration, conflict, energy shortages and the potential for disruption of international trade appear to be the gravest threats to Canadian security. Finally, this chapter delves into the potential opportunities for Canada including those in the areas of international trade and peacemaking. It is hoped that by recognizing the threats that climate change poses internationally, Canada will be more resilient to global instability and better able to cope with the resulting impacts.

2. **Background and Uncertainty**

In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) asserts that, “The global increases in carbon dioxide (CO₂) concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture” (IPCC 2007, 2). Despite relative certainty of changing climate trends and their anthropogenic roots, a high degree of uncertainty exists when trying to predict the impacts that will emerge from such a change (Gleditsch, Nordas and Salehyan 2007, 1). For instance, though many agree that changing precipitation patterns, melting ice caps and rising sea levels are current environmental trends, it remains difficult to predict the intensity, timing or geographic location of future floods. Similarly, though a global trend of increasing air temperature has been observed, its impacts are not uniform. In some regions a rapid rate of temperature increase is likely, while in others a more gradual shift will occur. With this level of uncertainty, prediction of climate related events or threats is a very difficult undertaking.

An additional source of uncertainty surrounds the connection between climate change and some of the expected outcomes with respect to physical security. For instance, as Thomas Homer-Dixon and others claim, “...environmental change may shift the balance of power between states either regionally or globally, producing instabilities that could lead to war” (Homer-Dixon 1991, 77). Indeed, many researchers have asserted that resource scarcity and other environment-related stresses lead directly to violent conflict between groups (Raleigh and Urdal, 2007; Barnett and Adger, 2007; Barnett, 2003; Homer-Dixon, 1995; Homer-Dixon, 2001).

Yet, there are others who have recently questioned the link between these factors. Richard Matthew et al. explain that, “...environmental factors are rarely if ever, the sole cause of conflict”, and elaborates that ideology, ethnicity, economic factors, rapid regime change and conflict in neighbouring countries are additional contributing factors (Matthew, Brown and Jensen 2009, 1). At this point, it remains difficult to measure the impacts of climate change on conflict. Understanding these gaps in knowledge, this paper seeks to establish that climate change is a security issue for all countries, including Canada.

3. **Resource Scarcity**

As Malthus asserted, with ongoing exponential population growth, there will not be enough resources (fresh water, arable land, food, trees etc.) to accommodate the needs of all people (Gleditsch, Nordas and Salehyan 2007, 5). With current global population at roughly 7 billion people, natural resources are already stretched to their limit in the most densely populated areas. If growth trends remain consistent, there could be close to 9 billion people on the planet by the latter half of the 21st century (Dyer 2008, 53-55). Under this scenario, it is likely that resource scarcity will become a major threat in the future.

In addition to the strain that population growth puts on the earth’s resources, recent information suggests that climate change will have an exacerbating effect on trends in desertification, resource scarcity and land use. This section will evaluate these links and determine how these threats will affect Canadian security.

3.1 **Water**

Freshwater is one of the world’s most valuable resources, important for sustaining human life and ecosystems. Not only is it essential for personal health and consumption, agriculture, energy production and sanitation are all highly dependent on a constant source of clean, fresh water as well. Although water is considered a renewable resource however, this term fails to adequately portray the differences in “renewability”, which depend on geographic location and local hydrological processes (Bates et al. 2008, 3; Pimentel et al. 1997). The IPCC has consistently projected that at high latitudes and in some tropical regions,

an increase in precipitation² and river run-off is likely to result in increased flooding. In contrast, lower and mid-latitude regions are expected to experience a decrease in precipitation, affecting the availability of surface water supplies and the frequency of droughts (Bates et al. 2008, 3). Moreover, as temperatures rise, ice sheets in the Arctic and Antarctic, and glaciers in high altitude are projected to melt at an accelerated pace. Though this may increase the amount of freshwater available in the short term, glacier-fed lakes and rivers are expected to decline and dry up in the longer term. In addition to directly impacting the renewability of surface water, climate change can contribute to the degradation of existing water supplies. For example, as sea level rises, salt leeches into coastal ground water supplies and contaminates drinking water.

The climate threat to freshwater renewability is exacerbated by geographic distribution. As Peter Gleick explains, fresh water resources are unevenly distributed and often “subject to substantial control by one nation or group” (Gleick 1993, 86-7; Cooley et al., 2009). This dynamic can be observed in regions that suffer from water scarcity, and along most major rivers. For example, along the Nile river, water use by Uganda or Sudan, directly affects the quality and quantity available for Egypt’s use. In many cases, control over freshwater resources has contributed to international insecurity and in some cases, has been used to exert control over foreign populations (CESR 2009, 1). Further complicating this problem is the fact that very little can be done to prevent or address regional water shortages on either the domestic or international stage. Redistribution to needy groups is economically unfeasible for most countries (Gleick 1993, 89-90). With few options available to them, groups who experience water shortages are often forced to migrate to more resource rich areas.

In addition to the human cost, limited freshwater also has significant economic implications for many industries. Most importantly, agricultural industries, including livestock production, are completely dependent on water (Easterling et al. 2007, 281) and present a substantial demand

on existing resources.³ Additionally however, essential industries such as energy production (oil refining in particular), manufacturing and mining place significant demands on the water supply as well (Environment Canada, 2008).⁴ A decreasing supply of freshwater will put strain on food security and will negatively impact resource-based economies, a category which includes many developing nations and Canada.

While Canada may experience its own water shortages and changing precipitation patterns as a result of climate change, it is also indirectly threatened by water shortages in other countries. Most notably, Southwestern United States has been suffering from consistent water shortages for an extended period of time, resulting in a decrease in local water tables of over 30 meters in Texas, Oklahoma and Kansas (Brown 2008, 72; Field et al. 2007). As the United States experiences increasing strain, shared freshwater resources such as the Great Lakes will be threatened. At present, international water treaties govern each nation’s use and extraction from the Great Lakes, but such treaties may not offer adequate protection if one party’s requirements increase substantially.

Many nations are projected to experience similar shortages. James Stuhltrager asserts that, “according to the International Water Management Institute, many countries in the world’s most troubled regions, such as North Africa and the Middle East, are already considered ‘water scarce.’ These countries will soon be joined by Pakistan, South Africa and large parts of India and China” (Stuhltrager 2008, 37). In just 15 years, it is expected that approximately 1.8 billion people will face ‘absolute water scarcity’ primarily due to concurrent population growth and decreasing water supplies (Stuhltrager 2008, 37).

As an increasing number of countries become stressed by a lack of water, resource-rich states such as Canada may become targets for environmental refugees; face more demands for resource based aid; and, in the case of our relationship with the United States, come under trade or even military-based pressure to share the wealth of water it possesses. In order to ensure adequate

2. Changes in precipitation include variances in the timing, amount, form of precipitation and intensity; temperature increase and its influence on evapotranspiration water demand, ground water recharge as well as snow and ice accumulation and melt.
3. For more information see Harris in this report.
4. For more information see Popovich in this report.

resources for its own use, Canada may be forced to take internationally unpopular action. Enforcing stronger regulations on the amount of water the US may remove from shared freshwater sources; militarily protecting access to water resources; and employing stricter immigration laws may be some actions that Canada could consider.⁵

3.2 Desertification

The trend of increasing desertification is closely related to the changing precipitation patterns attributed to climate change. Defined as the process whereby arable land is degraded into arid and semi-arid areas⁶ (OECD, 1997), desertification is “caused primarily by human abuse of the land” though it may be triggered or accelerated by climactic conditions including drought (Houero 1996, 146). Though present on all continents,

desertification is prevalent in many parts of Africa and getting steadily more severe as “rainfall in the region has fallen by 30% and the Sahara has advanced by more than a mile every year”, over the past forty years (Brown, Hammill and McLeman 2007, 1143). This represents a serious threat to national security because it not only reduces livable areas, but destroys arable land needed to grow food as well. Further, desertification is particularly dangerous because of its long-term effects. Unlike droughts, desertification destroys soil surface decreasing the soils resilience (Houero 1996, 158). It is expected that this trend could cause irreparable harm to areas that are already vulnerable. Figure 1. demonstrates the areas that are vulnerable to decreases in precipitation. Northern and Southern Africa, parts of Asia and South America face severe risk.

Multi-model projected patterns of precipitation changes

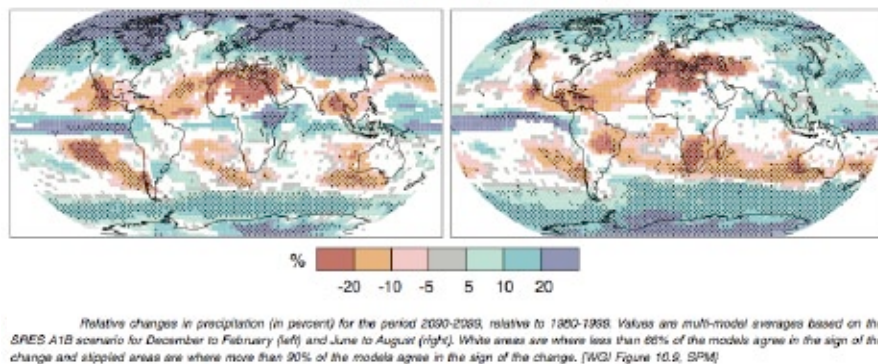


Figure 1 Bernstein et al., 2007

As one of the few nations expected to experience an increase in precipitation in several regions, Canada will undoubtedly face greater demand for the food products it exports. Additionally, as continuous droughts affect other regions, Canada will likely face increasing demand for monetary and food aid, and immigration.

3.3 Food Security⁷

One of the biggest security concerns related to climate change and resource scarcity is that

of food security. There are several ways in which food security is threatened. First, as previously discussed, the intensifying trend of desertification means that there is less arable land on which to grow crops or raise livestock, reducing global food stores (Houero 1996, 158; Stuhltrager 2008, 37). Secondly, temperature rise alone can affect the ability to raise crops. As Stuhltrager explains regarding agriculture in Ethiopia and the Sudan, “scientists estimate for every 1.8 degree Fahrenheit rise in temperature, grain production in these

5. For more information see Popovich in this report.

6. OECD. Glossary of Environment Statistics, Studies in Methods. New York: United Nations F(67) 1997. <http://stats.oecd.org/glossary/detail.asp?ID=605>

7. For more information see Harris in this report.

regions will be reduced by 10-38%" (Stuhltrager 2008, 38). This is a very serious security concern since the ability of a country to provide adequate food for its occupants, contributes greatly to its sovereignty by minimizing its reliance on external sources for necessities. Further, for a developing state that has little to trade and may have difficulty paying for imports, the ability to maintain subsistence farming is often a matter of life or death. In Africa, this problem will prove to be quite damaging, not only to the countries directly affected, but also to the continent as a whole. Stuhltrager expands, "many climatologists expect sub-Saharan Africa to have decreased precipitation that may result in the arid area in Africa increasing by nearly 10% by 2080. These changes have the potential to increase drought and famine throughout the continent (Stuhltrager 2008, 39). Indeed, over the last decade, food shortages in 25 African countries "placed as many as 200 million people on the verge of calamity," and climate models show that this problem will likely worsen (CNA 2007, 22).

With urbanization and population growth currently reducing the amount of available arable land (Brouwers, 2009), Canada may soon face its own food insecurity. Despite this trend, Canada's greatest threat related to food security remains connected to food scarcity abroad. Not only will this trend exert greater pressure on Canada's food exports, but demand for aid will also likely increase. Additionally, Canada will find it more difficult to import foodstuff as prices continue to increase, thus limiting consumer choice.

3.4 Land use

Climate change accelerates two processes that change the way that land can be used, namely: desertification and flooding. Having discussed desertification in some detail, this section will focus on sea level rise and flooding. Melting ice sheets and thermal expansion of the oceans, caused by climate change, are largely responsible for a sea level rise that is threatening coastal communities (IPCC 2007, 5; Gleditsch et al. 2007, 4;). This is a significant problem since "about two-thirds of the world's population lives near coastlines, where critically important facilities and infrastructure, such as

transportation routes, industrial facilities, port facilities and energy production and distribution facilities are located" (CNA Corporation 2007, 16; IPCC Technical Summary 2001, 26-7). In addition to these threats to people and infrastructure, coastal flooding threatens the land itself. Land loss through inundation and coastal erosion is a growing issue, having particularly severe effects for small island states (CNA 2007, 16). Countries such as the Maldives and Tuvalu are in danger of being completely inundated by rising seas. Additionally, sea level rise can contribute to an increase in salt-water intrusion that can "contaminate groundwater, inundate river deltas and valleys and destroy croplands" (CNA 2007, 16).

Flooding from extreme precipitation events is another, more widespread, threat to land use. An expected increase in hurricanes, and storm surges, in addition to increased occurrences of heavy precipitation events will leave more regions vulnerable to flooding (Bates 2008, 74). These trends may cause lasting damage and are particularly threatening for vulnerable regions where agriculture and large urban centres have strategically grown around bodies of water. To more clearly illustrate this threat, a look at the Nile River is appropriate. Along its length and especially at its delta, the Nile is a centre for population and supports the agriculture and livestock industries (Schubert et al. 2008, 5). In many countries such as Egypt, there are few alternate freshwater sources so population is tied to the river for survival. In this type of situation, flooding could destroy an entire country's agricultural output and prevent people from living near to a water source (Homer-Dixon 1991, 94).

As many international metropolises are based on or near water (examples include London, UK; Mumbai and Goa, India; Ho Chi Minh City, Vietnam; Bangkok, Thailand; Capetown, South Africa; and Shanghai, China among many others) to maximize trade and transportation, flooding events will have significant human costs in terms of injury and death. Moreover, as more of the population floods into cities and urban areas,⁸ a greater percentage of population and infrastructure now exists in concentrated, vulnerable areas.

8. According to the United Nations Population Fund, as of 2008 more than half of the world's populations resided in cities or urban areas. <http://www.unfpa.org/pds/urbanization.htm>

Geographical features often exacerbate the threat of flooding. Low-lying countries like Bangladesh frequently experience several different types of flooding. With natural valleys and troughs, Bangladesh is vulnerable to flash, riverine and storm surge floods which can occur simultaneously or consecutively and have devastated large areas of this country in the past (Monirul Qader Mirza 2002, 128). In a normal year, approximately 20 per cent of the country is inundated during the monsoon season. This percentage increases dramatically with the occurrence of an extreme precipitation event and can result in up to 70 per cent of the country suffering from flooding (Monirul Qader Mirza 2002, 128). Widespread flooding of this kind threatens food production and rural livelihoods as well as economic and human security (Rosenwig, 2002; Bates et al. 2002, 59).

3.5 Implications of International and Domestic Resource Scarcity for Canadian Security

Though it is easy to understand the threat that climate change poses for those living in regions that are already 'water scarce,' it is much more difficult to see the threat that this process would pose for a country rich in freshwater resources such as Canada. Likewise, in the case of desertification, food security or land use abroad, it might be difficult to imagine how these international resource scarcity issues might affect Canada's security. For the most part, these issues are region specific in that their effects will primarily impact foreign populations. They may demand a greater commitment to international aid but they will not challenge our own water, land use or agricultural security. The most important threat that climate related resource scarcities create for Canada surround the instability that such issues could cause. The following sections will explore potential climate-related instability and its connections to migration and conflict, energy and international trade.

4. Migration and Conflict

Throughout history, instability in the international system has manifested itself in conflict and migration. Having reviewed the connection between climate change and resource scarcity in the last section, this section will explore the linkages between resource scarcity, conflict and migration to demonstrate the role that climate change can play in creating international instability.

4.1 Migration

Migration is born of necessity. People rarely choose to uproot their lives and families unless they are forced to do so. The driving force is often related to unsuitable living conditions, whether they are related to politics, economics, social injustice or the environment. Regardless of the cause, increased migration can have negative impacts on the receiving region or country, slowing development by "...increasing pressure on urban infrastructure and services, by undermining economic growth, by increasing the risk of conflict and by leading to worse health, educational and social indicators" (Brown 2008, 9). These impacts make migration a significant challenge to international stability.

Climate change threatens to exacerbate this threat by intensifying or increasing the frequency of events and environmental conditions that could cause migration. With expected increases in the occurrence of droughts, desertification, floods, absolute water scarcity and land loss, environmentally induced migration is expected to significantly increase over the next 50 - 70 years (Bernstein et al. 2007, 53). The United Nations already predicts that "there will be millions of 'environmental' migrants by 2020" (High Representative and the European Commission 2008, 4). Since migration involves people, potentially thousands or even millions, crossing provincial, regional or international borders, and further since it has the potential to upset the economic, cultural and political balances of a receiving region or country, it is an issue of both international and national security for Canada. There are three types of migration: internal, cross-border and international, each with a different connection to environmental stressors and different implications for Canadian security.

Internal migration, occurring within a nation's borders, is most commonly related to environmental stressors since it is economically and logistically the simplest solution. For example, in cases of flooding, drought or water scarcity, people will most likely move locally to find less affected regions, often with the hope that they can move home again after the event (CNA 2007, 16). An example of this type of event was clearly observable in the United States in the aftermath of Hurricane Katrina, as residents of New Orleans migrated to other cities and states (some permanently) while

disaster crews completed their rescue and clean-up tasks (Smith-Oliver, 2006).⁹ Climate change may increase the number of people who need to utilize this strategy for survival.

In contrast, cross-border migration, involves individuals fleeing environmental hardship by crossing the border into an adjacent country. Though not occurring with the same frequency as internal migration, cross-border migration is a serious matter since the inflow of people can easily overwhelm the capacities of the host country (Stuhltrager 2008, 38). This is an especially worrisome outcome in low-lying regions like Bangladesh, where sea level rise and water shortages could “potentially cause the displacement of tens of millions of people” (CNA 2007, 16). It is such a fear that neighbouring India is pre-emptively building a fence to ensure that they can maintain control of their border in the event of a mass migration (CNA 2007, 24). This type of migration is less likely to be caused by a single climate event, since survivors of the crisis would most likely return to their homelands to ‘re-establish their lives’ (O’Brien et al. 2008, 23). Instead, cross-border migration is more likely caused by gradual degradation or increasing scarcity.

The third type of migration is global in nature, and may pose the most significant threat to Canadian security. As a country that is rich in natural resources and expected to adapt to most impacts of climate change, Canada makes a prime target for immigration. Indeed, as Brown, Crawford and Campeau explain, “while Canada’s geographic location removes it from the front lines of international environmental displacement, the country’s four largest sources of current immigration- China, India, the Philippines and Pakistan- all feature regularly in analyses of regions that are vulnerable to the most serious impacts of climate change” (2007, 17). While it is true that large-scale international migrations are not as common as the other two types of migration, due mostly to the cost required for such a move,¹⁰ they can have long-term effect on the host country.

Tensions can build due to religious or cultural issues between the host nation and the migrants. Additionally, the economic and political systems of the receiving country are often under immense strain while they cope with the large population influx. Though there are those who argue that international migration does not happen on a large enough scale to cause significant damage (O’Brien et al. 2008, 23), climate change is exacerbating the issue and large-scale international migrations are possible in the future (IOM, 2010). Additionally, there are several cases where international migration may be the only choice. The small island states of Tuvalu, Maldives and Kiribati are seriously threatened by sea level rise associated with climate change.¹¹ As Barnett explains, “there is widespread agreement that climate change and associated sea-level rise threatens the long term ability of people to remain living on their islands” (Barnett 2003, 7). In cases like these, international migration is an increasing probability and Canada might well be affected by it.

A link has been identified between migration and conflict. As Gleditsch et al. explain, “... environmental stress may lead to resource conflicts, and these conflicts may produce refugees” (2007, 4). Further, conflicts may arise from the influx of environmental refugees in a given region. This is especially true in areas where there is already resource scarcity; the extra strain on limited resources can cause tension as domestic groups fight to keep their scant stores for themselves. For example in Sudan, “the southern Nuba tribe...have warned that they could ‘restart’ the war if Arab nomads displaced south by the drought continue to cut down ‘their’ trees for fodder to feed their camels” (Brown, Hammill and McLeman 2007, 1143). As people migrate in search of new resources or safe havens, it “may exacerbate long-standing racial, ethnic and religious tensions” (Stuhltrager 2008, 39). Nigeria, for example, is a country geographically split between two main religious groups and an increase in migration could serve to put intense pressure on an already fragile state (CNA 2007, 21).

9. <http://understandingkatrina.ssrc.org/Oliver-Smith/>

10. Lori Hunter. *Climate Change, Rural Vulnerabilities and Migration*. Population Reference Bureau. <http://www.prb.org/Articles/200/ClimateChangeinRuralAreas.aspx>

11. In some cases, arrangements have been sought with larger nations in case of overwhelming sea-level rise. The government of Maldives has arranged for their population to be taken in by New Zealand.

4.2 Potential Effects for Canada

Migration is an issue of concern for Canada due to the implications it has for the security of the nation. As greater numbers of international refugees emerge due to growing resource scarcity, climate-related conflict or vulnerability to natural hazards, Canada faces increasing challenges in managing the immigration process. The influx of so many new immigrants could affect the economy and labour market, as newcomers look for work and stress social services such as welfare, health care and employment insurance. Additionally, there is potential for conflict as new cultures and religions attempt to integrate into established communities. It is important to note that given the ease with which immigrants can currently gain illegal access to the country, a combination of legislation, additional border protection, military precautions and stronger enforcement capabilities may be required to ensure that immigration occurs in a controlled manner. More importantly however, since these measures are not guaranteed to prevent migration, it is important to assist at-risk countries such as China or India, with tools for adaptation, since this tactic is more likely to prevent migration.

4.3 Conflict

Conflict is the quintessential security threat. Indeed, it is largely recognized that conflict, defined here as “causal linkages, whose dynamic can lead to social destabilization and ...violence” (Schubert et al. 2007, 2), has the potential to threaten Canadian security no matter where it occurs. Civil or national violence in developing countries can reach a level that demands international involvement. Alternatively, countries can devolve into failed states breeding violent ideologies and potentially, terrorism (CNA 2007, 17). Although there are several that question the link between conflict and climate change, (Gleditsch, Nordas and Salehyan 2007, 4), a strong argument can be made that climate change acts as a stressor, or ‘threat multiplier’ exacerbating existing tensions and scarcities. For example, “societies in transition from authoritarian to democratic systems are especially vulnerable to crises and conflicts. Climate change will affect many of these countries, putting them under additional pressure to adapt their societies during such phases of transition” (Schubert et al. 2008, 2). While it is true that we

cannot tell whether climate change is the key factor in conflict, we can determine that it is part of the combination of factors that contributes to the outbreak of violence.

Generally, it is developing countries that are most vulnerable to conflict over climate change related issues (Homer-Dixon 1991, 78; Schubert et al. 2008, 2). This can be related to a lower capacity to address environmental issues and ensure the safety and well-being of their people (Homer-Dixon 1991, 88). Such inability, on the part of state governments could cause frustration and tension between ethnic and religious groups and could lead to political radicalization (High Representative and the European Commission 2008, 5). In the Sudan, widespread droughts have led to a shortage of arable land for farming or herding, and have caused “the number of violent conflicts attributable to traditional disputes over the use of land” to escalate from the 1970’s onward (Smith and Vivekananda 2007, 12). ‘Economic and political marginalization’ also played an important role in creating the conflict, an observation that can be deduced from the fact that 16 other countries in the Sahel did not succumb to violence though they faced similar environmental stresses (Smith and Vivekananda 2007, 12). In the case of the Sudan, and many other climate-related conflicts, the violence is self-perpetuating. Violence depletes resource stores even further due to the demands of the fighting force, or through the damage caused by conflict. Indeed, a vicious cycle has been created, where “a lack of adaptive capacity can contribute to conflict, which can go on to undermine adaptive capacity further” (Brown, Hammill and McLeman 2007, 1150).

Overall, most regions vulnerable to this scarcity-induced conflict are in Africa, particularly the Sahel, North, Central and the Horn of Africa (OCHA 2008, 2). Importantly, these are also regions that are most vulnerable to climate change. Barnett and Adger explain the connection stating that “there are two broad ways in which conflict might be stimulated by climate change. First conflict could be caused by changes in the availability or affordability of energy resources due to mitigative action to reduce emissions from fossil fuels” (Barnett and Adger 2007, 640). Mitigation measures being demanded in international

negotiations, could move a country away from traditional energy sources such as oil or coal. This could cause conflict as those in regions rich in energy resources attempt to prevent such a move. Secondly, conflict could be “stimulated by changes in social systems driven by actual or perceived climate impacts” (Barnett and Adger 2007, 640). In water scarce countries, warlords or citizen militias may privately manage aquifers or water sources that had previously been left to state control, as concern about decreasing resources continues (High Representative and the European Commission 2008, 3). Already, examples of such conflicts are emerging. Countries that border the Nile are disputing each other’s rights to water and the conflict between the Palestinians and Israelis is partially connected to water scarcity in the region. As water resources become increasingly scarce, polluted or salinized, these conflicts may intensify since water cannot easily be redistributed and “unlike rare metals (or other resources)... water has no substitutes” (Gleick 1993, 89-90).

4.4 Potential Effects for Canada

After determining that climate change could exacerbate existing tensions and contribute to climate-related conflict, it is important to demonstrate the relevance of this information for Canadian security. First, and most importantly, “there is always the potential for regional fighting to spread to a national or international scale” (CNA 2007, 18). In Darfur for example, the tensions between farmers and herders over increasingly scarce land and water was one of the main underlying factors contributing to a nation-wide conflict (Brown, Hammill and McLeman 2007, 1143) which escalated to a point that demanded international intervention. Similarly, in Rwanda, environmental degradation, population density and resource scarcity contributed to the genesis of the genocide (Diamond 2005, 315). Finally, the fighting in Ethiopia that deposed Haile Selassie’s government was related in part to the inability of the government to address widespread food shortages (CNA 2007,18). While these conflicts began at regional level, they escalated to a

level necessitating international attention. As a country that regularly contributes peacekeeping troops, and moreover, as a concerned member of the international community, Canada must be aware of the role that climate change may play in exacerbating existing tensions and contributing to the creation of conflict abroad.

Additionally, conflict fuels increased levels of migration. As previously discussed, a significant influx of refugees may be difficult for Canada to accommodate.

Finally, environmental conflict can hamper Canada’s access to important goods and services including fuel (Borenstein, 2008, 6), food and important infrastructure components.

4.5 Fragile and Failed States

Climate change can place unmanageable pressure on fragile states, causing them to devolve into failed states.¹² This is a serious international security concern since failed states have been recognized as the breeding grounds for extremism and terrorism (CNA 2007, 16). Although the link between climate change, conflict and fragile/failed states is tenuous, it is highly probable that “the impacts of unabated climate change would hit these countries (weak or fragile states) especially hard, further limiting and eventually overstretching their problem solving capacities” (Schubert et al. 2007, 5). There are two ways in which climate change is thought to impact the fragility of states, and therefore their propensity for violence. First, climate change is likely to cause widespread environmental degradation, which can prove to be damaging in an already-weak state. With the government unable or unwilling to adequately relieve shortages and suffering, internal conflict becomes highly likely. Secondly, climate change mitigation and adaptation requirements and “activities may divert resources¹³ from fulfilling their core functions and this may lead to further destabilization” (Governance and Social Development Resource Centre 2008, 1). It is important to note that a number of other factors, including poverty, social cohesion, access to

12. Here failed states are defined by Brooks according to their main characteristics. Mainly, failed states “lose control over the means of violence and cannot create peace or stability for their populations or control their territories. They cannot ensure economic growth or any reasonable distribution of social goods. They are often characterized by massive economic inequities, warlordism and violent competition for resources” (Brooks 2005, 1161).

13. The diversion of monetary resources from obligations such as providing social services, food or protection, are of special interest in this case.

economic opportunities and effectiveness of state decision-making, are instrumental in determining the likelihood of violence (Barnett and Adger 2007, 641).

Failed states are dangerous because they have forfeited control over legitimate use of force and have lost the ability to regulate or mediate any conflicts that emerge within their borders (Thurer 1999, 731). This makes them vulnerable to violence and extremist movements. Given the fact that wealthy countries have historically produced the carbon responsible for the current climate change phenomenon, developing nations are sure to feel injustice as they bear the brunt of its negative effects. Moreover, since wealthy countries are more likely to be able to afford to adapt to climate change, the imbalance is exacerbated. It is plausible that under such circumstances, groups in developing nations may perpetrate acts of terrorism, as retribution against more developed nations who could have helped them adapt. Given the fact that Canada has been one of the countries least willing to act on climate change mitigation, and that they have not yet made a significant contribution to Least Developed Country adaptation, they may well be a target. Certainly, Canada will need to appreciate the seriousness of such a threat and make preparations to prevent an attack and to ensure resiliency in the event of an assault.

Finally, there have been some questions about the effectiveness of the Canadian government regarding its performance on its Kyoto obligations. Specifically, Canada has had difficulty developing a national climate change strategy that will limit the country's carbon emissions. This difficulty is due in part to competing provincial goals as well as the constitutional arrangements surrounding environmental jurisdiction. In particular, Alberta and Saskatchewan among others have been openly opposed to cap and trade or carbon tax-based strategies, due to the implications such programs would have for the businesses in their regions (Smith 1998, 29). As the ability to "commit the state in an effective and legally binding way, for example, by concluding an agreement" (Thurer 1999, 733), is a key characteristic of a strong and functioning state, Canada's inability to implement an effective national climate change strategy could be indicative of its fragility in this area. It would

be in the country's best interest to meet with the provinces and work out an appropriate agreement in order to address this problem.

4.6 Arctic Sovereignty

Canada must also concern itself with the conflict that could arise over the use and sovereignty of the Northwest Passage. Although the Arctic has experienced periods of warming in the past, the current warming is "dramatic, abrupt and directly correlated with industrial emissions of greenhouse gases" (Bogerson 2008, 2; Anisimov et al. 2007; Furgal and Prowse, 2008; Ouranos, 2004; Huntington et al., 2005; McBean et al., 2005; Overpeck et al., 2005; Bonsal and Prowse, 2006). It is also, most likely, long-term. As the Arctic ice melts, navigable sea-lanes become viable alternatives to current trade routes that must circumvent South America. Though this scenario is favourable for international trade (Furgal and Prowse 2008, 84), it has already led to new issues over sovereignty and political boundaries. Specifically, while the Northwest Passage is primarily within Canada's jurisdiction and was claimed as internal Canadian waters in 1944, it also includes waters off the coasts of the United States, Denmark, and other countries (Paskal 2007, 6; Furgal and Prowse 2008, 84; Pharand, 2005). Many of these adjoining countries are requesting that the route be designated an international strait and as such, be open to "free passage for all" (Paskal 2007, 6; Paskal, 2010). Canada would prefer to maintain sovereign control of the region, giving it the ability to regulate and monitor shipping and military traffic (Chalecki 2007, 213). It is especially important to national security since an increase in shipping "will also result in a rising number of vessels from hostile nations or non-state actors, who have no incentive to obey internationally-accepted laws regarding national waters, or even notify a country of their presence" (Chalecki 2007, 213).

Melting ice of the Arctic will also allow greater access to resources including fish, minerals and freshwater reserves (Bogerson 2008, 2). More importantly "it has been estimated that the Arctic region holds between 100 and 200 billion barrels of oil and approximately 2,000 trillion cubic feet of natural gas" (Killaby, 2009). Since the right to mine these natural resources is tied to political boundaries, and further, since maritime borders

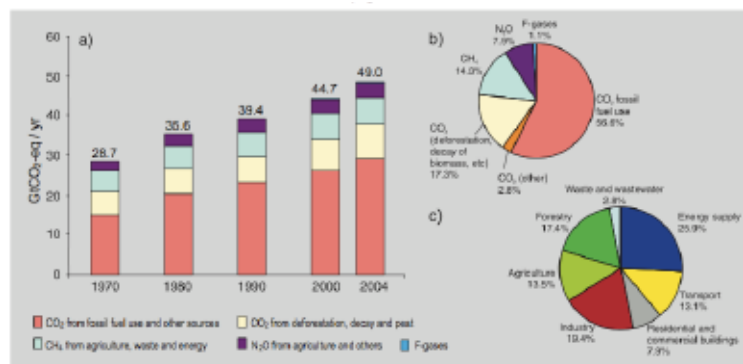
are often legally determined by coastlines, climate change may cause them to shift (Paskal 2007, 3). Moreover, Canada is threatened by the phenomenon of ‘creeping jurisdiction.’ Essentially, Denmark, Russia, Norway, Canada and the U.S. have “all used various interpretations of the Law of the Sea to stake territorial claims to parts of the Arctic seabed in order to exploit their considerable oil and natural gas reserves” (Chalecki 2007, 211). As these nations begin to exercise their ‘rights’ in this region, they may claim areas of the Arctic as “exclusive national jurisdiction through repeated use” (Chalecki 2007, 215). Although these issues are being raised at an international level, an adequate ruling has not yet been reached. If Canada is not able or willing to exercise its rights to the Northwest Passage, it may very well be divided among the relevant parties and Canada will remain unable to control or reap benefits from this region.

5. Energy

Energy plays an essential role in all societies: that of powering development. In this context,

maintaining a constant supply of affordable energy is essential to a nation’s security. Without it, not only would development be hampered, the existing standard of living could not be maintained. Currently, societies are built using cheap fossil fuels such as oil and coal. These fuels are both non-renewable, and their use has contributed to the acceleration of climate change due to their high carbon output (Bernstein et al., 2007). Additionally, it is widely estimated that ‘peak’ oil has been reached, and potentially surpassed (Dyer, 2008). Ironically, in a time when these fuels are considered harmful and increasingly scarce, the climate change that they contributed to may serve to limit alternative sources of energy, thus threatening security. It is important to examine how climate change can affect different types of energy production in order to understand the threat to energy sources. Figure 2 depicts the global annual emissions of anthropogenic GHGs from 1970 to 2004. The burning of fossil fuels caused the majority of these emissions.

Global anthropogenic GHG emissions



(a) Global annual emissions of anthropogenic GHGs from 1970 to 2004. (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of CO₂-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO₂-eq. (Forestry includes deforestation.) (WGI) Figures TS.1a, TS.1b, TS.2b)*

Figure 2 Bernstein et al., 2007

5.1 Hydroelectric Energy

Hydroelectricity, where the flow of water is used to generate electricity,¹⁴ is a common form of energy production and is critical as it often meets base load energy requirements. Dams on small rivers, as in BC Hydro operations, are capable of

outputting 2,450 mega-watts of energy, or 20% of the province’s needs (Turner 2007, 54). On major rivers, such as the Three Gorges Dam on the Yangtze River in China, a dam can generate 17 GW of energy (Gan 1997, 7). More consistent than solar or wind power, and with minimal limitations on its

14. Alternative Energy. <http://www.altenergy.org/renewables/hydroelectric.html>

production, hydroelectric energy is a preferred form of energy production. Additionally, as technology has improved, reservoirs and pumped storage¹⁵ have made it possible to store water to be used when needed to generate power during peak demand (Monbiot 2007, 80). This gives hydroelectricity a flexibility that other renewable energies do not have.

There has been much criticism of the fact that development of dams for hydro production can displace a significant number of people. For the construction of the Three Gorges Dam in China, almost one million people were required to move to 'make way' for this project (Heming and Rees 2000, 440). In addition to the one million displaced, the dam will also threaten nearby homes through the rising water of the reservoir during rainy season (Heming and Rees 2000, 440). With changing precipitation patterns, it is likely that flooding in the future will be more intense, thus affecting more people in the region.

Hydroelectric production requires a consistent supply of water to produce electric energy. Since climate change has such an enormous impact on water resources and precipitation amounts, it is bound to have an impact on the amount of energy, a river, or system of reservoirs, can produce (Mimikou and Baltas 1997, 661). Indeed, a study on the reliability of hydroelectric production in the face of climate change, found that an increase of up to 50% was needed in reservoir storage volumes, in order to maintain the current energy output (Mimikou and Baltas 1997, 661). Since most rivers will lose volume through climate change related processes, an additional source of energy will be needed to make up the difference. This is particularly important for Canada's security since it produces 12 per cent of the world's hydroelectric power.¹⁶ More importantly, several provinces including British Columbia, Manitoba and Quebec, "generate more than 75 per cent of their power through hydro-electricity."¹⁷ In the event that climate change detracted from the ability

to produce such large amounts of hydropower consistently, Canada would find it very difficult to replace such a large, renewable energy source.

5.2 Biofuel

Biofuel is defined as "fuel produced from a renewable biomass material, commonly used as an alternative, cleaner fuel source"¹⁸ and was undertaken in Brazil, Europe, Asia and America with enthusiasm. Recently, biofuels were questioned as a sound source of alternative energy because they could be more of a threat to international energy and food security, than an answer to low-carbon energy. For example, some assessments showed that more energy was expended to produce the fuel, than the resulting fuel would generate.¹⁹ Further, it was found that the amount of carbon that was saved by using biofuels was easily surpassed by the amount of carbon produced by the land use changes that were occurring to create an industry for biofuel. Farmers were clear cutting forest in order to plant the crops for biofuel. As Searchinger et al. explain, "by using a worldwide agricultural model to estimate emissions from land use change, we found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years" (Searchinger et al. 2008, 1238). In some cases, the resulting increase in carbon emissions was closer to 50% (Searchinger et al., 2008). It is now largely accepted that biofuels in their current form, are not the best choice for an efficient, sustainable alternate energy source. Figure 3 demonstrates the changes in agricultural systems that have occurred.

15. The process here is to expend energy to pump water into a higher reservoir and store it there. When there is a sudden demand for extra energy, the reservoir is opened and the water rushes down to the lower one, creating energy (Monbiot 2007, 80).

16. The Pembina Institute. "Renewable Energy: Energy Source: Hydropower" <http://re.pembina.org/sources/hydro-power>

17. Ibid.

18. Clean Energy Ideas. http://www.clean-energy-ideas.com/energy_definitions/definition_of_biofuel.html

19. Cornell University. Producing Ethanol and Biodiesel from Corn and Other Crops is Not Worth the Energy. www.physorg.com

Changes in physical and biological systems and surface temperature 1970-2004

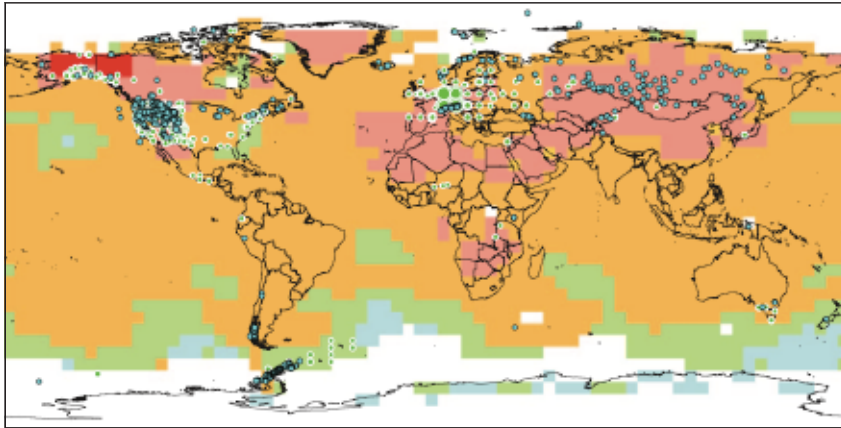


Figure 3 Bernstein et al., 2007

Most importantly, biofuel production poses a threat to food security. In the spring of 2008, there was a food crisis in the developing world. The price of basic foodstuffs skyrocketed as farmers in Asia, the Caribbean, Africa and South America, stopped growing staples like rice and wheat and switched to more lucrative cash crops such as corn for biofuel production. There were, of course other contributing factors, including droughts in several agricultural regions and high oil prices; however, it is significant that approximately 5% of the world's grains went to biofuel production (Shah, 2008). Moreover, the food crisis proved that such a status quo punishes the most vulnerable and can be a catalyst for international instability (Richard, Brown and Jensen 2009, 3).

Since climate change is set to affect temperature and precipitation patterns, it will undoubtedly affect the growing patterns of crops used for biofuel. Thus, climate change may make biofuel an inconsistent and unsustainable source of energy. These considerations are important for Canada in two ways. First, the biofuel industry impacts the prices of crops used for biofuels. Corn and soybeans are grown throughout the country and soaring or lagging prices will affect Canadian farmers. Secondly, and more importantly, biofuel is used in the Canadian auto industry. Flex fuel vehicles are currently in production and run on a combination of biofuel and unleaded gasoline.

5.3 Nuclear Energy

Nuclear energy has long been a consideration in national and international security due to its potential for disaster. This proves to be a persuasive disincentive for many nations to develop nuclear energy. As climate change mitigation efforts strengthen however, nuclear power is often discussed as a valuable alternative source of energy. It is a steady and predictable source of energy unlike wind or solar, which vary with weather conditions. It is able to be stored and not subject to variability the way hydroelectricity can be. Further, nuclear energy has a higher energy supply density and improves on conversion efficiencies (International Atomic Energy Agency 2008, 4), meaning that the energy is used most efficiently. Despite these benefits however, storing nuclear waste is still a problem that goes relatively unchecked (Monbiot 2007, 91).

In addition, there are security concerns related to the potential for nuclear energy to be converted into nuclear weapons. For example, "every state which has sought to develop a nuclear weapons programme over the past thirty years- Israel, South Africa, India, Pakistan, North Korea, Iraq and Iran- has done so by diverting resources from its civil reactors" (Monbiot 2007, 90). If the use of nuclear energy is increased in order to combat climate change, an international infrastructure is needed to regulate the use, exportation and competition of nuclear resources, and address concerns of

international security (Marceau 2009, 1-4). For example, the damaging effects of a meltdown or nuclear weapons inspire fear of terrorism. If the international community is to safely regulate nuclear energy, the World Trade Organization is needed to provide principles, enforceable regulation and, most importantly, an international agreement on energy (Cottier 2009, 10).

5.4 Potential Effects for Canada

Since the Canadian standard of living demands a large, reliable supply of energy, it is in Canada's best interest to understand how climate change is affecting energy supply and demand. The development and implementation of new alternative energies should also be studied further to better understand their impacts in Canada and abroad. It should be noted that the variety of energy sources available to Canada is not necessarily available to others due to financial, scientific or resource related limitations. For example, in many countries, hydroelectricity is not an option for energy production since large bodies of water, or appropriate harvesting points do not exist. Further as climate change affects Africa and Asia in particular, states in those regions may find that they are unable to produce the amount of power they need from hydroelectricity, due to decreasing water stores. Biofuel has largely been discredited and the international community, particularly the developed nations, is hesitant to promote nuclear power as a viable option. These restrictions will leave many countries with limited options but to continue using fossil fuels to meet their energy needs since wind and solar energy, while useful as supplements or for peak load requirements, are at this point, unable to provide consistent energy needed to accommodate a nation's baseload. With international disapproval and shrinking stores of fossil fuels, conflict may arise as states fight over the limited resources. Canada must be aware that as an energy rich country, holding oil, gas, hydro, wind, nuclear and solar capabilities, they may be targeted as other countries attempt to meet their needs.

6. International Trade

Since international trade is tied closely to economic development, it is a matter of serious concern for all countries. Many countries have fought over admission to markets and trading

routes, in an effort to secure access to resources and products they cannot provide for themselves. In some states, this may include luxury items such as foreign made cars and electronics, fish, produce from abroad, and lumber from exotic trees. For most however, international trade is an integral part of national security because it ensures access to essential products such as energy, food, natural resources for building and basic technology or medicine. It is a right that many feel should be protected at all costs.

Climate change and international trade impact each other in a number of ways. To begin with, international trade has, and continues to contribute to climate change due to its link with transportation services (Tamiotti et al. 2009, 58). As international trade increases, there is a simultaneous increase in transportation requirements, which is linked to an amplified demand for oil, gas, electricity and other forms of energy. Also, "trade may increase the vulnerability to climate change of some countries because it leads them to specialize in the production of products in which they have a comparative advantage, while relying on imports to meet the requirements for other goods and services" (Tamiotti et al. 2009, 62). Since climate change will affect the production of many goods, these countries may find themselves unable to meet their needs. Despite the negative effects that trade can have on climate change, it can also have positive influence as well. Most importantly, trade can encourage the dissemination of new, low-carbon technologies, therefore contributing to mitigation efforts (Stern Chapter 23 2007, 11).

The impacts that climate change could have on international trade are significant. It can "affect the pattern and volume of international trade flows... increase the vulnerability of the supply, transport and distribution chains upon which international trade depends" (Tamiotti et al. 2009, xiii) and encourage barriers to trade. This section will examine these factors as well as their potential and real impacts on international trade. Additionally, the threat to Canadian trade security in particular will be explored in some detail, especially with regard to the current and potential trade barriers that exist in Canada's trade relationship with the United States of America.

6.1 **Pattern and Volume of Trade Flows**

Climate change has the ability to change the current patterns of international trade by altering the comparative advantage of some regions (Tamiotti et al. 2007, 64). For instance, in countries that rely on exporting agriculture and food products, climate change may reduce agricultural production and affect the amount of exportable goods. By the same token, countries that were previously unable to export food products due to a shortened growing season, may find a comparative advantage in a warming climate. This proves to be a threat to Canada because it may mean that new trading partners need to be found for the provision of certain items. Additionally, climate change produces a competitive threat that other nations may be able to produce items that Canada previously held comparative advantage in.

6.2 **Vulnerability in Supply, Transport and Distribution Chains**

In addition to the agricultural output and other production patterns, the supply and distribution chains are vulnerable to climate change as well (Barnett and Adger 2007, 642). The most important example of this is observed in the heightened vulnerability of coastal regions. These areas are important, not only because they are home to a significant population, but also because they hold industry and infrastructure critical to national development and international trade (Bernstein et al. 2007). There are a number of industries ranging from tourism to shipping, fisheries and refineries that are dependent on proximity to water (Garg 2002, 4; Tamiotti et al., 2009). With sea levels projected to rise and storm surge effects becoming more common, coastal vulnerability increases (Homer-Dixon 1991, 94). In particular, “the east coasts of China and India as well as the Caribbean region, the United States and Central America” would be at risk (High Representative and the European Commission 2008, 4; Schubert et al., 2008)

Importantly, oil refineries and distribution operations are especially vulnerable to sea level rise. Interruption of these operations could cause disruption of energy flows. Moreover, critical infrastructure such as buildings, roads, bridges, port facilities and airports are often at risk due

to their proximity to the coast (Tamiotti et al. 2009, 22). Damages to these structures would limit the amount of transport and distribution, therefore restricting trade. It is clear that weather events related to climate change have the potential to negatively impact the operation of international trade. Protecting ports against floods and developing stronger ships to brave the increased hazard events would incur a significant cost for many nations (Stern 2006, 17).

6.3 **Barriers to Trade**

In addition to affecting the physical operation of international trade, climate mitigation efforts, such fiscal (Carbon taxes) and regulatory (energy efficiency standards) tools can change the way that transactions occur (ICTSD 2007,2). Unfortunately, there are concerns that these measures will negatively impact international trade by damaging competitiveness. Specifically, two concerns stand out: that businesses in countries without mitigation efforts will gain an unfair advantage, as they are not forced to comply with costly regulations. Additionally, there is the fear that states will create unfair market conditions in their attempts to ease local companies into new regulation (ICTSD 2007, 1-2).

Protective actions ensure that compliance with mitigation efforts does not put a nation at a competitive disadvantage (Schott and Fickling 2009, 2). Europeans, the first to institute taxes against countries that do not have a CO₂ cap on their industries (World Bank 2007, 3), view their actions as an equalizer; a means of spreading the cost of action to those who refuse to act (World Bank 2007, 3). Though complaining that such measures hurt competitiveness, the United States has begun to institute similarly protective measures. The Waxman-Markey bill, enacted in 2009 is meant to ‘blunt the cost’ of mitigation for the industry of America (Levi and Rubenstein, 2009). In fact, “most actions necessary for compliance with the bill will be subsidized via free allowances and auction revenues over the first decade or so (Schott and Fickling 2009, 4). The inherent problem in this bill is that it inadvertently rewards inefficient carbon intensity (Schott and Fickling 2009, 6). For instance, the bill moves to disband the multi-jurisdictional cap and trade agreements that presently exist between U.S. States and Canadian

provinces.²⁰ Since hydropower from Canadian provinces is no longer factored into U.S. tallies, states and businesses that use Canadian-produced energy are given financial credit for using less energy. Border states and companies will thus remain unmotivated to find local, renewable replacements (Schott and Fickling 2009, 7). Additionally, the bill encourages protectionist measures against imports, as the bill states that it aims to limit the import of energy intensive goods. These measures serve to unfairly target India and China, both sources of energy intensive goods (James 2009, 1). By antagonizing developing nations however, “the bill may undermine the very purpose for which it was ostensibly designed” (James 2009, 2).

This type of protectionism is a concern for Canada’s economic security since a significant portion of its trade with the United States concerns energy and energy intensive manufacturing. Moreover, since the vast majority of Canada’s trade is with the United States, protectionist measures will have a significant impact on the Canadian economy. Updating existing trade agreements to address changing regulations can help protect Canada from sudden changes.

7. Opportunities

While climate change certainly presents a threat to Canada’s physical, economic and development security, it offers opportunities as well. Specifically, it provides a chance for a nation to offer leadership and guidance in maintaining stability at the international level. Recently, Canada has lost influence on the world stage. The lack of involvement in foreign affairs, the declining number of peacekeeping and peace building missions²¹ and the inability to commit to action on a number of international issues including climate change, have relegated Canada to the sidelines of global affairs. Meeting climate-related demands for international aid, additional peacekeeping/peacebuilding forces will give Canada the chance to increase its influence at the international level.

7.1 International Aid

As a country with a long history of international aid, Canada dedicates millions of dollars, to states and nations all over the world. This money is set

aside for natural disasters, education, supplementary food, health supplies, humanitarian relief and water related issues, among others (CIDA, 2009). As demonstrated herein, climate change has a significant effect on the majority of these issues. In fact, “the UN estimates that all but one of its emergency appeals for humanitarian aid in 2007 were climate related” (High Representative and the European Commission 2008, 1). With an additional 325 million people feeling the effects of more natural disasters, droughts, floods, disease, resource scarcity and famine, (Global Humanitarian Forum 2009, 9) the demands on humanitarian aid will only increase. As an industrialized country that contributed to the onset of climate change and further, as a wealthy country, able to adapt to the effects of climate change, Canada will be called upon to contribute to international funds to assist those who are not financially capable of adapting. By strategically investing in adaptive measures in developing nations, Canada can alleviate climate stress in at-risk countries, contributing to the maintenance of international stability.

7.2 Peacebuilding/Peacekeeping

Given Canada’s historic position as a leader in international peace building and peacekeeping initiatives, climate-related threats to global stability provide a new opportunity to regain this post. As resources become scarcer and conflicts arise in vulnerable regions, the stability of the international system will be stressed. It is unrealistic to believe that these conflicts will remain isolated, especially when resource rich countries can be held up in comparison. In this world, the ‘have-nots’ will face both economic and environmental limitations, and are unlikely to remain peaceful in the face of such restrictions. In order to prevent conflicts from escalating to national or regional scales, greater peacekeeping and peacebuilding commitments are required. By contributing to these efforts Canada would work towards ensuring international stability and safety, and may regain the respect and influence they previously enjoyed. Finally, by contributing to peacebuilding missions, Canada would gain the ability to influence the rebuilding and development of affected nations, pre-empting future conflict.

20. These include the Regional Greenhouse Gas Initiative, the Western Climate Initiative and the Midwest Accord Cap and Trade Program.

21. Indeed, in the 1990’s Canada was involved with as many as 6 or 7 different peacekeeping missions simultaneously. Since 2000, there have only 17 missions in 9 years. Veteran’s Affairs Canada. www.vac-acc.gc.ca/youth/sub.cfm?source=teach.

8. Conclusion

Climate change threatens all aspects of life, from the basic necessities such as availability of water and food, to the security of one's country, borders, and lifestyle. *Canada's International Political Statement: a Role of Pride and Influence in the World* (2005) explicitly recognized that "security in Canada is dependent on stability abroad, and that stability is threatened in many states by environmental pressures, resource scarcity, pandemic disease and urbanization" (Brown, Crawford and Campeau, 2008, 17). Though Canada faces direct and indirect threats to its security, a solely military response would not be adequate or effective. It is important that the connection between climate change and international stability is identified so that the response to these threats can be appropriately addressed. The greatest concerns for Canada are the maintenance of economic, food, physical, water and energy security. To accomplish this, the threat of foreign vulnerability and discord must be taken into account.

The main threat that resource scarcity poses for Canada is with respect to trade, aid and peacekeeping. While it does not impact directly on Canadian sovereignty or physical security, resource scarcity acts as a causal factor in other impacts that will affect Canada directly. For instance, migration and conflict are both directly connected to rising resource scarcity, and pose a significant threat to Canadian security. Though peacekeeping and aid initiatives may help, they are at best a 'band-aid' solution to a much deeper problem. The core issue of climate change must be addressed in as much as it affects both threats.

While energy use, supply and demand do not seem to be directly affected by climate change, rather seeming to affect or contribute to the phenomenon, the changing political economy of energy may cause violence. Alternative energy sources such as nuclear, are vulnerable to misuse, a security concern for the international community. Finally, given the importance of economic security to continued development, it is important that Canada address climate change as it affects international trade. The time has come for Canada to act in its self-interest. The failure to do so would prove to be shortsighted.

9. Recommendations

There are several precautions that the Canadian government can take in order to ensure that climate-related threats to security are minimized. For the most part, the federal government must address these challenges, due to their international nature. However, local governments also have a role in such initiatives by increasing awareness among the population. This would not only serve to engage Canadians, but would help to put pressure on the federal government for swift action as well.

The provincial governments could assist businesses within their jurisdiction to diversify business partners. It is important that there are alternatives to current trade partners in case of climate-related trade issues.

Finally, the federal government of Canada needs to act quickly to address numerous climate security concerns. For instance, it is important that the Canadian aid agreements with developing countries be reviewed and adjusted where necessary in order to accommodate the growing need for assistance to address resource scarcity and disaster. Further, in order to ensure that migration does not dramatically increase, Canada may want to pre-emptively contribute to funds and projects designed to enhance the adaptive capacity of developing countries. To address the growing potential for conflict, a combination of military preparedness, peacekeeping ability and strategic aid is important to ensure conflicts abroad do not escalate and, in the event that they exceed the national capacity for mediation, that they are addressed quickly, and with as little bloodshed as possible.

In order to ensure that Canada is able to adopt low-carbon energy without resorting to harmful alternatives or fossil fuels, it is important that all renewable energy resources are explored and developed within the country. While solar or wind energy may not provide sufficient energy to sustain a country alone, in conjunction with nuclear and hydroelectricity, it may be possible. Currently, much research and development need to be completed before Canada would be able to wean itself from fossil fuels.

Another way that the federal government could protect itself is by exploring opportunities to broaden its trade base. Currently, over 85% of

national trade is with the United States. Given the potential for climate-related-destruction of coastal industries or barriers to trade, it is important that Canada diversify trade so as to avoid economic damage in the event that the United States introduces protectionist measures that negatively affect trade.

It must also be noted that with regard to climate-related threats to international stability, Canada cannot react with a solely militaristic response. Since climate change is a root cause, it is important that climate change be addressed in order to ensure that the threats are dealt with in a sustainable manner.

Finally, given the level of uncertainty with respect to climate change and related issues, a greater base of knowledge is needed if these issues to address concerns successfully. More research is needed to make solid connections between climate change and conflict for instance. The more people and governments understand about the impacts of climate change on their daily life, the more likely it is that real behavioural change can be achieved. Since part of the uncertainty surrounds mitigation efforts and their effectiveness, research into areas such as geo-engineering could prove to be beneficial. 🍁

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APPENDIX

Addressing Climate Change in the Context of Security Policy: Implications for Canada

Gordon A. McBean

2008

PREFACE

Climate security is an emerging policy objective which aims to address the security risks and opportunities arising from changing global and local climatic conditions due to climate change.

This paper, prepared in 2008, develops the concept of climate security and then sets out considerations for policy development with a particular focus on the Canadian context and on elements of policy actions needed to achieve climate security for Canada.

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EXECUTIVE SUMMARY

At a Glance:

Canada is already experiencing climate change impacts which are expected to increase in intensity and breadth in the near future.

The security implications of climate change warrant careful consideration to maintain the social, political and economic stability of a country, in addition to the implications for national defence.

International climate change conventions, agreements and declarations, together with insightful analysis by leading OECD countries, provide a useful framework for crafting an approach to climate security matched to Canadian circumstances.

Key adaptation policy considerations include ensuring clarity of the roles and responsibilities of governments, “mainstreaming” adaptation into government policy making, providing clear and consistent signals to the private sector and to capital markets, ensuring broad engagement and integration of the perspectives from public, private

and academic sectors, and building a cooperative approach to action using national partnerships.

Societies across the globe have generally become more vulnerable due to climate change impacts. Factors include population growth in vulnerable locations, greater complexity and interdependence of urban infrastructure, adverse effects of human interventions in the natural environment, and growing inequality between rich and poor.

Climate change will impact water, food, energy security, and the safety and security of infrastructure, each of which have implications for health and global economies. Climate change also links with natural hazards, both in terms of the nature of events and society’s responses.

Further, climate change can be viewed as a “threat multiplier.” That is, superimposing climate change on the wide range of other trends, such as globalization and an aging society, and other security issues, such as terrorism and pandemics, can result in a higher overall impact.

Climate security is an emerging policy objective arising from the imperative for societies, in both developed and developing countries, to address the risks and opportunities arising from changing global and local climatic conditions due to climate change.

Climate security is about freedom from danger, risk, and safety from the threats of present and future negative climate impacts (storms, floods, droughts, etc). For the purpose of this paper, climate security can be defined as: *“that achieved through the implementation of measures that ensure the defence and maintenance of the social, political and economic stability of a country and of the human population, including freedom from fear and want – both state and human security – from the affects of climate change and global-to-local response to it.”* It also means freedom from risks which could arise from the impacts of actions by governments

and the private sector to mitigate climate change effects, such as by reducing greenhouse gas emissions. Any definition of climate security needs to encompass the goal of achieving a secure and safe society faced by the impacts of climate change.

Climate security is achievable through the implementation of measures that address both the obvious implications for national defence, and also measures which address the maintenance of the social, political and economic stability of a country, which is the focus of this paper.

Setting the Stage for Policy Considerations - Addressing Climate Security

It is evident that climate change impacts are already being felt in Canada and they will be felt more strongly in the future. There is a growing awareness of the economic and environmental risks arising from climate change. The media is paying increasing attention to climate-related issues. Canada's natural resources, such as forestry and fisheries, are already being impacted by climate change and these impacts will be more substantial in the future. There will be impacts for energy systems, such as hydroelectric power production, other renewable systems, and changing demands for electric power. Capital markets are aware of the implications for new investments in infrastructure and for replacing capital stock.

Since we live in a world of high and increasing interdependence, climate security for Canadians also relates to the security of global communities and how a changing climate in other countries, with resulting economic and social impacts, affects trade, migration, travel and needs for overseas assistance. Climate security must be addressed in concert with other security issues – those of energy, food, health and economic security.

The National Assessment *“From Impacts to Adaptation: Canada in a Changing Climate 2007”*¹ provides a systematic overview and observed that:

- *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.*

Therefore, considerations of elements of strategies to address the security aspects of a changing climate are timely.

Policy interest in developed countries to date has been largely directed to mitigation initiatives designed to reduce the volume of GHG emissions overall. More recently, attention has been given to the importance of taking action now to adapt to climate change, relying both on the adaptive capacity of the natural environment and society, and also on specific adaptation actions.

International perspectives can usefully shed light on the features of a climate security strategy. Several international studies, by the European Union, the United Kingdom, Germany, the United States and Australia, have already examined climate change as an issue of security in their national or regional contexts.

1. See www.nrcan.gc.ca - Lemmen, D.S., Warren, F.J. and J. Lacroix. (2008): Synthesis: in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush.

Box 1 Implications for Canada

In Canada, there is a growing awareness of the economic and environmental risks arising from climate change. The media is paying increasing attention to climate-related issues. Canada's natural resources, such as forestry and fisheries, are already being impacted by climate change and these impacts will be more substantial in the future. There will be impacts for energy systems, such as hydroelectric power production, other renewable systems, and changing demands for electric power. Capital markets are aware of the implications for new investments in infrastructure and for replacing capital stock.

Since we live in a world of high and increasing interdependence, climate security for Canadians also relates to the security of global communities and how a changing climate in other countries, with resulting economic and social impacts, affects trade, migration, travel and needs for overseas assistance. Climate security must be addressed in concert with other security issues – those of energy, food, health and economic security.

The National Assessment *"From Impacts to Adaptation: Canada in a Changing Climate 2007"*² provides a systematic overview and observed that:

- 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.
- 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.

Another important domestic issue for Canada is the advent of an open-water season in the high Arctic and the consequent implications for sovereignty.

The EU³ identified the first step as *"build up knowledge and assess the EU's own capacities"* and also to examine financial implications.

The United Kingdom⁴ has observed that climate change can be viewed as an integrator of environmental-societal issues. It is also as a "threat multiplier" since superimposing climate change on the wide range of other concerns, tensions and risks to societies will result in increased

overall impact. The UK has also suggested strengthening the work of horizon scanning and forward planning; improving connections between strategies pertaining to defence, development, foreign and domestic security; and creating a national security forum, including representatives from government, politics, academia and others, to discuss strategy and exchange ideas.

2. See www.nrcan.gc.ca - Lemmen, D.S., Warren, F.J. and J. Lacroix. (2008): Synthesis: in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 1-20.

3. *Climate Change and International Security*, Paper from the High Representative and the European Commission to the European Council. Paper S113/08, 14 March 2008.

4. *The National Security Strategy of the United Kingdom, Security in an interdependent world*. Presented to Parliament by the Prime Minister, by command of Her Majesty. March 2008.

An interesting aspect is the design of the economic methodology to judge adaptation options. The US⁵ suggests using portfolio choice theory and methods and tools from the theory of investment and finance under risk and uncertainty.

Since Canada has not yet undertaken an analysis of climate change through the security lens, to determine if, and to what extent, climate change may generate public safety and security issues for Canada, these international studies provide a useful reference point for crafting a Canadian approach.

Actions which Canada should consider as components of a climate security policy

Canada needs to address climate change in this climate security context now. The impacts of climate change are already becoming evident. Although there is always a need for fuller information on the impacts being experienced at present and those expected in the decades ahead, now is the time to move forward on an approach to climate security.

From a broad perspective, the key question is: *How should Canada best position itself to be resilient to climate change and related pressures arising from global climate change for the benefits of this and future generations?* Some key considerations for Canada are:

- How will climate change drive international markets and security issues of most relevance to Canada?
- Where are the international “hotspots,” that is, countries or regions which are home to conflicts or developments with direct or indirect implications for Canada?
- What are the priority needs for information, analysis and debate with respect to next steps in formulating Canada’s climate agenda?
- Where are potential risks through policy choices that have been made or may be made in the near future?
- Within the present scope of policy initiatives, where is there potential for

synergies or mismatch when viewed from an overall security perspective?

- Where and how will the necessary leadership that is needed across the issue, come from? Leadership is needed to create collaboration, provide clear mandates and responsibilities and enhance communication?

There are many considerations in development of a national climate security strategy. Any strategy needs to involve decision makers across the private and public (at all three levels) sectors, non-governmental organizations, and across the disciplines of natural, social, business, health, legal and engineering sciences. At present, it is generally recognized that there is a deficit in risk management and in attention to adaptation aspects. A strategy will need to integrate both a national mitigation strategy and a national adaptation strategy. Key policy considerations are:

- In this field of decision making across various levels of government and broadly within society, there is need for clarity on responsibilities. In view of the broad implications of climate change, it is very important that the ministries of industry, economic development and trade be involved in the development of the adaptation strategy.
- It is important that governments take proactive, integrated actions to reduce the uncertainties, both in the future climate and in the future regulatory and fiscal regimes.
- Many governments require their agencies and ministries to prepare sustainable development frameworks. These are useful to “mainstream” adaptation into their programs.
- Companies and organizations should shift “to a mindset of resiliency” in light of the inevitable future impacts of climate change.

5. Center for Strategic & International Studies and the Center for a New American Security. *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change*. Authors: Kurt M. Campbell, Jay Gullledge, J.R. McNeill, John Podesta, Peter Ogden, Leon Fuerth, R. James Woolsey, Alexander T.J. Lennon, Julianne Smith, Richard Weitz, and Derek Mix. November 2007; Joshua W. Busby. *Climate Change and National Security: An Agenda for Action*. CSR NO. 32.

- There will continue to be competing visions about the future and about how scarce financial resources should best be allocated by society. Choices in future investments in adaptation will compete with investments in other issues, including climate change mitigation.
- A broad range of consultations and analyses is required to recommend on the appropriate balance for the roles of governments and of markets in achieving the goal of a climate secure society that is robust and resilient to climate pressures.
- Capital markets need to understand and be confident that they understand the impacts of climate change adaptation and mitigation, within Canada and in the global community. They also need to be confident that the signals from governments are clear and consistent.
- National partnerships are useful means to develop consistent methodologies to address social, economic, ecosystem vulnerabilities and how to establish priorities.
- Initial actions could be undertaken in the area of critical infrastructure, looking at issues of resiliency and possible redundancy, building on the growing interest in infrastructure renewal, in both public and private sectors. In rebuilding this capital stock, climate change must be incorporated in the planning and implementation.
- To move ahead, there is a need for leadership and broadly-based engagement across the private, public and non-governmental sectors which build collaboration provide clear mandates and responsibilities and enhance communication.

This paper develops the concept of climate security and then sets out considerations for the elements of policy to address it with a particular focus on the Canadian context and on policy considerations needed to achieve climate security for Canada.

1. **INTRODUCTION:** **Climate security, part of climate change adaptation**

Summary

- Climate security addresses the implications of climate change on the environment, economic activity, public safety and security.
- This paper develops this concept of climate security and sets out considerations for developing a climate security policy for Canada

In awarding the 2007 Nobel Peace Prize to the Intergovernmental Panel on Climate Change (IPCC) and Albert Gore, the Nobel Committee of the Norwegian Parliament stated that it *“is seeking to contribute to a sharper focus on the processes and decisions that appear to be necessary to protect the world’s future climate, and thereby to reduce the threat to the security of mankind. Action is necessary now, before climate change moves beyond man’s control.”* In so doing, it placed climate change in the context of global peace and security.

Security as a term has evolved through the years. As defined by the Canadian Department of National Defence,⁶ security is the condition achieved through the implementation of measures that ensure the defence and maintenance of the social, political and economic stability of a country. New, broader concepts of security policy extend this to include the ability to defuse political and socio-economic crises through the use of development and environmental policy measures. In 1994 the United Nations Development Programme (UNDP)⁷ introduced the concept of ‘human security’ placing the focus on the security needs of individuals. This concept has since played a major role in shaping the international security discourse. Security is no longer seen merely as ‘freedom from fear’, but also as ‘freedom from want.’ The UN Commission on Human Security,⁸ while recognizing that the state remains the key guarantor of security, noted that states may fail to meet their security obligations to their own populations: *“the focus must broaden from the state to the security of people*

6. Source: DND terminology database.

7. UNDP (United Nations Development Programme) (2002) *China Human Development Report 2002*. UNDP, New York.

8. Commission on Human Security (2003) *Human Security Now*. Commission on Human Security, New York.

– to human security.” Climate security can therefore tentatively be defined as: *“that achieved through the implementation of measures that ensure the defence and maintenance of the social, political and economic stability of a country and of the human population, including freedom from fear and want – both state and human security – from the affects of climate change and global-to-local response to it.”*

In this paper, the concept of security will be applied to the issue of climate change and its implications for global humanity and their security, as viewed through a Canadian lens. In the next section, the international framework for addressing climate change and related issues such as the conventions on Desertification and Biodiversity will be discussed, bringing in how security issues are relevant. There are also a variety of international agreements and declarations to which Canada has been associated. More recently, the G-8 and other forums have been the place for debate on climate change. For each of these, the implications for Canada will be given attention.

In the following sections, how the changing climate is a threat to security in a global and then Canadian context will be discussed. This will lead to a tentative definition of climate security which links climate change and human security. Other countries, including the European Union, United Kingdom, Germany, Sweden, the United States of America and Australia have already undertaken analyses of climate change as a security issue. Considering the implications of these for Canada will lead to the last two sections which set out considerations for actually addressing climate security for Canada and moving ahead.

2. International Framework for Addressing Climate Change and Security

Summary

- Climate security is being addressed within recent international conventions, agreements and declarations.
- Highlights are provided from the United Nations Framework Convention on Climate Change, conventions on Desertification and Biodiversity, other international agreements and declarations, and the outcomes of recent international fora and discussions on climate change.

- Taken together, these provide an international framework within which Canada should consider when formulating its strategies and policies.

In 1988, Prime Minister Brian Mulroney and Norwegian Prime Minister Gro Brundtland, opened the historic conference “Our Changing Atmosphere: Implications for Global Security.” This marked the first time that heads of government had addressed, in such a public way, the issue of climate change. The Conference summary statement led off with *“humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war.”* Later that year, in November 1988, governments agreed to a process by which climate change science assessments would be undertaken and created the Intergovernmental Panel on Climate to carry them out. The First Assessment Reports were completed in 1990 and formed the sound basis for the Second World Climate Conference of 1990. The political portion of the session, led by governmental leaders including Prime Minister Margaret Thatcher (UK), called for an international convention to address the threat of climate change.

2.1 UN Framework Convention on Climate Change

Following a UN resolution, international negotiations resulted in the United Nations Framework Convention on Climate Change (UNFCCC – the Climate Convention), signed at the 1992 Earth Summit by many Heads of State and Government, including Prime Minister Mulroney (assisted by his then Environment Minister Jean Charest), and President George Bush Senior. The Climate Convention formally entered into force in 1994 and 192 countries had ratified it as last reported in August 2007. Through its process of ratification in 1994, Canada took on a binding commitment. The UNFCCC Objective (Article 2) is

*...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent **dangerous** anthropogenic **interference** with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.*

The words dangerous and interference have been highlighted to stress the connection with the sense of security as defined above. The principles of the Climate Convention include security elements, such as protecting food production and enabling economic development to proceed.

The 1997 Kyoto Protocol of the UNFCCC was the first step towards emission reductions to avoid “dangerous interference.” The Kyoto Protocol has been, as of 13 May 2008, ratified by 181 countries, including Canada, with the total percentage of Annex I Parties emissions being 63.7%.

Canada participated in the UNFCCC 13th Conference of the Parties and endorsed the resulting Bali Action Plan.⁹ It was agreed to undertake actions leading to a long-term cooperative action for beyond 2012, to be adopted at its fifteenth session in late 2009. The Bali Action Plan calls for enhanced national and international action on climate change mitigation including:

(i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, ... (v) Various approaches, including opportunities for using markets, to enhance the cost-effectiveness of, and to promote, mitigation actions, ... (vi) Economic and social consequences of response measures.

With decisions to be adopted by end of 2009, it is important that countries, including Canada, do the analysis needed for establishing a policy basis for positions to be taken in the negotiations leading to the post-2012 protocol.

The Bali Action Plan also calls for enhanced action on adaptation “through vulnerability assessments, prioritization of actions, financial needs assessments, capacity-building and response strategies, integration of adaptation actions into sectoral and national planning, specific projects and programmes.” It also calls for means to create incentives for the implementation of adaptation actions and enable climate-resilient development and reduction of vulnerability. In this context the special needs of the least developed and most vulnerable countries were identified. These

general actions and the following actions apply to Canada as well as to all states:

(ii) Risk management and risk reduction strategies, including risk sharing and transfer mechanisms such as insurance; (iii) Disaster reduction strategies and means to address loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change; (iv) Economic diversification to build resilience.

The connections between climate change adaptation and disaster risk reduction are clear.

In support of both climate change mitigation and adaptation, the Bali Action Plan urges:

(d) Enhanced action on technology development and transfer to support action on mitigation and adaptation and (e) Enhanced action on the provision of financial resources and investment to support action on mitigation and adaptation and technology cooperation.

These lists of actions not only provide an international menu but also are appropriate for building a national action strategy within the country.

Many UN members are small-island developing states for which the most important threat is sea-level rise; several are already seeing the impacts. Some countries are being savaged by tropical cyclones or ongoing droughts. Canada’s position and actions on climate change will have direct and indirect impacts on our relationships that may come through political positioning vis-à-vis Canada and may come through trade and investment, and migration and tourism. The growing trend in the magnitude of disaster losses, recognizing that most are climate related, is a major constraint towards meeting the Millennium Development Goals, which has further implications for Canada.

2.2 Conventions on Desertification and Biodiversity

Although most of the international focus is on the UN Framework Convention on Climate Change, there are other important and relevant international conventions and agreements. The United

9. UN Framework Convention on Climate Change, see www.unfccc.int

Nations Convention to Combat Desertification (UNCCD) and the UN Convention on Biological Diversity (UNCBD) were both debated at the Earth Summit, with the UNFCCC, in Rio in 1992. The UNCCD was adopted in June 1994 and entered into force on 26 December 1996 and now has been ratified by 193 countries, including Canada in 1995. The UNCCD objective is:

...to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas.

The 2007 IPCC Assessments stated that drought-affected areas will likely increase in extent as the climate warms over the coming decades. Further, the continuing drought in the Sahel has been one of the causes of the Darfur conflict, making the connections between drought and climate change clear.

The Convention on Biological Diversity entered into force at the end of 1993 and now has 190 parties. Canada ratified in 1992. The UNCBD objectives:

...are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

The 2007 IPCC Assessments also stated that *“it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.”*¹⁰ IPCC Chair, R. Pachauri, has since noted that *“rising temperatures this century could bring risks for the extinction of up to 30 percent of the world’s species.”* Humans, through

their role in climate change, are also affecting environmental systems and biological diversity. Climate change will have major impacts on the less-developed nations, both directly and through further desertification and loss of biological diversity. Canada, as a party to the three related conventions, has obligations in that regard.

2.3 International agreements and declarations

Whereas the three conventions noted above, on climate change, desertification and biological diversity, are binding on governments in that they have undertaken a formal ratification process, international agreements and declarations do not hold the same legal weight. However, they are statements of government’s intentions and concerns so they have political if not legal significance. The Bali Action Plan is one such declaration.

The 2000 Millennium Summit passed a Declaration establishing a series of Millennium Development Goals¹¹ (MDG) with clear quantifiable targets to be achieved in all countries by, in most cases, 2015. The important goals include: halve extreme poverty and hunger; and ensure environmental sustainability. The World Summit on Sustainable Development’s (2002) Summit Plan of Implementation¹² linked climate change and international development in its strategy to meet the Millennium Development Goals, noting:

Change in the Earth’s climate and its adverse affects are a common concern of humankind. We remain deeply concerned that all countries, particularly developing countries, including the least developed countries and small island developing States, face increased risks of negative impacts of climate change and recognize that, in this context, the problems of poverty, land degradation, access to water and food and human health remain at the centre of global attention.

In 2005, governments, including Canada, attending the World Conference on Disaster Reduction¹³ (Kobe, Hyogo, Japan) agreed on the

10. IPCC, 2007: “Summary for Policymakers.” In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22.

11. Millennium Declaration and Goals (A/57/270 www.un.org/millenniumgoals)

12. Report of the World Summit for Sustainable Development, Johannesburg, South Africa, 26 August- 4 September 2002 (A/CONF.199/20*, www.un.org)

13. World Conference on Disaster Reduction, Kobe, Hyogo, Japan, 18-22 January 2005, paper A/CONF.206/L.1. (www.unisdr.org)

Hyogo Framework for Action of the International Strategy for Disaster Reduction,¹⁴ called for the use of:

knowledge, innovation and education to build a culture of safety and resilience at all levels; with research to develop: "improved methods for predictive multi-risk assessments and socioeconomic cost-benefit analysis of risk reduction actions at all levels; incorporate these methods into decision-making processes at regional, national and local levels.

The United Nations Secretary General¹⁵ stated:

Climate change is expected to cause more severe and more frequent natural hazards. As our cities and coasts grow more vulnerable, these hazards can lead to disasters that are far worse than those we have seen to date. We have a moral, social and economic obligation to build resilience by 2015. Implementing the Hyogo Framework for Action will also help us reach the Millennium Development Goals.

The UN Secretary General's statement links climate change and the Hyogo Framework for Action and the Millennium Development Goals.

In addition to these international agreements, there are multi- and bi-national agreements, such as the North American Free Trade Agreement, with its Commission for Environmental Cooperation and the Canada-US Boundary-Waters Treaty of 1909 and more recent air quality agreements, all of which have some level of commitment of Canada towards addressing environmental and, within that context, climate change issues.

2.4 Recent International Fora and Discussions on Climate Change

Although the interest of most heads of government ebbed during the later 1990's and into the 21st Century, climate change was put clearly back into their realm with discussions at a series of G-8 Summits, starting with the 2005 Gleneagles G-8 Summit whose communiqué¹⁶ stated, "*Climate change is a serious and long-term challenge that*

has the potential to affect every part of the globe." The most recent G8 summit in Japan stated in their Declaration:¹⁷

We reconfirm the significance of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) as providing the most comprehensive assessment of the science and encourage the continuation of the science-based approach that should guide our climate protection efforts" and "We are committed to avoiding the most serious consequences of climate change and determined to achieve the stabilization of atmospheric concentrations of global greenhouse gases consistent with the ultimate objective of Article 2 of the Convention and within a time frame that should be compatible with economic growth and energy security.

They also noted that: "*recognizing the linkage between the potential impacts of climate change and development, mitigation and adaptation strategies should be pursued as part of development and poverty eradication efforts.*"

The Declaration of Leaders Meeting of Major Economies on Energy Security and Climate Change, which met just after the G8 Summit, stated:

*Climate change is one of the great global challenges of our time. Conscious of our leadership role in meeting such challenges, we, the leaders of the world's major economies, both developed and developing, commit to combat climate change in accordance with our common but differentiated responsibilities and respective capabilities and confront the interlinked challenges of sustainable development, including energy and food security, and human health.*¹⁸

In both declarations, leaders reconfirmed the science of IPCC and committed to addressing the issue, while noting the connections of climate change, energy and food security, human health and development and poverty eradication.

On the issue of human health and climate change, the World Health Organization Director-General¹⁹ stated the "*core concern is succinctly stated: climate*

14. Hyogo Declaration, World Conference on Disaster Reduction, Kobe, Hyogo, Japan 18-22 January 2005.

15. Ban Ki-moon, Secretary-General of the United Nations.

16. G8 Communiqué (www.g8.gov.uk/servelet/Front?pagename=OpenMarket/Xcelerate/ShowPage&c=Page&cid=1094235520309)

17. G8 Hokkaido Toyako Summit Leaders Declaration Hokkaido Toyako, 8 July 2008 <http://www.g8summit.go.jp/>

18. Declaration of Leaders Meeting of Major Economies on Energy Security and Climate Change. (Australia, Brazil, Canada, China, the European Union, France, Germany, India, Indonesia, Italy, Japan, the Republic of Korea, Mexico, Russia, South Africa, the United Kingdom, and the United States) meeting in Toyako, Hokkaido, Japan, on 9 July, 2008 (in association with G8 meeting).

19. Statement by WHO Director-General Dr Margaret Chan, 7 April 2008, www.who.int

change endangers health in fundamental ways” and dedicated the 2008 World Health Day to the impact of climate change on human health. She went on to note that the effects of extreme weather events would be abrupt and acutely felt, affecting the fundamental determinants of health: air, water, food, shelter, and freedom from disease.

2.5 Implications for Canada

The three international conventions, namely the Climate, Desertification and Biological Diversity Conventions and the agreements such as the UNFCCC Bali Declaration, the Millennium Development Goals and its implementation plan, and the World Conference for Disaster Reduction and its Hyogo Framework for Action, to which Canada and most countries are parties, provide the international policies, laws and regulations related to response strategies for climate change. They are important in the international context and for many countries are the foci of their diplomatic attention, with corresponding social and economic responses to them. These provide an international framework within which Canada can formulate its strategies and policies.

3. The changing climate – a threat to security Summary

- The increasing frequency of extreme climatic events and the disasters they produce are widely recognized as significant growing threats to the safety and security of society.

Making matters worse, major segments of the world’s populations are already highly vulnerable due to their location in vulnerable locations, and the increasing complexity of infrastructure.

- The 2007 IPCC report projects global mean temperatures increasing slightly faster for the next few decades than the past few. By end of the century, the temperature could be 1.5°C to 4°C warmer compared to year 2000. More recent studies raise concerns about more dramatic impacts than in the IPCC report.

Climate change is most evident in extreme weather-related events which have been increasing in frequency. For the period 2000-2006, the International Strategy for Disaster Reduction (UN/ISDR) and Centre for Research on the Epidemiology of Disasters (CRED)²⁰ report annual impacts of disasters of approximately 74,000 people killed and 200 million people affected or displaced. Economic costs have ranged from about \$US35B to over \$US200B.²¹ Floods (44%) and storms (27%) (including hurricanes, typhoons, tornadoes, mid-latitude winter storms) are the most frequent events; these plus extreme temperature and droughts and other weather/climate-related events make up more than 80% of all natural disaster events²² and cause most disaster losses, whether measured in terms of the number of events, the lives lost or material destruction.²³ The number of weather-related major disasters, which have overwhelmed communities, has risen substantially since the 1960’s. With this increasing burden, the economic and social systems of developing countries are being stressed and the possibility of state failures has become more likely.

Societies across the globe have generally become more vulnerable. Increases in population, with people living by choice or circumstances in more hazardous zones, along coasts, riverbanks and mountain slopes, have put more people and communities at risk, particularly in low-lying and northern areas. There has also been a growing inequality between societies’ wealthier and poorer sectors with the latter being more vulnerable. In urban regions (and particularly in very large cities), the complex infrastructure systems increase the vulnerability of populations to disruptions caused by hazards. Commercial activities have become more interdependent and vulnerable, including relying more on the transportation of people and goods. Human interventions in the environment can also increase vulnerability to natural hazards. Examples include changes in land cover that increase risks of landslides or flooding and destruction of mangroves that increases the susceptibility of coastal areas to storm and tsunami damage.

20. EM-DAT: The OFDA/CRED International Disaster Database, (www.emdat.be)

21. EM-DAT: The OFDA/CRED International Disaster Database (www.emdat.be)

22. EM-DAT: The OFDA/CRED International Disaster Database

23. Berz, G., W. Kron, T. Loster, E. Rauch, J. Schimetschek, J. Schmieder, A. Siebert, A. Smolka and A. Wirtz. 2001: World Map of Natural Hazards – A Global View of the Distribution and Intensity of Significant Exposures. *Natural Hazards*, 23: 443–465

The 2007 Report of the Intergovernmental Panel on Climate Change placed important, authoritative scientific assessments before the global community. With a linear rate of warming of 0.18°C per decade²⁴ over the past 25 years, the IPCC concluded that *“most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.”* The rate of warming is projected for the next few decades to be a little higher, *“about 0.2°C per decade.”* By mid-century, the climatic warming associated with different global emissions scenarios diverge, with end of century values ranging from 1.5°C to 4°C compared to 2000, or about 2-5°C warmer than pre-industrial global temperature.²⁵ There will likely be more intense tropical cyclones with larger peak wind speeds and more heavy precipitation. Drought-affected areas will likely increase in extent and more frequent heavy precipitation events will augment flood risk. Reflecting on the disaster loss statistics in the previous section, Munich Re reported that *“in view of continued global warming, we anticipate a long-term increase in severe, weather-related natural catastrophes.”*²⁶

It is not just the extreme events that affect natural and human ecosystems. Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C. Melting permafrost in the Arctic is affecting infrastructure and transportation systems. Poor communities are especially vulnerable since they tend to have more limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies.

The IPCC Fourth Assessment report on Mitigation concluded that there is *“substantial economic potential for the mitigation of global GHG emissions over the coming decades that could offset*

*the projected growth of global emissions or reduce emissions below current levels.”*²⁷ However, the rate of increase for global fossil fuel emissions has more than doubled, from 1.3% year⁻¹ in the 1990's to 3.3% year⁻¹ for the period 2000-2006.²⁸ In 2006, global emissions were 8.4 GtC (billions of tonnes carbon equivalents), which was higher than even the most pessimistic of the IPCC emission scenarios. It is now clear that many countries, including Canada, will not meet their Kyoto Protocol targets. Clearly emission reduction strategies have, as yet, been ineffective on a global scale and this does not bode well.

To address the UNFCCC target of avoiding dangerous anthropogenic interference with the climate system, the European Union and some states have adopted as the target 2°C warmer than pre-industrial global temperatures, based on the information provided through the IPCC and other assessments. The IPCC assessments provides information as to which global emission scenarios would meet this target within limits of uncertainty.

However, since the publication of the 2007 IPCC Fourth Assessment Reports, the IPCC Chair, R. Pachauri, has stated: *“People are actually questioning if the 2°C benchmark that has been set is safe enough.”* Other studies have also raised alarms. M. Parry et al.,²⁹ in a paper published in Nature Reviews in May, 2008, commented that:

We are now probably witnessing the first genuinely global effects of greenhouse gas warming. The steep increases in food prices around the world are the result of rising costs and demand aggravated by drought in food-producing regions — in the case of Australia, probably due in part to global warming — and by a poorly conceived experiment in climate policy that has converted cropland to biofuel plantations. This should serve as a wake-up call: impacts of climate change can surprise us, especially when they act in combination with other pressures.

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24. IPCC, 2007: “Summary for Policymakers.” In: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
25. Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007: “Global Climate Projections.” In: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
26. Topics Geo - Natural catastrophes 2006 Analyses, assessments, positions. Copyright 2007. Münchener Rückversicherungs-Gesellschaft, Königinstrasse 107, 80802 München, Germany, Order number 302-05217 (available at www.Munichre.com).
27. Berz, G., W. Kron, T. Loster, E. Rauch, J. Schimetschek, J. Schmieder, A. Siebert, A. Smolka and A. Wirtz, 2001: World Map of Natural Hazards – A Global View of the Distribution and Intensity of Significant Exposures. *Natural Hazards*, 23: 443–465.
28. Global Carbon Project. Raupach et al., 2007, PNAS; Canadell et al., 2007, PNAS.
29. Parry, Martin, Jean Palutikof, Clair Hanson and Jason Lowe. “Climate Policy: Squaring up to reality.” *Nature Reviews: Climate Change*. 29th May 2008.

Their analysis showed that targets of 2°C were inadequate and concluded that: *“Both emissions reduction and adaptation will need to be much stronger than currently planned if dangerous global impacts of climate change are to be avoided.”* J. E. Hansen, speaking on 23 June 2008 to the US National Press Club and at a Briefing to the House Select Committee on Energy Independence & Global Warming, stated:

The disturbing conclusion, documented in a paper³⁰ I have written with several of the world’s leading climate experts, is that the safe level of atmospheric carbon dioxide is no more than 350 ppm (parts per million) and it may be less. Carbon dioxide amount is already 385 ppm and rising about 2 ppm per year. Stunning corollary: the oft-stated goal to keep global warming less than two degrees Celsius (3.6 degrees Fahrenheit) is a recipe for global disaster, not salvation.

Based on this and other evidence 130 Canadian climate science leaders³¹ sent a message to political leaders noting that:

New analyses show that global greenhouse gas concentrations are increasing, sea level rising and Arctic sea ice decreasing faster than projected only a few years ago. Water shortages are predicted in the western Prairies, the Okanagan and in the Great Lakes basin. Earlier targets to avoid human interference with the climate system are now seen to be inadequate.

They recommended that *“based on the compelling science at hand, our political leaders display the urgency and determination that we believe is required.”*

4. **Climate change and Canadian society** **Summary**

- The impacts of climate change, as reported in the media, and as seen in the forest, agricultural and energy sectors, are becoming widely recognized.
- A National Assessment of impacts and the need for adaptation actions in Canada

has provided an inventory of anticipated impacts which will exacerbate many current climate risks, and present new risks and opportunities.

- Enhancing adaptive capacity and providing better means to cope can simultaneously address the impacts of climate change and related issues such as natural hazards while contributing to economic development.
- It is important to better assess the future costs of the impacts of climate change so that planning and public policies to adapt in anticipation of climate change impacts reduces the strain on budgets.

There has been increasing attention paid to climate-related issues in a broader context in Canadian media with these other climate-related issues replacing the Kyoto Protocol as the focus on the front pages. In March 2008, the *Report on Business*³² article on “Water – The Decade’s Most Important Business Issue” opens with the statement:

Here in Canada, we tend to think that while water scarcity, drying rivers and toxic lakes may be huge global problems, they really only affect places like China and the Middle East. But the rapid development of Alberta’s oil sands, coupled with accelerating population growth and climate change, has turned arid Alberta into Canada’s ground zero for water.

Nikiforuk³³ notes that *“Climate change has also begun to disrupt the province’s water budget. A warmer and more extreme climate means less water when you need it most. (It can also mean too much water when you need it least.)”* On the same day, one front page headline was *“The new global menace: food inflation”*³⁴ while a major columnist headlined *“Global food catastrophe looms.”*³⁵ Climate change was directly and indirectly implicated. *“But the worst damage is being done by the rage for ‘biofuels’ that supposedly reduce carbon dioxide emissions and fight climate change. (But they don’t really – at least not in their present form.)”* Although biofuels are

30. Target atmospheric CO2: where should humanity aim? J. Hansen, M. Sato, P. Kharecha, D. Beerling, R. Berner, V. Masson-Delmotte, M. Raymo, D.L. Royer, J.C. Zachos, <http://arxiv.org/abs/0804.1126> and <http://arxiv.org/abs/0804.1135>

31. An Open Letter on Climate Change Science to all Canadian Elected Government Leaders, June 2008 (see www.cmos.ca)

32. *Report on Business*, April 2008, included with *Globe and Mail* newspaper on 29 March 2008.

33. A. Nikiforuk, *Report on Business*, April 2008, p. 46-52.

34. *Globe and Mail* Newspaper, column on front page by Barry McKenna, 29 March 2008.

35. *London Free Press* (and other papers), column by Gwynne Dyer, 29 March 2008.

posed as a “solution” to the mitigation issue, their use affects climate change adaptation by distorting the agricultural production system, which is also being affected by the changing climate. The link with international security issues is evident: *“this, in turn, has sparked growing tension between North and South over agricultural policies.”* Water and food security were both linked to climate.

Canada’s natural resources, such as forestry and fisheries, are already being impacted by climate change and these impacts will be more substantial in the future. Increased global forest productivity could contribute to lower prices for Canadian wood products if fire and insect infestation effects abroad are minimized. There will be impacts for energy systems, such as hydroelectric power production, other renewable systems (wind, solar ...), and changing demands for electric power. Infrastructure is a long-term investment and it is important to influence major investments as well as the timing considerations for capital stock turnover.

There is a substantial body of information on climate change impacts on Canada in existing assessments. The 2007 Intergovernmental Panel on Climate Change (IPCC)³⁶ Assessment provides a global view with chapters for North America and the Polar Regions. The Arctic Climate Impact Assessment³⁷ is a circumpolar Arctic assessment of climate change and its vulnerabilities. This year, the National Assessment *“From Impacts to Adaptation: Canada in a Changing Climate 2007”*³⁸ has been published and it included:

- *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.*
- *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.*

The second bullet about impacts and adaptations around the world affecting Canada is particularly pertinent to this discussion of climate security.

The Canadian Climate Change and Health Vulnerability Assessment,³⁹ released in July 2008, overview includes the following:

- *... the combined effects of projected health, demographic and climate trends in Canada, as well as changes related to social conditions and infrastructure, could increase the vulnerability of Canadians to future climate-related health risks in the absence of effective adaptations.*
- *Concerns exist about the effectiveness of current adaptations to health risks from climate variability.*
- *Barriers to adaptation exist in Canada and include an incomplete knowledge of health risks, uneven access to protective measures, limited awareness of best adaptation practices to protect health, and constraints on the ability of decision makers to strengthen existing health protection programs or implement new ones.*

The two Canadian Assessments have a similarity in the conclusions on the importance of adaptation, the varying adaptive capacities and the need for further research and actions.

36. Intergovernmental Panel on Climate Change Fourth Assessment Reports, www.ipcc.ch

37. Arctic Climate Impacts Assessment, delivered to the Arctic Council, see www.acia.uaf.edu

38. See www.nrcan.gc.ca - Lemmen, D.S., Warren, F.J. and J. Lacroix. (2008): “Synthesis”: in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 1-20.

39. See www.sc-hc.gc.ca

An important issue for Canada is the Arctic and issues of sovereignty. The EU Security Report⁴⁰ noted the

...opening up new waterways and international trade routes. In addition, the increased accessibility of the enormous hydrocarbon resources in the Arctic region is changing the geo-strategic dynamics of the region with potential consequences for international stability and European security interests... There is an increasing need to address the growing debate over territorial claims and access to new trade routes by different countries which challenge Europe's ability to effectively secure its trade and resource interests in the region and may put pressure on its relations with key partners.

It is evident that climate change impacts are being felt and will be felt more strongly in the future. Therefore, adaptation strategies for a changing climate are necessary.⁴¹ The National Assessment⁴² defines adaptation as:

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.

As Burton notes, because “climate will continue to change for many decades, adaptation is an ongoing process that involves building the capacity to undertake continual adjustments in response to changes in climate and other stresses.” He also stresses that adaptation is about reducing the impacts of negative impacts of climate change and taking advantage of the opportunities that climate change will bring.

Adaptation will build upon adaptive capacity or the “*adaptability of an affected system, region, or community to cope with the impacts and risks of climate change*”⁴³ which is determined by local or regional socioeconomic conditions. Enhancing adaptive capacity and providing better means to cope can simultaneously address issues of climate change and related issues such as natural hazards while contributing to development. This is the natural means of connecting these intersecting issues.

It is important to assess and incorporate the future costs of the impacts of climate change in planning exercises and public policy development. Incorporating adaptation initiatives, in anticipation of climate change impacts, will reduce the strain on future budgets. Secondary effects of climate impacts may include higher prices, reduced income and job losses. In order to develop the most effective adaptation strategies,⁴⁴ there is need for increased knowledge and awareness of the impacts of changing climate, a broader understanding of the role of adaptation, a more anticipatory and strategic approach to adaptation, building on present activities. If this is not done, additional investments will be needed to compensate for future, unanticipated impacts.

There are important intersections of adaptation and emission reduction strategies. Emission reduction strategies need to be viewed in a global context while adaptation strategies are national, regional to local and personal. Emission reduction strategies may affect price and availability of energy with implications for adaptation strategies. Emission reductions policies based on conversion to corn or other food-based ethanol have had implications for the price of food.⁴⁵ There may also be increased costs of transportation, again affecting adaptation strategies. In March 2008, the federal government announced its latest plan to reduce greenhouse gas

40. Climate Change and International Security, Paper from the High Representative and the European Commission to the European Council, Paper S113/08, 14 March 2008.

41. Burton, Ian, Chapter 10: Moving Forward on Adaptation. In. D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON.

42. See www.nrcan.gc.ca - Lemmen, D.S., Warren, F.J. and J. Lacroix. (2008): “Synthesis”: in *From Impacts to Adaptation: Canada in a Changing Climate 2007*, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 1-20.

43. IPCC Climate Change 2001 – Impacts, Adaptation and Vulnerability Working Group II, Chapter 18 – Adaptation to climate change in the context of sustainable development and equity, Executive Summary.

44. Burton, op cit.

45. “Harper’s biofuels policy sputters out on the Hill” Use of food crops for fuel has some MPs urging caution and others expressing concern about a ‘global food catastrophe’ <<http://www.theglobeandmail.com/servlet/story/RTGAM.20080430.wethanol30/EmailBNStory/National/home>>

emissions.⁴⁶ There are now a series of provincial actions, regional alliances, etc., that may mean added costs to industries in working across the country.

Chapter 9 of the National Assessment entitled “*Canada in an International Context*” stressed that 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. The effects on Canada arise from impacts that occur elsewhere in North America, in the surrounding oceans or globally. An important factor for Canada is trade with other countries which means understanding the actual and potential impacts on other countries and how those will change the market place.

There will be both opportunities and challenges. These have been recognized by some, including the UK Prime Minister, whose speech on 1 May 2008, was headlined as: “*The Prime Minister has told business leaders to prepare for a technological revolution and embrace the opportunities available in tackling climate change.*”⁴⁷

The Lawrence National Centre for Policy and Management reported on both a low carbon society and transportation policy in the Ontario - Québec Continental Gateway and Trade Corridor.⁴⁸ In recognition of the already changing climate, the governments of Canada,⁴⁹ Ontario and British Columbia, the National Roundtable on the Environment and the Economy and the Conference Board of Canada are now examining adaptation strategies.

5. Climate change and human security

Summary

- Climate change will have widespread impacts affecting safety and security of infrastructure, food production, energy security, frequency and severity of extreme events, public health.
- Climate security is about achieving freedom from danger, risk, and safety from

the threats of present and future negative climate impacts (storms, floods, droughts, etc).

- Canada and Canadians need to address these security aspects of climate change in this multi-faceted global security context, and in concert with other security issues in energy, food, health and economic security.

As has been discussed above, climate change is about water, food, and energy security, and safety and security of infrastructure which have implications for health and global economies. Climate change also links with natural hazards; both in terms of events and responses. In the end, a changing climate has or will have impacts on all aspects of human and planetary well being.

Climate change can be viewed as a threat multiplier such that superimposing climate change on the wide range of global trends, such as globalization and an aging society, and other security issues, such as terrorism and pandemics, can result in a higher overall impact.

Climate security is therefore about freedom from danger, risk, and safety from the threats of present and future negative climate impacts (storms, floods, droughts, etc). It also means freedom from risk, including financial, due to actions taken by governments and others to deal with climate change impacts. It also relates to the impacts of governments’ and private actions to mitigate climate change effects, such as reducing greenhouse gas emissions. Since we live in a world of high and increasing interdependence, climate security for Canadians also relates to the security of global communities and how a changing climate in other counties, with resulting economic and social impacts, affects trade, migration, travel and needs for overseas assistance. Climate security must be addressed in concert with other security issues – those of energy, food, health and economic security. For a secure future, Canada and Canadians need to address climate change in this security context.

46. *Turning the Corner: An Action Plan to reduce Greenhouse Gases and Air Pollution* March 2007: see www.ec.gc.ca

47. : UK Prime Minister speech. <http://www.number-10.gov.uk/output/Page15424.asp>

48. Lawrence National Centre for Policy and Management at the Richard Ivey School of Business, the University of Western Ontario. D. Cunningham, Director. *Developing Sustainable Energy Policy Workshop, Building Paths to a Low Carbon Society* Series. October 22-24, 2006, 73pp. and the *Ontario - Québec Continental Gateway and Trade Corridor: Developing Competitive and Sustainable Transportation Policy* Workshop, March 9-11, 2008.

49. *From Impacts to Adaptation: Canada in a Changing Climate* April 2008 see www.ec.gc.ca

6. Other countries' approaches to climate security

Summary

- International perspectives provide useful insights on the features of a climate security strategy.
- The international studies see climate change as an issue of national security with impacts within the country and also, and sometimes more importantly, with impacts on other countries.
- Concerns include international governance stability, migration, international trade and conflicts resulting from a changing climate.
- These international studies provide a useful reference point for framing a Canadian approach.

Several countries have already undertaken analyses of climate change as an issue of security in their national or regional context. No comparable examination has been undertaken to determine if, and to what extent, climate change may generate public safety and security issues for Canada.⁵⁰

6.1 The European Union

The Council of the European Commission recently adopted a report on the security implications of climate change⁵¹ noting that *“the impact of climate change on international security is not a problem of the future but already of today and one which will stay with us.”* The report states that:

The risks posed by climate change are real and its impacts are already taking place. The UN estimates that all but one of its emergency appeals for humanitarian aid in 2007 were climate related. In 2007 the UN Security Council held its first debate on climate change and its implications for international security.

The report recommends that any discussions on the European Security Strategy take into account of the security dimensions of climate change.

6.2 The United Kingdom

The United Kingdom's national security strategy⁵² identified the security challenges as terrorism, weapons of mass destruction, transnational organized crime, global instability and conflict, failed and fragile states and civil emergencies. In their discussion of drivers of insecurity, climate change is specified as *“potentially the greatest challenge to global stability and security and therefore to national security. Tackling its causes, mitigating its risks and preparing for and dealing with its consequences are critical to our future security, as well as protecting global prosperity and avoiding humanitarian disaster.”* Also, they note that although many climate impacts will:

affect the United Kingdom directly, but the direct effects are likely to fall most heavily on those countries least able to deal with them, and therefore most likely both to suffer humanitarian disaster but also to tip into instability, state failure, or conflict. That further increases the responsibility of the international system to generate collective solutions. While the possibility of disputes may increase, climate change also presents new opportunities to strengthen international cooperation; but if the international system fails to respond, the effect on its credibility would have further knock-on effects on security.

The strategy also stated that *“providing security for the nation and for its citizens remains the most important responsibility of government.”*

6.3 Germany

In April 2008, the German Advisory Council on Global Change⁵³ presented its report *“Climate Change as a Security Risk.”* The core message is that *“without resolute counteraction, climate change will overstretch many societies' adaptive capacities within the coming decades”* which could result in destabilization and violence, jeopardizing national and international security to a new degree. They used the term climate-induced conflict

50. Statement made by Margaret Purdy, a former federal deputy minister with extensive experience in national security, public safety and emergency management matters and now a Resident Scholar in the Centre of International Relations, The University of British Columbia.

51. *Climate Change and International Security*, Paper from the High Representative and the European Commission to the European Council. Paper S113/08, 14 March 2008.

52. *The National Security Strategy of the United Kingdom, Security in an interdependent world*. Presented to Parliament by the Prime Minister, by command of Her Majesty, March 2008.

53. German Advisory Council on Global Change (WBGU). *Climate Change as a Security Risk*. 271 pp.

constellations and identified four specific types, namely climate-induced: degradation of freshwater resources; decline in food production; increase in storm and flood disasters; and environmentally induced migration. They then mapped regional “hotspots” as areas of special concern.

6.4 Sweden

A Commission on Climate and Vulnerability was appointed by the Swedish Government in June 2005 to assess regional and local impacts of global climate change on the Swedish society and produced a study called “Sweden facing climate change – threats and opportunities.”⁵⁴ Among their important conclusions was “It is necessary to make a start on adapting to climate changes in Sweden. The principal features of the climate scenarios, despite uncertainties, are sufficiently robust to be used as a basis.”

6.5 The United States of America

There have been several US studies on climate change security; two examples prepared by non-governmental organizations are discussed. The Center for Strategic & International Studies and the Center for a New American Security entitled their report as “The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change.”⁵⁵ The Executive summary opens with:

In August 2007, a Russian adventurer descended 4,300 meters under the thinning ice of the North Pole to plant a titanium flag, claiming some 1.2 million square kilometers of the Arctic for mother Russia. Not to be outdone, the Prime Minister of Canada stated his intention to boost his nation’s military presence in the Arctic, with the stakes raised by the recent discovery that the icy Northwest Passage has become navigable for the first time in recorded history.

They took a scenario approach looking at expected climate change at 2040, a severe change also for 2040 and a catastrophic scenario for 2100. Selected conclusions follow:

- *Perhaps the most worrisome problems associated with rising temperatures and sea levels are from large-scale migrations of people — both inside nations and across existing national borders.*
- *A few countries may benefit from climate change in the short term, but there will be no “winners.”*
- *Climate change effects will aggravate existing international crises and problems.*
- *Any future international agreement to limit carbon emissions will have considerable geopolitical as well as economic consequences*
- *At a definitional level, a narrow interpretation of the term “national security” may be woefully inadequate to convey the ways in which state authorities might break down in a worst case climate change scenario.*

The Council for Foreign Relations study on Climate Change and National Security: An Agenda for Action⁵⁶ concludes that:

*The policy proposals presented here...have the potential to strengthen national security by reducing U.S. vulnerabilities to climate change at home and abroad, securing and stabilizing important partners, and contributing to other goals such as energy security and industrial revitalization. In a world of new security challenges, forging a climate policy along these lines must be a national priority.*⁵⁷

Other US reports take the more traditional analysis of climate change impacts but they need to also be considered in this security context. The US National Research Council⁵⁸ examination of the impacts of climate change on the transportation sector concluded that:

54. *Sweden facing climate change – threats and opportunities*. Final report from the Swedish Commission on Climate and Vulnerability, Stockholm 2007. Swedish Government Official Reports SOU 2007:60.

55. Center for Strategic & International Studies and the Center for a New American Security. *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change*. Authors: Kurt M. Campbell, Jay Gullledge, J.R. McNeill, John Podesta, Peter Ogden, Leon Fuerth, R. James Woolsey, Alexander T.J. Lennon, Julianne Smith, Richard Weitz, and Derek Mix. November 2007.

56. Joshua W. Busby. *Climate Change and National Security: An Agenda for Action*. CSR NO. 32, NOVEMBER 2007 COUNCIL ON FOREIGN RELATIONS

57. See http://www.cfr.org/publication/14917/council_report_argues_for_new_policies_to_protect_national_secu

58. *Potential Impacts of Climate Change on U.S. Transportation*, Transportation Research Board, Special Report 290, US National Research Council, 2008.

Climate change will have significant impacts on transportation, affecting the way U.S. transportation professionals plan, design, construct, operate, and maintain infrastructure. Decisions taken today, particularly those related to the redesign and retrofitting of existing or the location and design of new transportation infrastructure, will affect how well the system adapts to climate change far into the future. Focusing on the problem now should help avoid costly future investments and disruptions to operations.

The Center for Integrative Environmental Research (CIER) at the University of Maryland⁵⁹ concluded that climate change impacts will place immense strains on public sector budgets and that secondary effects could include higher prices, reduced income and job losses.

6.6 Australia

The Australian-based Lowy Institute for International Policy supported a study on climate change and security, completed in 2006, which concluded that:

Crucially, however, there is no consensus about appropriate strategies for dealing with the consequences of climate change, primarily because there is no agreement about its seriousness for international security. The reality is that climate change of the order and time frames predicted by climate scientists poses fundamental questions of human security, survival and the stability of nation states which necessitate judgments about political and strategic risk as well as economic cost.⁶⁰

Again the issue of security is raised and the need for strategic assessment of risks highlighted.

6.7 Other relevant studies

Although identified as a marginal issue in the six categories of global threats to human security

in the UN reports⁶¹ before Hurricane Katrina, environmental degradation, which is linked with desertification, loss of biological diversity and climate change, has now become a major issue. The United States explicitly takes account of environmental degradation⁶² and Germany's White Paper on Security Policy also refers explicitly to the potential risks of global environmental change when it speaks of migration, natural disasters and environmental destruction as being causes of instability.⁶³ Climate change is certainly a cause and related to environmental degradation, destruction and natural disasters. The 2008 NATO Security Science Forum on Environmental Security addressed the linkages between the environment and security and concluded that:

Even though the causes of conflict and insecurity are often complex, evidence suggests that environmental degradation and resource depletion are a source of tension in many regions of the world. Land degradation, climate change, water quality and quantity, and the management and distribution of natural resources (e.g. oil, forests, minerals) are factors that can contribute directly to conflict or be linked to them by exacerbating other causes such as poverty, migration, infectious diseases, poor governance and declining economic productivity. In sum, environmental problems can threaten human livelihoods and contribute to social and economic inequalities.⁶⁴

For states, ecosystems or sectors of society that are already fragile and burdened the additional imposition of a changing climate may overload those systems, perhaps beyond their breaking thresholds' leading to failed states, but at least to new enhanced levels of stress. A 2002 US National Security Study concluded that "America is now threatened less by conquering states than we are by failing ones" where a "failed state" is one whose central government is so weak or ineffective that it has little practical control over much of its

59. The US Economic Impacts of Climate Change and the Costs of Inaction A Review and Assessment by the Center for Integrative Environmental Research (CIER) at the University of Maryland October 2007.

60. Alan Dupont, A. and G. Pearman, 2006: *Heating up the planet, Climate Change and Security*. Lowy Institute Paper 12 First published for Lowy Institute for International Policy 2006.

61. UN (United Nations) (2004) A More Secure World: Our Shared Responsibility. Report of the High-level Panel on Threats, Challenges and Change. UN, New York.; UNSG (United Nations Secretary General) (2005) In *Larger Freedom: Towards Development, Security and Human Rights for all*. Report of the Secretary-General. UN, New York.

62. White House (2006) *The National Security Strategy of the United States of America*. The White House, Washington, DC.

63. BMVg (Bundesministerium für Verteidigung) (2006) Weißbuch zur Sicherheitspolitik Deutschlands und zur Zukunft der Bundeswehr. BMVg, Berlin.

64. NATO Environment and Security report see www.nato.int/docu/environment/environment-e.pdf

territory.⁶⁵ Former U.N. Secretary-General Kofi Annan warned that *“ignoring failed states creates problems that sometimes come back to bite us.”* Former French President Jacques Chirac spoke of *“the threat that failed states carry for the world’s equilibrium.”*⁶⁶

6.8 Implications for Canada

Other important countries consider climate change as an issue of national security. In each of the reports cited, there is a strong case made that climate change will have national security implications. These implications arise both through the impacts within the country and also, and sometimes more importantly, through the impacts on other countries. Concerns are expressed in all about issues such as international governance stability, migration, international trade and conflicts resulting from a changing climate.

Since Canada has not yet undertaken an analysis of climate change through this lens of security, these international studies provide a strong starting point for a Canadian analysis.

7. Addressing Climate Security for Canada Summary

- Key questions for careful consideration in formulating of a policy for Canada on climate security are: How will climate change drive international markets and security issues? Where are the international “hotspots”? What are the priority needs for information, analysis and discussion? Where are potential policy risks? Where is there potential for synergies or mismatch? And, where will the necessary leadership come from?
- Important elements of a “made in Canada” climate security strategy include: integration of mitigation and adaptation strategies, examination of existing legislation and regulations to identify aspects which have a bearing on adaptation, clarification of the roles of government departments and improve coordination and alignment among them,

consider the establishment of strategic development frameworks, and developing “a mindset of resilience”

- Taken together, these actions will serve to promote “mainstreaming” of climate change adaptation into all public and private sector decision making.

There is now a large amount of information and assessments available on climate change. What we do not have is a “made-in-Canada” comprehensive synthesis of climate change from the perspective of climate security (as defined in Chapter 1). A strategy needs to be developed involving decision makers across the private and public (at all three levels) sectors and non-governmental organizations and across the disciplines of natural, social, business, health, legal and engineering sciences.

The fundamental question is: ***How should Canada best position itself to be resilient to climate change and related pressures arising from global climate change for the benefits of this generation and future generations?***

When addressing this climate security issue, the EU identified the first step as *“build up knowledge and assess the EU’s own capacities”* and also to examine financial implications. Other analyses should be undertaken around the globe, region-by-region, to look in more detail at what the security implications are likely to be and at how they will affect Canadian interests, with special attention to the most vulnerable regions and potential international climate security “hot spots.”

The United Kingdom, in its security analysis, discusses the interdependence of threats, risks and drivers, and further notes that *“climate change and related effects on water, energy and food security will multiply other threats and interact with other drivers of insecurity, including demographic pressures and the spread of disease.”* Climate change can be viewed as an integrator of environmental-societal issues and as a threat multiplier such that superimposing climate change on the wide range of international concerns and tensions and risks to society will result in overall more impact and as strategy must take these issues into account.

65. Based on *Failed States: The Abuse of Power and the Assault on Democracy*, by N. Chomsky, Metropolitan Books, 2006, 320 pp.

66. The Failed States Index by Foreign Policy and Fund for Peace (July-August 2005)

see www.foreignpolicy.com/users/login.php?story_id=3098&URL=http://www.foreignpolicy.com/story/cms.php?story_id=3098

As part of the UK response to these issues, some points are especially relevant for Canada, including:

strengthening the work of horizon scanning and forward planning; strengthening the capability to offer a strategic perspective on security priorities and improve connections between defence, development, foreign and domestic security strategies; and creating a national security forum, including representatives from government, politics, academia and others, to discuss strategy and exchange ideas.

An interesting issue identified in the US report as a research question is that of the economic methodology to judge adaptation options. They argue that the usual approach of finding an optimum level of adaptation when these benefits are equal to the marginal cost of adaptation (marginalist approach) is flawed. They suggest a more adequate methodology which treats

adaptation actions as bulky investments in natural, human-made and social capital, with the goal of maintaining or enhancing the services they provide. A methodological approach consistent with that viewpoint will need to rest in portfolio choice theory (i.e., how rational investors will use diversification to optimize their portfolios, and how a risky asset should be priced or valued) and needs to include methods and tools from the theory of investment and finance under risk and uncertainty.

There are some strategic opportunities and challenges in development of a national climate security strategy. Such a strategy will need to include both a national mitigation strategy and a national adaptation strategy. These need be integrated, as has been discussed. Whereas an emission reduction strategy will need to be negotiated in a global context, a national adaptation strategy can, and should be, Canada-centric. One of the issues will be the debate on individual responsibilities versus collective responsibilities and the relative roles of governments. As part of removing barriers to action and enhancing institutional capacity, existing legislation should be examined vis-à-vis climate change adaptation. Another role of government, usually assigned to the environment ministry, is the role of environmental protection and protection from the environment,

sometimes shared with the health ministry (as in the case of polluted air). For the issue of climate change adaptation these ministries (public safety, environment and health) would be expected to be the lead departments (although in Canada it may presently reside federally with Natural Resources Canada). Many governments require their agencies and ministries to prepare annual sustainable development frameworks and these could be used to “mainstream” adaptation into their programs. The Canadian Environmental Assessment Act, Ontario’s Clean Water Act and similar acts could be used to implement adaptation.

A fundamental role of government is the protection of citizens. Climate change is raising the public’s awareness of the risks due to weather-related events. The responsibility of the national weather service and the federal Department of Public Safety should be another consideration, in coordination with corresponding emergency management roles exercised by other levels of government. Natural hazard mitigation and prevention acts and agreements, such as the Disaster Financial Assistance Act and the new federal-provincial agreement National Disaster Mitigation Strategy (NDMS)⁶⁷ could be modified to include requirements and funding for proactive adaptation strategies. The goal of the NDMS is: “To protect lives and maintain resilient, sustainable communities by fostering disaster risk reduction as a way of life.” Its third program element is to “Apply and promote scientific and engineering best practices in order to build a knowledge base for sustainable, cost-effective mitigation decisions that contribute to community resiliency.” The NDMS states that the strategy’s success will depend on contributions at all levels of government and notes that the “NDMS should leverage, acknowledge and encourage new, developing and existing mitigation activities (e.g. climate change adaptation, seismic safety, dam safety, transportation and storage of dangerous goods).” Disaster mitigation and climate change adaptation are inherently linked.

The studies and workshops of the Conference Board on issues of business continuity, risk management and now resilience have stressed that companies and organizations should shift

67. See: Public Safety Canada website: www.ps-sp.gc.ca

“to a mindset of resiliency.” In the study on Building Resilience,⁶⁸ six principles of effective emergency response were identified, based on the analysis of the 1997 Red River flood, the 1998 ice storm, the SARS outbreak, the 2003 blackout, Hurricane Juan, the 9/11 terrorist attacks, the London transit bombings, and Hurricane Katrina. These principles form the foundation for effective response to national security and public safety incidents: define and recognize leadership and accountability; ensure cooperation and coordination; clarify mandates and provide resources; ensure frequent, clear and credible communications; ensure fair and equitable treatment of all stakeholders; and learn from experiences and adjust accordingly. Half of these events were weather-related and hence linked to climate change security and adaptation.

In view of the broad implications of climate change, it is also very important that the ministries of industry, economic development and trade be involved in the development of the adaptation strategy. This is consistent with the usual sense of “mainstreaming” climate change adaptation into all public and private sector decision making.

Building on the climate security analyses of the European countries, US and Australia, the sectoral climate change challenges within national and international climate change assessments and discussions with decision makers, some key questions pertinent to Canada are:

- How will climate change drive international markets and security issues of most relevance to Canada?
- Where are the international “hotspots” with direct or indirect implications for Canada?
- What are the priority needs for information, analysis and debate with respect to next steps in formulating Canada’s climate agenda?
- Where are potential risks through policy choices that have been made or may be made in the near future?
- Within the present scope of policy initiatives, where is there potential for synergies

or mismatch when viewed from an overall security perspective?

- Where and how will the necessary leadership that is needed across the issue, come from? Leadership is needed to create collaboration, provide clear mandates and responsibilities and enhance communication?

8. Closing Observations and Conclusions Summary

- Action towards addressing climate security is warranted now, regardless of an incomplete knowledge of the impacts and implications of climate change on the environment, the economy and society.
- Challenges will arise in the form of competing demands for funding and resources, in coordination of roles and responsibilities, in ensuring broad consultations, in providing consistent and stable messaging to capital markets.
- Stepped-up efforts are called for in Canada on adaptation policy and risk management, working through national dialogue and partnerships.
- The growing interest in infrastructure renewal and in replacing capital stock provides a good target area for action.

The impacts of climate change are already happening. Actions cannot wait for perfect information. Although there is need for information from now to decades ahead, it is no longer reasonable to be paralysed by uncertainty and now is the time to move forward. In this field of decision-making across various levels of government and broadly within society, there is need for clarity on responsibilities. The regulatory and fiscal frameworks need to be consistent, comprehensive, clear and issue-based (rather than politics-based) as was advocated by the Executive Forum on Climate Change of November, 2005, *“... we need policy certainty for post-2012. We need a strategy now for the next 50 years, with short and medium-term targets to guide us. Governments must set clear markers along the way to unleash*

68. “Building Resilience - Leadership and Accountability.” *National Security and Public Safety Report* March 2008, Conference Board of Canada. See www.e-library.ca

*competitive market forces ...*⁶⁹ It is also urgent for Canada to take its place at the UNFCCC COP15 (December, 2009) with positions based on comprehensive analysis of these issues.

In addressing climate security, there will continue to be competing futures. Choices in future investments in adaptation will compete with investments in other issues, including climate change mitigation. The key challenges will be to reduce the uncertainty and manage risk against possible futures. It is important that governments take proactive, integrated actions to reduce the uncertainties, both in the future climate and the future regulatory and fiscal regimes. A broad range of consultations and analyses is required to recommend on the appropriate balance for the roles of governments and of markets in achieving the goal of a climate secure society that is robust and resilient to climate pressures. Capital markets need to understand - and be confident that they understand - the impacts of climate change adaptation and mitigation, within Canada and in the global community. They also need to be confident that the signals from governments are clear and consistent. As was stated in the context of sustainability and energy security, *“Canada needs credible long-term strategies, developed with key stakeholder involvement and armed with the political will to implement them.”*⁷⁰ Clearly, a proactive approach to climate change mitigations

and adaptations, building on the synergies where they exist, is needed.

It is generally recognized that there is a present deficit in risk management and an adaptation deficit.⁷¹ Canada needs to develop national partnerships consistent methodologies to address social, economic, ecosystem vulnerabilities and how to establish priorities. Some of the issues are strategies for resilient transportation systems, infrastructure investments, management of the fishery, energy systems (fossil and renewable) and structural adaptation. It is important that initial actions be started with critical infrastructure, looking at issues of resiliency and possible redundancy. Within Canada there is now the beginning of infrastructure renewal, both public and private, and in rebuilding this capital stock. Climate change must be incorporated in the planning and implementation.

In the Report on “Building Resilience: Leadership and Accountability,” the failure of leadership was highlighted, due to “muddled mandates,” the need for “creating collaboration” and the problems of “confused communication.” Hence, to move ahead, there is a need for leadership across the issue that can create collaboration, provide clear mandates and responsibilities, and enhance clear communication. 🍁

69. Executive Forum on Climate Change, Call to Action on Climate Protection, Energy and Sustainable Development, United Nations Climate Change Conference: Montreal 2005, November 2005.

70. *Sustainability and Energy Security: Wrestling with Competing Futures*. Conference Board of Canada, Briefing April 2006.

71. Ian Burton, “Adapt and thrive: options for reducing the climate change adaptation deficit.” *Policy Options*, December 2005-January 2006.