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**THE COMING ASCENDENCY OF BLUE GOLD: STRATEGIC IMPLICATIONS FOR
CANADIAN SECURITY**

By/par ...

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La présente étude a été rédigée par un stagiaire du Collège des Forces canadiennes pour satisfaire à l'une des exigences du cours. L'étude est un document qui se rapporte au cours et contient donc des faits et des opinions que seul l'auteur considère appropriés et convenables au sujet. Elle ne reflète pas nécessairement la politique ou l'opinion d'un organisme quelconque, y compris le gouvernement du Canada et le ministère de la Défense nationale du Canada. Il est défendu de diffuser, de citer ou de reproduire cette étude sans la permission expresse du ministère de la Défense nationale

ABSTRACT

This paper examines the strategic implications for Canada's national security from threats arising from a changing hydrological cycle. First, it discusses the strategic importance of water and the critical importance of the hydrological cycle to life. Then it argues that global warming, an increasing demand for water due to population growth, and the poor water management practices of many countries are adversely altering the world's hydrological cycle. The consequences will likely include increased water scarcity in certain regions of the world, rising sea levels, and an increase in the number and severity of tropical storms. Next it analyses the potential consequences of a transformed water cycle and discusses the strategic implications of these environmental threats to Canada's national security. Finally, it proposes a number of initiatives to address these threats: the establishment of a Centre for National Environmental Security (CNES), the development of a modern National Water Policy (NWP), and the adoption of water security as a key pillar of Canada's foreign aid policy.

THE COMING ASCENDENCY OF BLUE GOLD: STRATEGIC IMPLICATIONS FOR CANADIAN SECURITY

INTRODUCTION

Governments of sovereign states have a fundamental responsibility to protect the sovereignty of their state and provide security for their citizens. As Canada's 2004 National Security Policy states, "there can be no greater role, no more important obligation for a government, than the protection and safety of its citizens."¹ This expectation is also enshrined in the Canadian Charter of Rights and Freedoms, which declares, "Everyone has the right to life, liberty and security of the person...." It is no surprise then that since the devastating terrorist attacks on the World Trade Center occurred on 11 September 2001 and the Campaign Against Terror began, much of the dialogue and most of the existing and new resources assigned to national security have been dedicated to the terrorist threat. However, not all threats to Canadians are terrorist, military, or even criminal in origin. In the last decade, floods, ice storms, and forest fires have also threatened the security of Canadians. Further, the 2000 E. coli contamination of water supplies in Walkerton, Ontario killed seven people and the E. coli contamination of the Kashechewan First Nation's water source forced their evacuation in 2005 and 2006. Finally, the serious ramifications of humankind's alteration of the carbon cycle and the resultant acceleration of global warming have also begun to receive global attention.

All of these potentially devastating threats are environmental in origin and fall under the umbrella of the relatively new field of environmental security. Surprisingly though, they have received little consideration as a threat to national security. More specifically, they, and

¹Privy Council Office, *Securing an Open Society: Canada's National Security Policy* (Ottawa: Privy Council Office, 2004), 5.

environmental security more generally, are absent from Canada's 2004 National Security Policy.

This is worrisome, at the least. As Norman Meyers, an early scholar on the subject, points out:

...national security is not just about fighting forces and weaponry. It relates to watersheds, croplands, forests, genetic resources, climate and other factors that rarely figure in the minds of military experts and political leaders, but increasingly deserve, in their collectivity, to rank alongside military approaches as crucial in a nation's security.²

This paper will examine three of the most critical environmental threats that will affect Canada's security in the coming years: water scarcity, rising sea levels and increasingly destructive tropical storms. Humankind's alteration of the hydrological cycle through global warming, population growth and poor water management has the potential to transform water into a catalyst of instability and destruction, threatening Canadian security as well as Canada's most precious strategic natural resource.

It begins by looking at the strategic value of water and the critical importance of the hydrological cycle to all living things. Water scarcity will pose an increasing threat to water security for billions of people and as a result it will make water a key strategic resource, or, as some put it, "the blue gold of the 21st century." Although Canadians have typically felt that their country has an abundance of this blue gold, a closer examination will show that Canada does need to treat water as a critical resource.

Next, a strategic analysis will be undertaken on the effects that global warming, an increasing demand for water due to growing populations, and poor water management practices, by both individuals and governments, have on the hydrological cycle. This is crucial as mounting scientific studies show that rising global temperatures will likely have an adverse impact on the world's hydrological cycle. This will lead to increased water scarcity for large areas of the world,

exacerbated by rising populations and poor water management practices, elevated sea levels and more destructive tropical storms.

This paper will then consider the national security implications of a transformed hydrological cycle. This analysis is critical as access to potable water, a seemingly basic human right, may be the spark of future conflicts, population migrations and significant economic and quality of life shifts. Rising sea levels and the intensification of severe tropical storms will not only contribute to the scarcity of fresh water, but could also lead to increased requirements for humanitarian assistance and necessitate substantial reinvestment in coastal infrastructure.

Finally, this paper will make recommendations to address the impending consequences of altering the hydrological cycle: the establishment of a Centre for National Environmental Security (CNES), the development of a modern National Water Policy (NWP), and adoption of water security as a key pillar of Canada's foreign aid policy.

The aim of this paper is to demonstrate that due to the strategic implications of the increasing importance of water to international and domestic security, Canada needs to treat water as a key strategic resource and to treat the unintended consequences of an altered hydrological cycle as a threat to national security.

DISCUSSION

Water – A Strategic Natural Resource

Millions have lived without love. No one has lived without water.
Turkish Businessmen, 1998³

²Norman Myers, "The Environmental Dimension to Security Issues," *The Environmentalist* (1986): 251, quoted in Colonel W. Chris King, *Understanding International Environmental Security: A Strategic Military Perspective*. (Atlanta: Army Environmental Policy Institute, 2000), 3.

³Marq De Villiers, *Water* (Toronto: Stoddart Publishing, 1999), Preface.

Although it is a renewable and seemingly abundant natural resource, water has been receiving increasing attention in scientific and academic circles. In the media it has been coined “blue gold” or “the oil of the 21st century,” referring to its growing importance as a key strategic natural resource on par with that of the “black gold” of the 20th century, petroleum. It is the growing scarcity of water that is fit for human consumption, otherwise called drinking or potable water, which is making it a key strategic resource and an important element in many international disputes and conflicts. However, despite holding 20 percent of the world’s freshwater supplies⁴ or perhaps because of that, Canada does not treat water as a strategic natural resource. Unfortunately, this approach is detrimental to the long-term security to all Canadians. To understand why Canada needs to treat water as a strategic natural resource, one must first understand the importance of water and the hydrological cycle to humans and human civilization and second, understand how that is being threatened.

Without a doubt water is our most precious natural resource. Sixty percent of the human body, 70 percent of the human brain and 90 percent of our lungs are composed of water. Humans need to consume 2.4 litres of water on a daily basis to survive.⁵ It is used for growing the food we eat and for ensuring the good sanitation and hygienic practices necessary for our health. Society uses water to generate power, as a raw material in the production of industrial goods and for the movement of people and goods. It is an essential element of the earth’s ecosystems. In short, water is a basic ingredient of life.

⁴Environment Canada. “Freshwater Website: Informational Resources and Services,” http://www.ec.gc.ca/water/en/info/misc/e_FAQ.htm; Internet; accessed 18 January 2007.

⁵U.S. Geological Survey. “The Water in You,” <http://ga.water.usgs.gov/edu/propertyyou.html>; Internet; accessed 21 January 2007.

Fortunately, water is also earth's most widely occurring and abundant resource. Our blue planet contains about 1.4 billion cubic kilometres of water⁶ covering 70 percent of its surface. Water also exists as vapour in the air, and in the ground, as soil moisture, and in aquifers. However, 97.5 percent of the world's water supply is salt water. Of the remaining fresh water, 68.9 percent is frozen in glaciers and permanent snow cover and 30.8 percent is groundwater, leaving only 0.3 percent of the world's fresh water in lakes and rivers.⁷ This equates to approximately 34,000 cubic kilometres of clean, drinkable water for humans. This would be more than sufficient for the planet's population if it were evenly distributed across the globe.⁸ However, it is not. Approximately 75 percent of the world's precipitation falls over areas occupied by less than one third of the world's inhabitants.⁹ Further, it does not fall at a uniform rate throughout the year, but varies considerably from one season to another.

The quantity of water on earth is finite; the same amount that existed in early geological times over 4 billion years ago exists today. It is in constant movement in a closed system called the hydrosphere (the earth and its atmosphere). Water moves around the world, between oceans, lakes, rivers, aquifers, groundwater, atmosphere, and organic and non-organic materiel from an above ground height of 15 kilometres to a depth of approximately 5 kilometres.¹⁰ It transforms between solid, liquid and gas, is used by plants and animals, but it never really disappears. It can be polluted and abused, but it cannot be created or destroyed.

Water circulates in the hydrosphere by way of what is called the hydrological cycle. It is this process that determines the amount of usable water to which humans have access. The sun

⁶Marq De Villiers, *Water...*, 30.

⁷Environment Canada. "Quickfacts," http://www.ec.gc.ca/water/en/e_quickfacts.htm; Internet; accessed 21 January 2007.

⁸Marq De Villiers, *Water...*, 32.

⁹Jill Boberg, *One World, One Well: How Populations Can Grow on a Finite Water Supply*. <http://www.rand.org/publications/randreview/issues/spring2006/water.html>; Internet; accessed 19 January 2007.

¹⁰Marq De Villiers, *Water...*, 29.

starts the cycle by causing the evaporation of the water from the surface of the earth's oceans, lakes and rivers. When the water vapour rises, it cools and condenses in the atmosphere to form clouds. The winds move the clouds across the planet distributing the water vapour. Eventually the clouds release the moisture in the form of precipitation, most of it falling into the oceans. Of the precipitation that falls on land, it either evaporates; infiltrates the soil to become groundwater, eventually seeping back to oceans, lakes, rivers or aquifers; or becomes runoff. Runoff occurs when precipitation falls faster than it can infiltrate the ground. Runoff remains on the surface and flows into streams, rivers, and eventually large bodies of water such as lakes, or oceans. Runoff is the renewable portion of this natural resource. Unfortunately in many parts of the world all of the available runoff is being used and there is nothing available for future population, agricultural or industrial expansion. These areas include large sections of southwestern United States, northwestern China, much of Europe and the Ganges basin in India.¹¹

Further, in distributing runoff, nature does not account for the human factor - demographics, poor water management, pollution and artificially induced climate change. As a result, many well-respected politicians, scientists and organizations feel the world is already in a water crisis. For instance, last year, former Soviet Union president Mikhail Gorbachev warned that "Clean drinking water, and water that can be used for irrigation, is in short supply in many countries, even today," and that by "2020 the water crisis would spread across half the world, leaving many countries without drinking water and proper sanitation."¹² Koïchiro Matsuura, Director-General of the United Nations Educational, Scientific and Cultural Organization

¹¹Thomas Homer-Dixon and Jessica Blitt, *Ecoviolence: Links Among Environment, Population, and Security*. (Lanham, MD: Rowman & Littlefield, 1998), 3.

¹²As quoted by Robert Mancuso in "Water in the News" *AAP News* July 22, 2006. <http://www.waterionizer.org/site/898596/page/878497>; Internet: accessed 21 January 2007.

(UNESCO), has stated "Of all the social and natural crises we humans face, the water crisis is the one that lies at the heart of our survival and that of our planet Earth." ¹³

There are a number of distressing facts that support these views. Every year 1.8 million people die from water related diseases. Ninety percent of these deaths are children under five years of age who live in developing countries. Across the planet 2.4 billion people lack access to adequate sanitation. Of these, one billion lack access to safe drinking water. ¹⁴

With 20 percent of the world's freshwater resources within its borders many Canadians believe that Canada will always be safe from any water crisis. This view of unlimited water availability may be why most Canadians have a cavalier attitude towards water. However, as John Sprague, an aquatic scientist, puts it, this perception of an abundance of water is simply a myth. Less than fifty percent of Canada's freshwater, equal to 6.5 percent of the world's freshwater supply, is renewable. ¹⁵ It also comes with some important caveats: more than half of that supply drains north to the Hudson Bay and the Arctic while close to 85 percent of the population lives along the border in southern Canada. Even the Great Lakes, which provide drinking water to 8.5 million Canadians and are the largest fresh surface water system in the world, have limitations: less than one percent of the water there is renewed annually. ¹⁶ As a result, only 2.6 percent of the world's water supply is actually accessible to Canadians – a comfortable, but not excessive amount, and certainly well below the mythical 20 percent figure. ¹⁷

¹³United Nations Educational and Scientific and Cultural Organization. "The World's Water Crisis Report," 4 <http://unesdoc.unesco.org/images/0012/001295/129556e.pdf> ; Internet: accessed 22 January 2007.

¹⁴Environment Canada. "Quickfacts," ..., 2.

¹⁵John B. Sprague, "Great Wet North? Canada's Myth of Water Abundance," in *Eau Canada: The Future of Canada's Water* edited by Karen Bakker, 23-35. (Vancouver: UBC Press, 200), 25.

¹⁶Environment Canada. "Quickfacts" ..., 5.

¹⁷John B. Sprague, "Great Wet North? Canada's Myth of Water Abundance," ..., 25.

Even this supply should be ample enough for the population. However, despite water being fundamental to our health and contributing between \$7.5 and \$23 billion annually to the Canadian economy,¹⁸ Canadians have become wasteful. They are second only to the Americans as the world's biggest per capita users of water. For example, between 1972 and 1996 Canada's population grew by one third; however, the rate of water withdrawal increased by 90 percent.¹⁹ As a result, between 1994 and 1999 droughts and poor infrastructure led to 26 percent of Canadian municipalities experiencing water shortages.²⁰ In 2006, Tofino, a West Vancouver Island community that receives three metres of rain annually, came within days of exhausting its water supply.

Pollution and poor water management have also led to tragedies. In 2000, Canadians were shocked when seven people died from E. coli contamination in the water supplies of the community of Walkerton, Ontario. A further 2,300 became sick. A year later in North Battleford, Saskatchewan, 7,000 became sick due to parasitic-infected water. In 2005 and 2006 the First Nation community of Kashechewan was evacuated due to the E. coli contamination of its water supplies. Water supply contamination is not an isolated event. Health Canada estimates that unsafe drinking water causes 90 deaths and 90,000 illnesses in Canada each year.²¹

Although Canada does not have the same water availability challenges as do many parts of the world, these examples show that it is not immune to water problems. Unfortunately there is growing evidence that the water crisis will get worse before it gets better. Global warming, combined with population growth and poor water management, has the potential to dramatically

¹⁸National Water Research Institute. "Threats To Water Availability In Canada – a Perspective." Des O'Neil DONMEC Consulting: 2; [Http://www.nwri.ca/threats2full/perspective-e.html](http://www.nwri.ca/threats2full/perspective-e.html); Internet; accessed 23 February 2007.

¹⁹Environment Canada. "Water, Water, Everywhere": 1; http://www.ec.gc.ca/EnviroZine/english/issues/30/feature2_e.cfm ; Internet: accessed 18 January 2007.

²⁰National Water Research Institute. "Threats To Water Availability In Canada – a Perspective." ..., 5.

alter the hydrological cycle and thereby exacerbate the current water crisis. This in turn would create serious environmental security implications for Canada, both domestically and internationally. As the moniker *blue gold* implies, water will become critical to our security and therefore needs to be recognized as a strategic natural resource.

Environmental Security

Environmental security encompasses a wide range of interrelated issues including climate change, ozone depletion, deforestation, food security and water security. However, it is a relatively new field of study and one can find a wide range of definitions that have been used to define it. For the purposes of this paper a blend of the definitions used by Colonel C. King, a professor at the United States Military Academy, and that of the United Nations Millennium Project will be used:

Environmental security is the relative safety from environmental dangers caused by natural or human processes due to ignorance, accident, mismanagement or design and originating within or across national borders.²² It is also the process for effectively responding to changing environmental conditions that have the potential to reduce peace and stability in the world and thus affect Canadian national security.²³

It follows that water security is a function of sustainable access to adequate quantities of safe drinking water for human and environmental uses, on a watershed basis.

“National security deals with threats that have the potential to undermine the security of the state or society,”²⁴ and fortunately for its citizens, Canada has been relatively secure and

²¹Sierra Legal Defence Fund, “Water Proof 2: Canada’s Drinking Water Report Card,”: 8; <http://www.sierralegal.org/reports/waterproof.II.report.pdf>; Internet; accessed 24 April 2007.

²²Millennium Project. “Environmental Security Study: Emerging International Definitions, Perceptions, and Policy Considerations”: 1; <http://www.acunu.org/millennium/es-exsum.html> Internet: accessed 31 January 2007.

²³Colonel W. Chris King, *Understanding International Environmental Security: A Strategic Military Perspective*. . . ., 17.

²⁴Privy Council Office, *Securing an Open Society: Canada’s National Security*.

prosperous. Even so, it has experienced a diverse range of threats, from Russian bombers and missiles to natural disasters and epidemics. So when the events of 9/11 challenged the state of Canadian national security, the federal government implemented a number of major initiatives and invested billions of dollars to ensure its citizens remained secure and that the Canada/United States border remained open and to the greatest extent possible unencumbered by trade and customs restrictions.

One of the government's initiatives was to publish its first ever national security policy, *Securing an Open Society: Canada's National Security Policy*, in April 2004. Unfortunately, it does not mention environmental security and only vaguely refers to some of the threats pertaining to environmental degradation.

Nevertheless, environmental security and more specifically its sub component - water security - has become an increasingly important issue in world affairs. For nations inhabiting the arid and semi-arid areas of the world, water scarcity has made water security an essential component of national security. As environmentalist Arun Elhance states, "...national security – human security, food security, economic security – can be seriously undermined by water security."²⁵ Recognizing that transborder water scarcity issues on a large scale can lead to instability, the US National Intelligence Council warned that water will become the principal resource scarcity issue by 2015 and that it will have an increasingly significant impact on United States national security.²⁶ This instability arises because many water security threats have transborder and global implications that require international cooperation to manage. As a result,

Policy. . . ., 3.

²⁵Arun P Elhance, *Hydropolitics in the 3rd World: Conflict and Cooperation in International River Basins* (Washington, D.C. : United States Institute of Peace Press, 1999), 230.

²⁶Maude Barlow, "Water Incorporated: The Commodification of the World's Water" *Global Policy Forum*: 1; <http://www.globalpolicy.org/globaliz/special/2002/0305water.htm> Internet; accessed 31 January 2007.

international efforts to resolve environmental problems may come into conflict with national sovereignty.

Accordingly, it is important to understand how the catalysts of global warming and population growth will make water the focal point for many of our environmental security concerns in the not so distant future.

Global Warming

The scientific community has understood for almost a hundred years now that the burning of fossil fuels and the resultant release of carbon dioxide (CO²) into the atmosphere affects the earth's climate. At first, the research was largely done out of curiosity. However, in 1957, a seminal paper written by Roger Revelle, an oceanographer, and Hans Suess, a chemist, predicted that the world's oceans' ability to absorb CO² would not be able to keep pace with humanity's ability to produce CO² emissions. As a result, the excess CO² would create a greenhouse effect that would eventually lead to global warming. In their famous declaration they stated:

Through his worldwide industrialized civilization, man is unwittingly conducting a vast geophysical experiment. Within a few generations he is burning the fossil fuels that slowly accumulated in the earth over the past 500 million years.²⁷

Since then the debate over the causes and effects of global warming on climate change has been intensifying. In 1988, in response to growing concerns about climate change, governments, through the World Meteorological Organization and the United Nations Environmental Program, established a process to investigate the human and natural effects that contributed to it. The organization formed to carry out this task was the Intergovernmental Panel on Climate Change

²⁷R. Revelle and H. Suess, "Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO₂ during the past decade." *Tellus* 9, (1957): 18-27.

(IPCC) and was composed of the world's leading climate and social scientists. In its fourth and most recent report, "Climate Change 2007: The Physical Science Basis" the IPCC concluded:

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.²⁸

The principal cause of climate change is the increase in greenhouse gases due to human activity such as the burning of fossil fuels and deforestation. When in the atmosphere, greenhouse gases insulate the earth from heat loss, producing a "greenhouse effect." Some of this is natural and necessary as the greenhouse effect regulates the earth's temperature. Without the natural greenhouse effect, which produces an average earth surface temperature of 15 degrees centigrade, all heat would escape out of the atmosphere resulting in an average surface temperature of -18 degrees centigrade. Most life would not survive. However, since the Industrial Revolution began, the concentrations of greenhouse gases in the atmosphere have increased sharply; carbon dioxide has gone up 30 percent, methane by 145 percent and nitrous oxide by 15 percent.²⁹ Even if the level of greenhouse emissions is stabilized at 2006 levels, it would still commit the world to being 3 to 10 degrees centigrade warmer by 2100. To understand the severity of this one must consider that the average temperature difference between the last ice age and today was 5 degrees centigrade.³⁰ As the globe heats up, the hydrologic cycle will be altered, producing a number of significant and undesirable consequences: changes in precipitation distribution patterns, more extreme weather events and a rise in sea levels. All of

²⁸Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis Summary for Policymakers*: 5; http://www.ipcc.ch/WG1_SPM_17Apr07.pdf; Internet; accessed 2 February 2007.

²⁹Environment Canada. *The Science of Climate Change*: 1; http://www.ec.gc.ca/climate/overview_science-e.html Internet; accessed 6 Feb 2007.

³⁰HM Treasury. *Stern Review on the Economics of Climate Change*; Part 2, Table 3.1, 57; http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm Internet; accessed 30 Jan 2007.

these changes will produce effects that will lead to increased water scarcity and natural disasters in many regions of the world.

Changes to Precipitation Distribution Patterns

The manner in which climate change will alter the patterns of precipitation distribution is still not entirely understood. However, one can postulate future distribution patterns by extrapolating from historical trends. One such trend is global warming. Eleven of the last twelve years rank among the twelve warmest since 1850 when the instrumental recording of global temperatures first began. As the world warms up there is greater likelihood of the hydrological cycle being affected. Shifts to weather patterns will occur because warming will not be uniform around the world; it will be greater at the poles than it will be over the oceans.³¹ In addition, rising temperatures increase the amount of water vapour that can be held in the atmosphere allowing more water to evaporate from the land in hotter areas across the globe.

Some regions will gain additional precipitation from the changes in the weather patterns. Meteorological data from the last 100 years show that there have been significant increases in annual precipitation to the eastern parts of North and South America, northern Europe and northern and central Asia. Environment Canada's climate model simulations predict an average precipitation increase of 10 to 20 percent in the higher latitudes of the Northern Hemisphere by 2100.³²

Conversely some regions will see a decrease in precipitation. A study from the Met Office Hadley Centre, the United Kingdom's official centre for climate change research, predicts that an

³¹Temperatures in the Arctic have increased at close to twice the global rate over the last 100 years. Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis Summary for Policymakers*: 7; http://www.ipcc.ch/WG1_SPM_17Apr07.pdf Internet; accessed 2 Feb 2007.

increase of 3 to 4 degrees centigrade in global temperature will increase the percentage of land area experiencing droughts from 10 percent to 40 percent while the proportion of land area experiencing extreme droughts will increase from 3 percent to 30 percent.³³ This is consistent with observations taken since the beginning of the twentieth century, which have found that drying has occurred in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Further, more intense and longer droughts have been observed in the tropics and subtropics over the last four decades than ever before.³⁴ This trend is also expected to continue. The decrease in precipitation will reduce runoff and as a result, will contribute significantly to a water scarcity problem for millions of people in the areas of the world least able to deal with it.

Increase in Severity of Extreme Weather Events

As greenhouse gases, through their insulation effect, increase the temperature in the troposphere, the warmer air heats up the surface of the world's oceans. Since the fuel that generates hurricanes comes from the latent heat generated when water vapour condenses, warmer oceans generate stronger storms. The consequences are profound. As Tim Flannery, author of the *Weather Makers*, describes it:

As the troposphere has warmed over the last decade, the world has seen the most powerful El Nino ever recorded (1997-1998), the most devastating hurricane in 200 years (Mitch, 1998), the hottest European summer on record (2003), the first South Atlantic hurricane ever (2002) and one of the worst storm seasons ever experienced in Florida (2004). This series of events, many would argue, indicates that the potential for the new climate to generate extremes is already increasing.³⁵

³²Environment Canada. *Projections for Canada's Climate Future*: 18; http://www.msc-smc.ec.gc.ca/saib/climate/ccd_00-01.pdf; Internet; accessed 25 April.

³³HM Treasury, *Stern Review on the Economics of Climate ...*, Part II, 62.

³⁴Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis Summary for Policymakers...*, 7.

³⁵Tim Flannery, *The Weather Makers*. (Toronto: HarperCollins Publishers Ltd., 2006), 136.

The IPCC has come to a similar conclusion. Observational evidence since 1970 shows a correlation between increases in tropical sea surface temperatures and increases in the intensity of hurricane activity. As oceans are expected to continue to warm, the IPCC expects that hurricanes will become even more intense in the future with greater wind speeds and heavier precipitation.³⁶ A study by the National Center for Atmospheric Research found that over the last 35 years, the number of Category 4 and 5 hurricanes³⁷ that occur each year, had almost doubled and traced the increase to rising ocean temperatures.³⁸ More intense hurricanes have the potential to have considerably more destructive winds, and carry with them stronger storm surges. Hurricanes similar to Hurricane Mitch or Hurricane Katrina, which caused devastation along much of the American north-central Gulf Coast in 2005, can be expected to become more common. Our ability to react quickly and effectively to these natural disasters will be crucial to thousands of potential victims in the future.

In addition to the destructive kinetic effects of hurricanes, the storm surges brought on by these powerful storms can permanently contaminate coastal fresh water sources with salt water and destroy vital coastal wetlands. Larger storms also mean increased rainfall, and when the inundation of rain overwhelms the earth's ability to absorb it the resulting runoff causes floods. In 2002, South Korea called out its military to help recover from floods that broke out when 20

³⁶Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis Summary for Policymakers...*, 9.

³⁷Using the Saffir- Simpson hurricane scale, a category 4 hurricane is characterized by winds between 210 and 249 km/hr and surges between 13 and 18 feet above normal. A category 5 hurricane is characterized by winds greater than 249 km/hr and surges greater than 18 feet above normal. More detailed descriptions can be found at the National Hurricane Center website; <http://www.nhc.noaa.gov/aboutsshs.shtml>; Internet; accessed 24 April 2007.

³⁸The National Center For Atmospheric Research, "Hurricanes Are Getting Stronger, Study Says." September 15, 2005. <http://www.ucar.edu/news/releases/2005/hurricanestudy.shtml>; Internet; accessed 16 May 2007.

percent of the country's annual rainfall fell in one week. During the same summer China suffered dramatic floods, which affected 100 million people.³⁹

Rising Sea Levels

During the last ice age, over 15,000 years ago, sea levels were more than 100 metres lower than they are today. Sea levels more or less stabilized 8,000 years ago after the great North American glaciers finally stopped melting. Over the last couple of hundred years sea levels have begun to rise, albeit very slowly. Most of the rise has been caused by thermal expansion of ocean waters and to a lesser extent by melting glacier and ice caps. However, as global temperatures rise, melting ice sheets are causing significant concern. The Columbia Glacier in Alaska has retreated 12 kilometres in the last 20 years. The Greenland and Arctic icecaps shrank an astonishing record 1 million square kilometres in 2002. Further, in 2004 scientists discovered that the Greenland icecap was melting at ten times the rate previously thought.⁴⁰ Although the melting Arctic icecap is mostly sea ice and therefore does not contribute to higher sea levels, the melting icecaps over land do.

It is not surprising then that the IPCC found sea levels to have risen at an average rate of 1.8 millimetres per year from 1961 to 1993, but at a much faster rate of 3.1 millimetres per year from 1993 to 2003. By the year 2100 sea elevations are projected to rise by up to 880 millimetres.⁴¹ Since the IPCC is a multi government organization it is reasonable to expect that these are conservative figures. Unfortunately, indications from scientific studies in Antarctica indicate that the IPCC figures may be too conservative. In 2002 Antarctica's Larsen-B ice shelf,

³⁹Tim Flannery, *The Weather Makers...*, 138.

⁴⁰*Ibid.*, 144.

⁴¹Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis Summary for Policymakers...*, 5.

approximately the size of Luxembourg, broke up over the course of a few weeks. It is expected that the rest of the Larsen ice-shelf will break up before the end of the century. Perhaps even more consequential to rising sea levels is the Amundsen ice plain. In 2004 NASA researchers published a report showing that in as few as five years large sections of the plain could break off and disappear as the Larsen-B ice shelf has. The runoff from the plain in 2004 was sufficient to raise sea levels by .25 millimetres a year and has the potential to raise them by 1.3 metres.⁴² Scientists have also raised concern about the West Antarctica ice sheet, which has the potential to raise oceans by an additional 16 to 50 millimetres by 2100. These figures, however, should be somewhat offset by increased snow that is expected to fall over the Arctic and Antarctica landmasses due to changing precipitation distribution patterns.⁴³ It is also comforting to know that at the extreme poles scientists have found that the temperatures have surprisingly gotten colder, indicating that a complete meltdown of the icecaps may not occur for hundreds if not thousands of years.⁴⁴

Nevertheless, even the IPCC's predicted 880 millimetre rise in sea levels by 2100 will pose a significant flooding threat to the more than 200 million people living in coastal floodplains around the world. More than 2 million square kilometres of land are less than a metre above sea elevation.⁴⁵ Large coastal cities such as London, Calcutta, Tokyo, New York, Miami, Mumbai, Manila, Lagos, Karachi and Shanghai will have to spend billions of dollars to build up flood defences. Wealthier cities like Hong Kong and Amsterdam have already demonstrated that they can adapt to rising sea levels through careful city planning, flood defences and reclamation projects. For those cities that do not act, or cannot afford to act, the risk of a flooding catastrophe

⁴²Tim Flannery, *The Weather Makers...*, 148.

⁴³Ibid., 149.

⁴⁴Ibid., 144.

⁴⁵HM Treasury, *Stern Review on the Economics of Climate...*, Part II, 76.

similar to that experienced by New Orleans in 2005 could become a distinct possibility. Island nations in the Pacific Ocean and the Caribbean Sea will also be threatened and the country of Bangladesh will be particularly hard hit as more than 25 percent of its population lives within coastal floodplains. Vietnam and parts of India and China will also be vulnerable, as will countries bordering the African coastline and the Nile River.

Whether flooding comes from slowly rising sea levels or from devastating storm surges brought on by powerful hurricanes, humanitarian crises will likely be much more common occurrences in the future. As populations are displaced, temporarily or even permanently, water will be in short supply and relief operations like that conducted by Canada's Disaster Assistance Relief Team (DART) after the 2004 tsunami in Indonesia will be required much more often. The second order destructive effects of coastal flooding could be even more damaging as the inundation of coastal lands by salt water will cause long-term contamination of vital underground streams and freshwater aquifers and thereby aggravate water scarcity challenges in many areas.

Impact of Population Growth on Water Scarcity

An old Chinese proverb says, "A single monk carries his own bucket of water; two monks carry their bucket of water together; but when there are three monks, there is no water at all." The unprecedented growth of the world's population has been a key factor in the growing scarceness of fresh water in many regions of the world. Over the last 70 years the world's population has increased three-fold; however, water consumption has increased six-fold.⁴⁶ By 2050 it is expected that there will be 9.3 billion people walking on the earth. As most of the growth rate will come from developing countries in arid regions it is predicted that anywhere

from 2 to 7 billion people will be living with water scarcity.⁴⁷ This can be seen in Map 1 where the greatest growth is in the developing countries where water is already limited and where economic and political resources are insufficient.



Map 1: Population growth rate in percent, as listed on CIA fact book (2006 estimate).

Water is used for three principal reasons: domestic consumption (drinking, sanitation, and landscaping) accounting for 10 percent of the world's use; agriculture (irrigation and livestock) accounting for 70 percent; and industry, accounting for 20 percent.⁴⁸

As developing countries become more industrialized the demand for water will increase. It is estimated that one ton of industrial product requires an average use of 200 tons of water. The production of one ton of steel and aluminium requires 40,000 and 300,000 gallons respectively. Refineries need 20,000 tons of water to produce one ton of petrol from crude oil. It takes 200,000 gallons of water to produce one ton of artificial fibre.⁴⁹ As a result, it is likely that water scarcity in developing countries will inhibit the development of water intensive industries.

⁴⁶Jill Boberg, *One World, One Well: How Populations Can Grow on a Finite Water Supply...*, 2.

⁴⁷United Nations Educational and Scientific and Cultural Organization. *The World's Water Crisis Report*: 12; <http://www.unesco.org/water/wwap/wwdr/pdf/chap1.pdf>; Internet; accessed 22 January 2007.

⁴⁸Jill Boberg, "One World, One Well: How Populations Can Grow on a Finite Water Supply." <http://www.rand.org/publications/randreview/issues/spring2006/water.html>; Internet; accessed 19 January 2007.

⁴⁹Water Desalination International "Water for the Future": 1; <http://www.waterdesalination.com/introduction.htm> Internet; accessed 12 February 2007.

More important for developing countries is their ability to grow food. It takes 1000 tons of water to grow one ton of potatoes or one ton of wheat. As populations grow and water scarcity increases, the agricultural sectors in these countries may not be able to keep up with the demand. The International Food Policy Research Institute expects that by 2025, demand for water will increase by 65 percent from 1995 levels. However, agricultural demand will only rise by 4 percent during the same time period, in large part due to limitations caused by scarcity of water for the world's farmers. This will mean slower growth in food production and changes in where the world's food is cultivated.⁵⁰ Food security will be a luxury. Developing countries, especially in dry areas, will be hit hardest and will dramatically increase their reliance on food imports. Although it is easier to import wheat than it is water, developing countries may not have the financial resources to do so. Ironically, countries like Canada and Russia, whose agriculture sector is expected to benefit from global warming, may also benefit from the plight of less fortunate countries as demand for their crops will likely increase.

Urbanization and the trend towards smaller households are also worsening the water situation. Urban sprawl reduces the ability of the land to filter rainwater before it reaches our rivers and lakes while smaller households increase the per capita usage of water.

As human settlements expand across the globe, deforestation tends to occur. Unfortunately, the removal of trees and their roots intensifies the erosion of the soil by runoff. Not only does it reduce the growing capacity of the area but also it reduces the ability of the soil to store water with a net effect of reduced water availability over time.⁵¹

⁵⁰International Food Policy Research Institute "Water and Food to 2025: Policy Responses to the Threat of Scarcity." 3; <http://www.ifpri.org/pubs/ib/ib13.pdf> Internet; accessed 17 March 2007.

⁵¹Colonel W. Chris King, *Understanding International Environmental Security: A Strategic Military Perspective* (Atlanta: Army Environmental Policy Institute, 2000), 53.

Desertification is also a growing problem as it affects 70 percent of all dry lands. It occurs when populations expand into dry areas; too much wood is cut, overgrazing occurs and too much groundwater is withdrawn, leading to the point where there is not sufficient water or soil to sustain vegetative cover. One sixth of the world's population is affected by desertification. Global warming will accelerate it some areas and have the opposite effect in other areas. When desertification does occur there will be extreme water scarcity, likely leading to mass human migrations.⁵²

Impact of Pollution & Waterborne Diseases

Another Chinese proverb provides excellent and timeless advice when it comes to water. “When drinking water, think of its source.” Some 2 million tons of waste are disposed of in water systems daily. Much of this is industrial waste, chemicals, pesticides and fertilizers. In developing states the impact is more pronounced, as developing countries tend to exercise poor governance over wastewater and have few facilities and little infrastructure to treat it. For instance, a study of India's rivers reported:

India's rivers, especially the smaller ones, have all turned into toxic streams. And even the big ones like the Ganga are far from pure. The assault on India's rivers – from population growth, agricultural modernization, urbanization and industrialization – is enormous and growing by the day.... Most Indian cities get a large part of their drinking water from rivers. This entire life stands threatened.⁵³

Unfortunately, many other developing countries have a similar problem. This not only reduces the availability of potable water, but also contributes to water contamination and the proliferation of water borne diseases. Contaminated water is the medium through which the vast

⁵²Ibid., 57.

⁵³United Nations Educational and Scientific and Cultural Organization. “The World's Water Crisis Report”: 11; <http://www.unesco.org/water/wwap/wwdr/pdf/chap1.pdf> Internet: accessed 22 January 2007.

majority of diseases are transmitted. In the developed world sewage is treated before it is discharged. In developing cities sewage often flows directly into the surface water system. Water scarcity reduces the amount of water available to move the waste from populated areas, thus affording flies and mosquitoes the opportunity to transmit the disease. Three water related diseases that have spread explosively in recent years are Dengue Fever, malaria and cholera. The World Health Organization estimates that there are 50 million cases of Dengue infection each year with fatality rates of up to 20 percent. Malaria strikes over 300 million people annually, killing over 1 million of those infected. As air temperatures rise and water scarcity increases, the percentage of humans exposed to malarial parasites is expected to rise from 45 to 65. Although cholera is not normally life threatening, it has spread dramatically in Africa and Latin America largely due to poor sanitation practices.⁵⁴

Waterborne diseases and contamination are not limited to the developing world. As mentioned earlier, Canada has had E. coli outbreaks and in 1993 Minneapolis had a waterborne disease outbreak, Cryptosporidium, which infected over 400,000 and killed 100 people.⁵⁵ It therefore behoves all governments to put proper water governance processes in place.

Water Scarcity Mitigation

Sometimes called the Holy Grail of water supply, desalination does offer some potential to improving the world's water situation. Desalinization is the process of producing freshwater by removing salt from seawater or brackish water. As a result desalinization plants are often looked upon as the solution to the world's water scarcity problems. Indeed, there are over 7,500

⁵⁴P.H. Gleick A. Singh and H. Shi. *Emerging Threats to the World's Freshwater Resources*. (Oakland: Pacific Institute for Studies in Development, Environment and Security, 2001), 9.

⁵⁵Colonel W. Chris King, *Understanding International Environmental Security: A Strategic Military Perspective*. . . ., 65.

desalination plants in operation around the world. The vast majority of these are small systems designed to support industrial or commercial operations. However, there are some large systems that produce water for cities in the United Arab Emirates, Saudi Arabia, Kuwait and Israel. Island nations such as Singapore and Trinidad also get some of their water supplies from desalination plants as will the city of Tampa Bay, Florida, when its desalination plant is completed in spring 2007.⁵⁶

The problem with desalination plants is that they are very expensive, and to date are really only economically viable in arid and wealthy countries. This is due to high capital and maintenance costs and an operating process that is very energy intensive. Desalination plants also produce brine, an environmentally hazardous by-product that is expensive to dispose of.

There are other methods for increasing water availability, including water conservation, building dams to control the flow of runoff, watershed rehabilitation through reforestation, pollution reduction and control, water reclamation, and regional water transfers. These are all proven water management techniques that can help mitigate water scarcity. To be successfully implemented they require strong national leadership, something often lacking in developing countries. As reported by UNESCO, “In many places of the world a staggering 30 to 40 percent of water or more goes unaccounted for due to water leakages in pipes and canals and illegal tapping.”⁵⁷ Water governance requires a water security strategy and a national water policy to achieve optimal results.

⁵⁶Jill Boberg, “Liquid Assets: How Demographic Changes and water Management Policies Affect Freshwater Resources,” 71; http://www.rand.org/pubs/monographs/2005/RAND_MG358.pdf; Internet; accessed 24 April 2007.

⁵⁷United Nations Educational and Scientific and Cultural Organization. “The 2nd United Nations World Water Development Report, 2006.” Chap 2, pg 4; http://www.unesco.org/water/wwap/wwdr2/pdf/wwdr2_ch_2.pdf; Internet; accessed 3 February 2007.

Strategic Implications for World Security

Whiskey is for drinkin'; water is for fighting.
Mark Twain

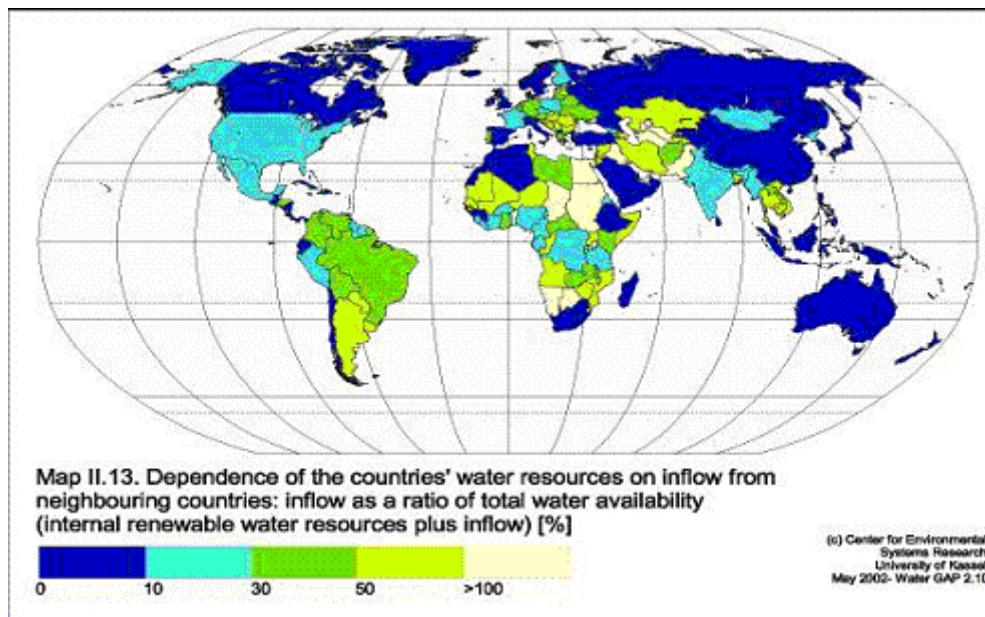
As water flows from upstream to downstream users, the amount withdrawn and the way it is used in upstream locations may affect the quantity and quality of the water that flows downstream. This gives water a geopolitical dimension that in extreme cases can lead to interstate conflicts. Although historically the number of conflicts generated by water disputes is low compared to the number of cooperative arrangements that have taken place between countries sharing the same water source, this dynamic may be changing. Dr. Peter Gleick, a leading water scientist, recorded 41 incidents involving conflict over water between 2000 and October 2006. They ranged from individuals fighting over access to wells, to terrorist attacks on water supplies, to governments cutting off water supply to neighbouring countries in trade disputes.⁵⁸ Further, there is growing evidence and concern that increasing water scarcity over the coming decades will cause water to be a leading contributor to international conflicts and wars as states vie for limited water resources.

As it is in Canada's national interest to have a world that is stable and conflict-free, it is important to understand the potential hotspots that may erupt over water disputes. There are 261 river basins in the world that are shared by two or more countries and 19 that are shared by five or more.⁵⁹ Although many treaties exist that contain provisions for water resources, few are detailed enough to assure coordinated management of international basins, particularly in the

⁵⁸Dr. Peter Gleick, *Water Conflict Chronology* (Pacific Institute for Studies in Development, Environment and Security) <http://worldwater.org/conflictchronology.pdf>; Internet; accessed 9 March 2007.

⁵⁹United Nations Educational and Scientific and Cultural Organization. "Water Security and Peace: A Synthesis of Studies Prepared Under the PCCP-Water for Peace Process."; 67. <http://unesdoc.unesco.org/images/0013/001333/133318e.pdf>; Internet; accessed 24 April 2007.

developing world.⁶⁰ When a country is dependent on its neighbour for, and when there is not sufficient water to satisfy everyone's needs, water or the lack of it becomes a contributing factor or even a cause of conflict. As shown in the following map, many countries in Africa, the Middle East and southern South America are dependant on their neighbours for over half of their water supply.



Map 2: Dependence of countries' water resources on inflow from neighboring countries.⁶¹

The University of Oregon conducted the largest study of water conflict and cooperation to date in 2001. By identifying historical indicators of international freshwater conflict and cooperation it sought to create a framework for identifying and evaluating international river basins at potential risk for conflicts in the future. No single indicator stood out as a primary catalyst for conflicts over water; however, there were some that correlated significantly with

⁶⁰Arun P Elhance, *Hydropolitics in the 3rd World: Conflict and Cooperation in International River Basins...*, 5.

⁶¹United Nations Educational and Scientific and Cultural Organization "Water Security and Peace: A Synthesis of Studies Prepared Under the PCCP-Water for Peace Process."; ..., 69.

water conflicts. These indicators were high population density, low per capita GDP, overall unfriendly international relations, and the absence of (or only limited) international freshwater treaties. The most likely indicators to cause conflicts were those associated with sudden changes to the governmental or infrastructure systems (for example, the building of dams) within a basin. Not surprisingly, the majority of basins the study found to be at risk (see Table 1 below) are in southern Asia and central and northern Africa.

#	Basin Name	Basin Riparians
CATEGORY 1 - Negotiating Current Conflicts		
1	Aral Sea	Afghanistan, China, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan
2	Jordan	Israel, Jordan, Lebanon, Palestinians, Syria
3	Nile	Burundi, Congo (Kinshasa), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda
4	Tigris-Euphrates	Iran, Iraq, Jordan, Saudi Arabia, Syria, Turkey
CATEGORY 2 - Indicators and Protests Over Water		
5	Asi/Orontes	Lebanon, Syria, Turkey
6	Ganges-Brahmaputra-Meghna	Bangladesh, Bhutan, Burma, China, India, Nepal
7	Han	North and South Korea
8	Indus	Afghanistan, China, India, Pakistan
9	Kune	Angola, Namibia
10	Lake Chad	Algeria, Cameroon, Central African Republic, Chad, Libya, Niger, Nigeria, Sudan
11	Mekong	Burma, Cambodia, China, Laos, Thailand, Vietnam
12	Okavango	Angola, Botswana, Namibia, Zimbabwe
13	Salween	China, Burma, Thailand
14	Senegal	Guinea, Mali, Mauritania, Senegal

Table 1: River Basins at Risk of Conflict ⁶²

The first category includes those basins that have ongoing conflicts, are widely recognized as hot spots and, although negotiations may be ongoing, in their cases the likelihood of continued

disputes remains. The second category lists basins where the potential for future conflicts exists. These include proposed development projects such as dams, large irrigation projects or other stresses upon the water system that have raised protests among the neighbouring countries. A brief examination of the top three cases in Table 1 will show the extent to which water scarcity can cause instability in a region.

Aral Sea: The Aral Sea Basin gets most of its water from two rivers, the Amu and the Syr, which begin in the Himalayas and wind their way north through valleys and the Kara Kum and Kyzyl Kum deserts before respectively feeding into the northern and southern tips of the Aral Sea. It is bordered by five former Soviet states: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, while Afghanistan and China are significant upstream players. Due to wide ranging water diversion schemes and other poor water management programs under the governance of the former Soviet Union, the Aral Sea has shrunk dramatically, losing 60 percent of its water in just 30 years. Further, the salt concentration has increased from 10 to 23 percent. Marq de Villiers, a Canadian water scientist and author, put it bluntly:

Without any exaggeration, the Aral Sea has become the greatest man-caused ecological catastrophe our benighted planet has yet seen, an awful warning of the consequences of hubris, greed and political ignorance.⁶³

The shrinking sea has wreaked havoc on the surrounding communities' livelihoods as fisheries and agriculture have been severely affected. Local weather patterns have also been changed, creating a much warmer and dryer environment. Water scarcity is now a major issue in the region. Indirectly, Canada is also affected by this water scarcity situation; Afghanistan, which occupies nearly 25 percent of the Amy Darya basin, currently uses very little of the water in the

⁶²Shira B Yoffe, *Basins at Risk Project*: Chap 4
http://www.transboundarywaters.orst.edu/projects/bar/BAR_chapter4.htm ; Internet; accessed 3 February 2007.

⁶³Marq De Villiers, *Water...*, 130.

region. However, should the situation in the country stabilize, it will likely draw upon more upstream withdrawals for agricultural and domestic use, further stressing the situation. Efforts to eradicate poppies have also been hampered by the unwillingness of farmers to switch to much more water intensive crops. If Canada is going to be successful in stabilizing the region, it would be prudent for it, and its allies, to address the water scarcity issues there.

Jordan River Basin: Then Israeli Prime Minister Yitzhak Rabin stated in 1999, “If we solve every other problem in the Middle East, but do not satisfactorily resolve the water problem, our region will explode.”⁶⁴ Israel, Jordan, Lebanon, Syria and the Palestinians share the basin. It is composed of the Jordan River; fed by the Baregit, Dan, Hasbani and Yamuk Rivers; wadis (small streams); and underground aquifers.

The region is one of the most obvious areas of the world where one state has improved its water security by occupying neighbouring territories.⁶⁵ Therefore it is not surprising that water is one of the major sticking points preventing peace in the area. Water scarcity in this region is caused by a number of factors; the aquifers are gradually being depleted, reducing the available water supply; the area’s population is booming (primarily among the Jordanians and Palestinians), thereby increasing demand; the pollution of the Jordan River is flowing into Jordan; and the uneven division of the water supply between the Israelis and the Palestinians is enraging the weaker side.

Since the region does not receive enough rainfall to meet its needs, water security is a perpetual concern. In an effort to reduce the water deficit, Israel has been building desalination plants, which are expected to meet 30 percent of its requirements. Unfortunately, due to

⁶⁴Scott Peterson, *What Could Float or Sink Peacemaking* Christian Science Monitor July 14 1999.

⁶⁵Arun P Elhance, *Hydropolitics in the 3rd World: Conflict and Cooperation in International River Basins*. ..., 86.

geography and wealth, this will not solve the water scarcity issues for Palestinians or Jordanians. These issues will need to be resolved by strong water governance regimes.

Nile River Basin: This area is home to an estimated 160 million people. They are divided among 10 countries that share the basin: Burundi, Rwanda, the Democratic Republic of Congo (DRC), Tanzania, Kenya, Uganda, Ethiopia, Eritrea, Sudan and Egypt. Recent UN figures highlight the problems of water scarcity in the region. Of 180 countries listed for water availability per person per year in the recently released World Water Development Report, Kenya is ranked 154th, Uganda 115th and Ethiopia 137th. The downstream countries of Sudan and Egypt are ranked 156th and 129th respectively.⁶⁶ Within the next 25 years, population within the Basin is expected to double, adding to the increased demand for water generated by growth in industry and agriculture.

The contention partly arises from two agreements signed during the colonial era - the 1929 Nile Water Agreement and the 1959 Agreement for the Full Utilization of the Nile - that gave Egypt and Sudan extensive rights over the river's use. The upstream countries, including the East African countries of Kenya, Uganda and Tanzania, have expressed concern over the long-standing arrangements, arguing the treaties have served to give Egypt unfair control over the use of the river's waters. They feel that none of the colonial treaties involved all the riparian countries and therefore did not deal equitably with the interests of the upstream countries. Regional analysts suggest that Egypt and Sudan have been reluctant to renegotiate the treaties. This has strained relations between the upper- and lower-riparian nations. The environmental damage – the degrading of water systems, the poisoning of rivers and aquifers, and the disruption

⁶⁶United Nations Educational and Scientific and Cultural Organization. *The 1st United Nations World Water Development Report*, ..., Part II, Table 4.2.

of the natural course of water - that characterizes water conflicts has magnified the water shortages in this basin.

In summary, water scarcity has the potential to instigate instability in many regions of the world. It arises because of intense political pressures to assure availability of this vital yet finite resource. Because water ignores political borders, these political pressures tend to lead to international disputes and can potentially, in extreme cases, be a contributor to the origins of international conflicts.

Strategic Implications for Canadian Security

Three significant trends stand out from a review of the above discussion on global warming and population pressures: the average temperature across the globe will continue to rise this century by 3 to 10°C; the world's population will likely rise to over 9.3 billion people by 2050 before stabilizing; and demand for water will likely rise due to continued population growth. These points are significant and as a result of them converging together global warming and human population growth will radically transform the hydrological cycle and humankind's relationship with it. Assuming that there is no dramatic, world-wide change in environmental policy in the immediate future, the global consequences of this transformation will be numerous:

1. Global warming will change the planet's precipitation distribution patterns, pushing them northward. Annual runoff will change regionally. Additionally, higher temperatures will lead to increased evaporation and, combined with growing populations, will lead to increased water scarcity for more than 3 billion people by the

year 2025.⁶⁷ The areas most affected will be Central and North Africa, Middle East, South and Central Asia and the Southwestern United States;

2. Warmer air temperatures will lead to warmer oceans. This will increase the intensity, destructive power and number of severe tropical storms (category 4 and 5);
3. Warmer air temperatures will increase the melting rate of glaciers and icecaps and increase the thermal expansion of the oceans. As a result sea levels will rise up to 880 millimetres by 2100; and
4. Water scarcity and stresses resulting from burgeoning populations will lead to the spread of waterborne diseases, particularly in developing countries that are least able to implement good sanitation governance.

It is evident from the above consequences that environmental degradation will pose serious threats to the world's stability and thus Canada's national interests and values. From these consequences a number of strategic international environmental security implications can be drawn for Canada.

Human health: Increased water scarcity will cause enormous hardship and poor health for billions of people. It will also cause reduced crop yield, particularly in tropical regions, leading to food shortages. Since humans vie for access to assured water availability, the potential for mass migration, conflicts and instability will increase. As the quantity and quality of water decreases waterborne disease will spread. The frequency of extreme weather events will also affect human health, directly during the storm and indirectly from the aftermath. It is likely that Canada will be called upon to provide foreign aid and disaster relief.

⁶⁷Intergovernmental Panel on Climate Change, "Climate Change 2001: Impacts Adaptation and Vulnerability," 3.1; http://www.grida.no/climate/ipcc_tar/wg2/011.htm; Internet; accessed 7 April 2007.

Conflicts: In water scarce regions of the world, water is already a strategic resource; it is essential for personal health, food production, sanitation, transportation and it is critical for many industries to operate. As a result, when water is in short supply political pressure will be intensified to make it available. For states sharing international river basins the potential for interstate disputes or conflicts will be increased, most notably in those countries bordering the Aral Sea, the Jordan River Basin and the Nile River Basin. This could lead to increased instability in these regions and throughout the international community. Even conflicts contained within a country can have international ramifications. As Homer-Dixon, the noted academic, states, “Conflicts generated by environmental scarcity can have significant indirect effects on the international community.”⁶⁸ Conflicts can lead to economic uncertainty, which could play havoc with international money markets again creating instability. In both situations Canada could be expected to provide military assistance and foreign aid.

Flooding: Rising sea levels will have an impact on many low-lying coastal areas affecting millions of people. They will also eliminate millions of acres of cropland reducing food production. Additional flooding will occur from more frequent and severe tropical storms. Finally, more flash flooding will occur, as warmer temperatures will enable the atmosphere to hold more water vapour, causing more intense rainstorms. Canada will likely be expected to provide military and disaster assistance relief.

Food Security: The transformation of the hydrological cycle will have positive effects on some regions of the world, but only on two countries: Canada and Russia will gain 90 percent of the agricultural benefits. The African continent, as well as India, the second most populous nation in the world, will lose out heavily as crop yields will be reduced by warmer temperatures

⁶⁸Thomas Homer-Dixon and Jessica Blitt. *Ecoviolence: Links Among Environment, Population, and Security*. Lanham, MD: Rowman & Littlefield, 1998, 228.

and less water available for irrigation.⁶⁹ Canada will likely be expected both by the international community as well as its citizens, to provide food through foreign aid initiatives as it did in response to the 1984 - 1985 Ethiopia famine.⁷⁰

Sovereignty: Since environmental security threats are often global in their origins and their impact, environmental security cannot be addressed in isolation. International cooperation is required to encourage other nations to address environmental threats. This means that situations could develop where national sovereignty could be threatened from actions imposed by other nations to ensure global environmental security. Whether it is encouraging, perhaps through sanctions, a reduction in greenhouse gas emissions or in securing access to freshwater resources, sovereignty could be challenged. As typified by the Kyoto Accord, Canada, as one of the largest per capita emitters of CO², will need to ensure that its legislation and emission output satisfies the expectations of the global community. Otherwise it could face steep financial penalties and international isolation. It will also have to closely watch the situation in the United States and have policies in place to deal with the potential pressure to sell southwestern states bulk water.

Changes to the hydrological cycle are also going to cause numerous challenges domestically. The strategic implications are significant; some are beneficial but again assuming no radical international policy changes in the immediate future, many will create serious challenges to overcome.

Agriculture: A warmer climate will lengthen the growing season thereby increasing agriculture productivity for certain crops. This benefit may be somewhat offset by reduced availability of water in the southern parts of the Prairie provinces.

⁶⁹Tim Flannery, *The Weather Makers...*, 288.

Shorter winter: A shorter and milder winter will result in reduced heating costs, snow removal and road and vehicle maintenance costs benefiting individuals and governments.

Water scarcity: The western provinces already face water availability challenges. Some parts are semi-arid and Alberta faces huge growth in water demand from its population and industrial expansion. In certain areas water renewal levels are matched and often exceeded.⁷¹ Compared to a century ago, summer flows have already decreased by 40 percent in many of Alberta's rivers.⁷²

Infrastructure: New Brunswick, Prince Edward Island and British Columbia are already threatened by rising sea levels. Over the course of the 20th century the sea level around PEI rose by 25 centimetres.⁷³ Should it continue to rise, as predicted by the IPCC, close to 50 percent of its coastal buildings could be lost by 2100. As a result, the effects of rising sea levels on coastal infrastructure, especially in low-lying areas, will need to be studied. Zoning and building codes will require amending. There will be a need to develop and encourage the rebuilding of existing ports, bridges and highways to allow for rising sea levels. In the interior it will be necessary to ensure that bridges, highways, and buildings are capable of withstanding more frequent and more severe flooding.

The North: The effects of receding permafrost in the North will need to be studied to determine its impact on the Inuit and their way of life, the fauna and flora of the Arctic. Major costs will be incurred as pipelines, roads, and buildings will require relocation or strengthening due to increased land instability. Further, as the ability to use ice bridges to re-supply northern

⁷⁰Brian Stewart, "Beyond Tears," *CBC news on-line*, 14 December 2004; available from <http://www.cbc.ca/news/background/ethiopia/beyond-tears.html> Internet; accessed 22 April 2007.

⁷¹Standing Senate Committee on Energy, the Environment and Natural Resources. *Water in the West: Under Pressure: Intro*; <http://www.parl.gc.ca/38/1/paribus/commbus/senate/com-e/enrg-e/rep-e/rep13nov05-e.htm> Internet; accessed 8 April 07.

⁷²Ibid., Climate Change and Water.

communities will lessen, alternate methods will need to be developed. As the Northwest Passage becomes more navigable, a strategy to cope with the possible threat to sovereignty will have to be developed.

Lower lake levels: Increased evaporation is expected to decrease average water levels in the Great Lakes. This will cause a reduction in tonnage carried by ships traversing the Seaway. Reduced lake levels elsewhere may also adversely affect hydroelectric projects.

Waterborne Diseases: Mounting scientific evidence links weather as a factor in waterborne disease outbreaks. In the US a study found that more than half of the waterborne disease outbreaks followed a period of heavy rainfall.⁷⁴ Health Canada recently funded a study into the relationship between waterborne diseases and climate change. Its main conclusions were that waterborne diseases are a burden to Canadians; the risk of waterborne diseases is related to ambient temperature and rainfall; and climate change will alter the distribution risk of waterborne diseases in Canada.⁷⁵ For example, in the last few years, malaria, lyme and West Nile virus have spread through southern Canada.⁷⁶

Whether looking at the strategic implications from either a domestic or international perspective, the destabilizing potential to the world from global warming and a changing hydrological cycle is of sufficient magnitude for environmental security to warrant consideration as a key component of Canada's national security. Within the environmental security sector, water security should merit consideration for being the foundation upon which environmental security can be achieved.

⁷³Environment Canada. *The Science of Climate Change - Impacts of Climate Change*. http://www.msc-smc.ec.gc.ca/education/scienceofclimatechange/understanding/impacts_e.html; Internet: accessed 25 April 2007.

⁷⁴Ecosystems Climate Change and Health Omnibus Project. "Climate Change and Waterborne Diseases in Canada." <http://www.eccho.ca/projects.asp?ID=2> Internet; accessed 20 March 2007.

⁷⁵Ibid.

⁷⁶Environment Canada. *The Science of Climate Change- Impacts of Climate Change ...*

THE WAY AHEAD

When it comes to climate change the world is a single theatre of operations and Canada is an integral part of it. In order to protect the national values and interests of Canada the coordination and synchronization of the full array of national power is needed to counter the threats arising from changes to the hydrological cycle. This would include the development of mitigation strategies focusing on reducing climate change through the reduction of carbon emissions. In addition, adaptation strategies need to be developed and funded in recognition that even if we stopped all human made carbon emissions today, the effects of climate change would continue for decades.

Therefore, in order to address all the strategic security implications discussed above it is recommended that the following initiatives be implemented:

1. The establishment of a Centre for National Environmental Security (CNES);
2. The reorientation of foreign aid policy towards improving water security; and
3. The development of a national water policy.

Centre for National Environmental Security

The risk of international conflicts and destabilizing incidents will grow as the impact of global warming on the hydrological cycle becomes more pronounced. Water scarcity, rising sea levels and intensifying weather events will generate a number of threats to Canada's national security. It is also likely that climate change will produce even more complex, unpredictable and potentially devastating threats in the future.

These environmental threats are not the normal military and terrorist threats that Canada has faced in the past. Nevertheless, the Canadian government's ability to prevent or at least lessen the impact of them is vital to ensuring national economic, social and political stability. Since preventive action requires early anticipation and proactive policy making, government resources need to be devoted to early warning and analysis of these types of threats. An organization dedicated to environmental security would be able to provide the most timely and effective response. A timely response is critical to dealing with any emerging threat. As Sir Winston Churchill said:

One ought never to turn one's back on a threatened danger and try to run away from it. If you do that, you will double the danger. But if you meet it promptly and without flinching, you will reduce the danger by half.⁷⁷

Further, in many situations it is not a shortage of information that prevents a timely response to a threat, but rather the analysis and then translation into policy and political will to do something about it that is lacking.⁷⁸ Therefore, in order to assess and respond to the security implications of a changing hydrological cycle it is recommended that the Government of Canada establish a CNES.

As a federal agency it will need to forge links to other federal agencies and departments such as Environment Canada's National Water Research Institute. Since water governance in Canada is divided between the federal government (fisheries, navigation, environment and international relations including the management of trans boundary waters with the United States) and the provinces (flow regulation, water supply, pollution control, water use development and hydroelectric power development), CNES will also need to build relationships

⁷⁷From internet. <http://www.quotationspage.com/quote/2450.html>

⁷⁸International Commission on Intervention and State Sovereignty *The Responsibility To Protect: Report of the International Commission on Intervention and State Sovereignty* (Ottawa: International Research Development Centre, 2001), 21.

with provincial water departments. Similar relationships will have to be formed with municipalities, to whom drinking water treatment and wastewater treatment is normally delegated by the provinces.⁷⁹

Composed of analysts educated in analytical techniques and knowledgeable in multiple disciplines, the CNES would be dedicated to studying these non-traditional threats to security and the new and emerging environmental risks they pose to Canada's national interests and values.

To carry out its important mandate CNES needs to be structured as a professional, politically independent and neutral organization. In Canada's partisan political system, where short term thinking dominates, a non-partisan organization that can conduct strategic research and provide politically baggage-free recommendations on the strategic implications of complex, long term threats, is essential. Otherwise threats and response strategies will get caught up in short term politics and will be at best diluted or at worst ignored. Although neutral, if the elements of national power are to be harnessed in a planned manner, the CNES should have the authority to provide strategic advice directly to cabinet. This would give the governing power access to thorough analysis and advice on emerging environmental security threats and issues, allowing it to provide direction and a reasoned response. In addition, from a political perspective, by having an organization look out at emerging issues in a proactive manner, the government could prepare strategies in advance to counter or deflect criticism from the opposition.

A fundamental tenet of any threat response is the development of a strategy for the prevention of and, if that is not possible, the implementation of rapid and stabilizing influences. The CNES would be responsible for developing a national environmental security response

⁷⁹Environment Canada. "Freshwater Website: Water Policy and Legislation." http://www.ec.gc.ca/water/en/policy/coop/e_juris.htm; Internet; accessed 22 April 2007.

strategy. Responses to complex threats require a national strategy to drive the application of all elements of power at the government's disposal. They require a whole of government approach that analyses economic, political, military, scientific, cultural, environmental, legal and ethical implications, from both domestic and international viewpoints. Further, response strategies need to be developed with an understanding of the strategic implications these strategies have on Canada's national interests and on its values. For instance a National Water Policy might be developed which prohibits the shipping of bulk water to the United States. It could be argued that this supports Canada's values; however, if water becomes extremely scarce in the US Midwest in the future, as some predict, alienating our number one trading and security partner may be not in our national interest. In any case the full consequences and risks associated with a particular response strategy, including second and third order effects, need to be understood before it is implemented:

True strategic thought (thinking) rests not in the development and implementation of successful solutions to problems, but rather in the consideration of the unintended and often unexpected consequences of those solutions.⁸⁰

This analysis is critical if an effective response strategy is going to be developed. Because of the very technical and complex nature of environmental threats, an organization devoted to the study of these issues, such as the CNES, would be very beneficial. Its initial work should focus on:

1. Determining mitigation and adaptation strategies for dealing with the growing and potential severe consequences of changes to the water cycle, including growing water scarcity, increasingly severe storms, rising sea levels and proliferation of waterborne diseases, for both Canadian and international water resources;

⁸⁰Conversation with Capt (N) Mark Norman, original author unknown, 15 February 2007.

2. Providing guidance on integrating research efforts into water security and water science and policy from among the various federal and provincial agencies and departments;
3. Working with appropriate agencies to identify necessary steps to ensure the physical security of the nation's water resources and water infrastructure;
4. Encourage the development of environmental friendly technology by Canadian industry;
5. Developing recommendations for a Canadian role in identifying and addressing global water security problems, using a whole of government approach; and
6. Making recommendations for reducing the risks of international tensions over shared water resources and bulk water sales with the United States.

With sufficient resources, a CNES could also be structured and mandated to provide a number of other benefits in improving the nation's understanding of and approach to environmental security issues. These would include:

1. The provision of comprehensive knowledge and expertise to politicians and senior bureaucrats on subjects that they would not be normally intellectually prepared for or have the time to develop.⁸¹ This could be done through individual or group briefings or courses for newly minted parliamentarians;
2. The undertaking of studies, or the provision of advice, to members of parliament or senior government officials on matters of national environmental security;
3. The coordination of research into issues of national concern, leveraging off other capabilities and centres of excellence across the nation or around the world. These

- include universities, private institutions, and other government departments and agencies. In doing so it would be able to provide an integrated whole of government approach to major environmental security issues; and
4. The coordination of the development of mitigation and adaptive strategies. This is key, as the consequences of climate change will require comprehensive adaptive measures for all societies.

Water Security: The Foundation of Canadian Foreign Aid Policy

Canada has decided to take a whole of government approach to improving development effectiveness in fragile states. The top three priorities for the government are Afghanistan, Haiti and the Sudan. Interestingly enough, water scarcity is an issue in all three countries. In Afghanistan, 99 percent of the water is used for agricultural purposes, only 13 percent of the population has access to safe drinking water and only 12 percent has access to sanitation.⁸² Sudan has had a long history of droughts and poor water management. Water scarcity has also contributed to instability in the densely populated island nation of Haiti, the source of numerous interventions by Canada and its allies. It can only provide its people with 30 liters of water per person per day, it has very poor sanitation and it is completely deforested.⁸³

Although Canada does contribute to stability in these states through the Canadian International Development Agency (CIDA), the results have been at best limited, or perhaps even a failure, as the Standing Committee on Foreign Affairs and International Trade has bluntly

⁸¹John English, "The Member of Parliament and Foreign Policy." Chapter 4 in *Canada Among Nations 1998: Leadership and Dialogue*, ed. Fen Osler Hampson and Maureen Appel Molot. (Toronto: Oxford University Press, 1998), 69-80.

⁸²Colonel W. Chris King, *Understanding International Environmental Security: A Strategic Military Perspective...*, 65.

⁸³Ibid ..., 94.

assessed all of CIDA's efforts in Africa.⁸⁴ This is partly due to limited funding; Canada's yearly budget for development aid is only 0.3 percent of gross national product. But CIDA's poor performance is also due to incoherent policy and strategy. The policy encourages the funding of a plethora of diverse and relatively smaller projects within a fragile state. The Senate report encourages CIDA to focus on governance and economic development.⁸⁵ For instance, in Afghanistan CIDA provides aid to projects involving education, roads, justice, police, borders, medicine and water. As a result, the impact of its efforts is spread too thin, limiting effectiveness to the point where it is hardly noticed beyond the immediate area. If CIDA were to concentrate its efforts in only a couple of areas of expertise it would be easier to get the "most bang for its buck" and it might find that it can "make a difference." By focusing CIDA's efforts, Canada's ability to effectively contribute to the stability of a country would be strengthened. It would also be easier to manage, develop expertise and measure results. One area that CIDA should concentrate on is economic development through water security. Whether building hand wells, karezes, traditional Afghan canals, drainage projects, irrigation projects, wastewater systems, dams, or improving water management through education, by taking a leading role in the development of water security, Canada could make a difference to the health of a target country's citizens. At the same time it would build the foundation for economic development of what are typically agricultural based societies.

National Water Policy

Water shortages, water contamination, and pressure to export water in bulk to the United States are but some of the water related issues Canada needs to address to assure water security.

⁸⁴Standing Committee on Foreign affairs and International Trade. *Overcoming 40 Years of Failure: A New Road Map for Sub-Saharan Africa*: 9; <http://www.parl.gc.ca/39/1/parlbus/commbus/senate/com-e/fore-e/rep-e/repafriFeb07-e.pdf> Internet; accessed 8 April 2007.

⁸⁵Ibid., 14.

However, Canada's national water policy has not been updated since 1987 and is poorly equipped to meet the demands of today, never mind the requirements of the future.⁸⁶ This is partly due to the division of responsibilities for water between federal, provincial and municipal authorities. It is also due to the myth that Canada has an abundance of freshwater within its borders. As the Senate committee report *Water in the West: Under Pressure* states:

Water is too critical a resource to be ignored. The threats to water availability and quality are real and are particularly evident in the West. Population growth, economic expansion and climate change all contribute to putting western Canada's water resources at risk.⁸⁷

A national water policy would contribute to Canadian water security by addressing water security issues, such as:

Bulk Water Transfers: Pressure to transfer water in bulk to the United States has lessened in recent years largely due to reduced growth in demand for water, environmental concerns and the exorbitant costs associated with the more ambitious transfer schemes. However, this may change if global warming severely affects the agricultural segment of the American economy.⁸⁸

Water Supply Contamination: As demonstrated by contamination of water supplies in Walkerton, North Battleford and Kashechewan, along with hundreds of boil water advisories a year, water contamination is very real problem in Canada. Accordingly, national clean drinking water standards need to be established.

Water Scarcity: Although Canada is a water rich nation by any standard, the water is not always in the right place. Water scarcity is already a problem in the Prairies and in particular

⁸⁶Karen Bakker, *Eau Canada: The Future of Canada's Water* (Vancouver: UBC Press, 2007), 4.

⁸⁷Standing Senate Committee on Energy, the Environment and Natural Resources. *Water in the West: Under Pressure...*, conclusion.

⁸⁸Frederic Lasserre, "Managing Water Diversion from Canada to the United States" *International Journal*. Winter 2006-2007. (Advance copy), 92.

Alberta as well as in many municipalities that rely on finite supplies of groundwater. A conservation strategy needs to be part of the National Water Policy.

CONCLUSION

Global warming is inexorably changing the hydrological cycle. While a change of only 1 degree centigrade can significantly alter weather patterns around the world, the IPCC is forecasting a warming of between 3 and 10 degrees centigrade by 2100. This has the potential to drastically alter precipitation distribution patterns, raise sea levels and intensify the severity of storms thereby creating severe threats to Canadian and international security.

Water security is already a global issue, as more than one billion of the world's inhabitants lack easy access to fresh drinking water. Changing precipitation patterns, human population growth and poor water management practices mean that by 2025 two out of three people across the globe will be living with serious water shortages, or absolute water scarcity.

Many think Canada's abundant water resources make it immune to water security issues, but unfortunately that is just a myth. Canada already has experienced deadly water contamination incidents, localised water shortages, an increase in waterborne diseases and water disasters caused by extreme weather events. Regrettably, Canada does not have a national strategy to address water security issues. The current federal national water policy is two decades old and predates our contemporary understanding of climate change.

To deal with the emerging threats of a changing hydrological cycle, Canada needs to establish a Centre for National Environmental Security and adopt water security as a key pillar in its foreign aid strategy. It further needs to develop a National Water Policy that treats water as a strategic natural resource. It is through these initiatives that mitigation and adaptation strategies

for these environmental threats can best be developed and implemented, assuring Canada's national security.

Finally, it is imperative that action be taken sooner rather than later as the consequences of water scarcity, rising sea levels, and more frequent and intense storms are already being felt. Global warming will only make it worse. "The cost of not responding to emerging water challenges," as explained in the Senate report on *Water in the West*, "would likely dwarf the cost of addressing them, and failure to respond will jeopardize life as we know it."⁸⁹

⁸⁹Standing Senate Committee on Energy, the Environment and Natural Resources. *Water in the West: Under, Water Under Pressure*.

BIBLIOGRAPHY

Bakker, Karen. *Eau Canada: The Future of Canada's Water*. Vancouver: UBC Press, 2007.

Barlow, Maude. "Water Incorporated: The Commodification of the World's Water" *Global Policy Forum*, 5 March 2002
<http://www.globalpolicy.org/globaliz/special/2002/0305water.htm> ; Internet; accessed 31 January 2007.

Boberg, Jill. "One World, One Well: How Populations Can Grow on a Finite Water Supply." <http://www.rand.org/publications/randreview/issues/spring2006/water.html>; Internet; accessed 19 January 2007.

Boberg, Jill. "Withdrawing Liquid Assets: How Demographic Trends Affect the Freshwater Supply." http://www.rand.org/pubs/research_briefs/RB9102/index1.html; Internet; accessed 20 January 2007.

Bodner, Maj M.A. *Water, Water Everywhere?* Toronto: Canadian Forces College, 2001.

Bouguerra, Larbi. *Water Under Threat*. Black Point: Fernwood Publishing, 2006.

Canada. Privy Council Office. *Securing an Open Society: Canada's National Security Policy*. Ottawa: Privy Council Office, 2004.

Canadian Water Network. "Safeguarding Surface and Groundwater in Oil-Rich Alberta." <http://www.cwn-rce.ca/index.php?fa=Media.showFeatureNov2005>; Internet; accessed 8 March 2007.

Conference Board of Canada. *Operationalizing Adaptation to Climate Change*. Briefing February 2007.

De Villiers, Marq. *Water*. Toronto: Stoddart Publishing, 1999.

Earth Sciences. "Hydrologic Cycle." <http://www.und.edu/instruct/eng/fkarnar/pages/cycle.htm>; Internet; accessed 28 January 2007.

Elhance, Arun P. *Hydropolitics in the 3rd World: Conflict and Cooperation in International River Basins*. Washington: United States Institute of Peace Press, 1999.

English, John. "The Member of Parliament and Foreign Policy." In *Canada Among Nations 1998: Leadership and Dialogue*, edited by Fen Osler Hampson and Maureen Appel Molot, 69-80. Toronto: Oxford University Press, 1998.

- Environment Canada. "Freshwater Website: Informational Resources and Services." http://www.ec.gc.ca/water/en/info/misc/e_FAQ.htm; Internet; accessed 18 January 2007.
- Environment Canada. "Quickfacts." http://www.ec.gc.ca/water/en/e_quickfacts.htm; Internet; accessed 21 January 2007.
- Environment Canada. "Water, Water, Everywhere." http://www.ec.gc.ca/EnviroZine?english/issues/30/feature2_e.cfm; Internet; accessed 18 January 2007.
- Environment Canada. "The Science of Climate Change." http://www.ec.gc.ca/climate/overview_science-e.html; Internet; accessed 6 February 2007.
- Flannery, Tim. *The Weather Makers*. Toronto: HarperCollins Publishers Ltd., 2006.
- Gleick, P.H., A. Singh, and H. Shi. *Emerging Threats to the World's Freshwater Resources*. Oakland: Pacific Institute for Studies in Development, Environment and Security, 2001.
- HM Treasury. "Stern Review on the Economics of Climate Change." http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm; Internet; accessed 30 January 2007.
- Holm, Wendy. *Water and Free Trade: The Mulroney Government's Agenda for Canada's Most Precious Resource*. Toronto: J. Lorimer, 1988.
- Homer-Dixon, Thomas and Jessica Blitt. *Ecoviolence: Links Among Environment, Population, and Security*. Lanham, MD: Rowman & Littlefield, 1998.
- Intergovernmental Panel on Climate Change. "Climate Change 2001: Impacts Adaptation and Vulnerability." <http://www.ipcc.ch/pub/online.htm>; Internet; accessed 7 April 2007.
- Intergovernmental Panel on Climate Change. "Climate Change 2007: The Physical Science Basis Summary for Policymakers." <http://www.ipcc.ch/index.html>; Internet; accessed 2 February 2007.
- Intergovernmental Panel on Climate Change. "Climate Change 2007: Impacts, Adaptation and Vulnerability Summary for Policymakers." <http://www.ipcc.ch/index.html>; Internet; accessed 22 April 2007.
- International Committee of the Red Cross. *Forum: war and water*. Geneva: International Committee of the Red Cross, 1999.
- International Commission on Intervention and State Sovereignty. *The Responsibility To*

- Protect: Report of the International Commission on Intervention and State Sovereignty.* Ottawa: International Research Development Centre, 2001.
- International Food Policy Research Institute “Water and Food to 2025: Policy Responses to the Threat of Scarcity.” <http://www.ifpri.org/pubs/ib/ib13.pdf>; Internet; accessed 17 March 2007.
- Keating, Michael. *The Last Drop.* Toronto: Macmillan of Canada, 1986.
- King, Colonel W. Chris. *Understanding International Environmental Security: A Strategic Military Perspective.* Atlanta: Army Environmental Policy Institute, 2000.
- Klare, Michael T. *Resource Wars: the new landscape of global conflict.* New York: Metropolitan Books, 2001.
- Lasserre, Frederic. “Managing Water Diversion from Canada to the United States” *International Journal.* Winter 2006-2007. (Advance copy)
- Laxer, James. “The Greene-ing of Canadian Independence: The Canadian Challenge” In *Independence: The Canadian Challenge*, edited by Abraham Rotstein and Gary Lax, 139-155. Toronto: Committee for an Independent Canada, 1972.
- Lonegan, Steve. “Water and War.” <http://www.ourplanet.com/imgversn/154/lonegan.html>; Internet; accessed 31 January 2007.
- Macnamara, W.D. and Ann Fitz-Gerald. *A National Security Framework for Canada.* Montréal: Institute for Research on Public Policy, October 2002.
- Mancuso, Robert. “Water in the News” *AAP News* July 22, 2006. <http://www.waterionizer.org/site/898596/page/878497>; Internet: accessed 21 January 2007.
- Millennium Project. “Environmental Security Study: Emerging International definitions, Perceptions, and Policy Considerations.” <http://www.acunu.org/millennium/es-exsum.html>; Internet; accessed 31 January 2007.
- Mitchell, Alanna. “Here Comes the Heat.” *The Walrus*, March 2007, 33-41.
- The National Center For Atmospheric Research. “Hurricanes Are Getting Stronger, Study Says.” September 15, 2005. <http://www.ucar.edu/news/releases/2005/hurricanestudy.shtml>; Internet; accessed 16 May 2007.
- NASA’s Observatorium. “Hydrologic Cycle.” <http://observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html>; Internet; accessed 28 January 2007.

- National Water Research Institute. "Threats To Water Availability In Canada – a Perspective." Des O'Neil DONMEC Consulting [Http://www.nwri.ca/threats2full/perspective-e.html](http://www.nwri.ca/threats2full/perspective-e.html); Internet; accessed 23 February 2007.
- Nichiporuk, Brian. "The Security Dynamics of Demographic Factors." http://www.rand.org/pubs/monograph_reports/MR1088/index.html ; Internet; accessed 27 January 2007.
- Pearse, P.H., F. Bertrand and J.W. Maclaren. *Currents of Change: Final Report Inquiry on Federal Water Policy*. Ottawa: The Inquiry, 1985.
- Peterson, Scott. "What Could Float or Sink Peacemaking" *Christian Science Monitor* July 14, 1999.
- Revelle, R. and H. Suess. "Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO₂ during the past decade." *Tellus* 9, (1957): 18-27.
- Rothfeder, Jeffery. *Every Drop for Sale: Our Desperate Battle Over Water in a World About to Run Out*. New York: Penguin Putnam, 2001.
- Schwartz, Peter, and Doug Randall. "An Abrupt Climate Change Scenario and Its Implications for United States National Security." October 2003 http://www.environmentaldefense.org/documents/3566_AbruptClimateChange.pdf; Internet; accessed 7 March 2007.
- Sierra Legal Defence Fund. "Water Proof 2: Canada's Drinking Water Report Card." <http://www.sierralegal.org/reports/waterproof.II.report.pdf> ; Internet; accessed 24 April 2007.
- Standing Senate Committee on Foreign affairs and International Trade. "Overcoming 40 Years of Failure: A New Road Map for Sub-Saharan Africa." <http://www.parl.gc.ca/39/1/parlbus/commbus/senate/com-e/fore-e/rep-e/repafriFeb07-e.pdf>; Internet; accessed 8 April 07.
- Standing Senate Committee on Energy, the Environment and Natural Resources. "Water in the West: Under Pressure." <http://www.parl.gc.ca/38/1/parlbus/commbus/senate/com-e/enrg-e/rep-e/rep13nov05-e.htm>; Internet; accessed 8 April 07.
- United Nations Educational and Scientific and Cultural Organization. "The 1st United Nations World Water Development Report: Water for People, Water for Life," http://www.unesco.org/water/wwap/wwdr1/table_contents/index.shtml ; Internet; accessed 22 January 2007.
- United Nations Educational and Scientific and Cultural Organization. "The 2nd United

- Nations World Water Development Report, 2006.”
<http://www.unesco.org/water/wwap/wwdr/>; Internet; accessed 3 February 2007.
- United Nations Educational and Scientific and Cultural Organization. “Water Security and Peace: A Synthesis of Studies Prepared Under the PCCP-Water for Peace Process.”
<http://unesdoc.unesco.org/images/0013/001333/133318e.pdf> ; Internet; accessed 24 April 2007.
- U.S. Geological Survey. “The Water in You.”
<http://ga.water.usgs.gov/edu/propertyyou.html>; Internet; accessed 21 January 2007.
- Victor, David G. *CIAO Case Study: Climate Change* Stanford University and the Council on Foreign Relations, June 2005.
<http://www.ciaonet.org/casestudy/case002/caseo0e.html>; Internet; accessed 15 January 2007.
- Water Desalination International. “Water for the Future.”
<http://www.waterdesalination.com/introduction.htm>; Internet; accessed 12 February 2007.
- World Health Organization and United Nations Children’s Fund. “Global Water Supply and Sanitation Assessment 2000 Report.”
http://www.financingwaterforall.org/fileadmin/Financing_water_for_all/MDGs_Costs_Estimates/WSS_Assessment_2000_Report.pdf; Internet; accessed 22 January 2007.
- Yoffe, Shira B. “Basins at Risk Project.”
<http://www.transboundarywaters.orst.edu/projects/bar/>; Internet; accessed 3 February 2007.
- Young, John. “Black Water Rising,” *World Watch*, Sep/Oct 2006, 26-51.