PROTECTION OF FRESH WATER RESOURCES - CANADA AND THE UNITED STATES OF AMERICA

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Summary

Canada and the United States have abundant freshwater resources which have enabled them to achieve some of the highest levels of economic and human development on Earth. While the countries are not in immediate danger of running out of freshwater, several problems loom on the horizon which collectively have the potential of compromising the sustainability of the resource in the long term. Among them are the spatial unevenness in the distribution of the resources, rapid population growth in water-stressed regions, groundwater mining, deterioration of water quality, and the threat of climate change. These pressure points are widely recognized and are being addressed at levels ranging from local to international. The results, to date, show a slow reduction in

per capita demand, increased efficiency in irrigation and industrial water use, and a greater sensitivity to water pollution. These positive trends notwithstanding, citizens of the two countries remain uneasy about their water resource present and future. In Canada, especially, there is little evidence of a national action plan for protecting freshwater. In the United States, despite a stronger federal presence in water resource monitoring, conflicting stakeholder interests have not helped forge a national vision for a sustainable freshwater future. Construction of a new generation of continental scale integrated water resources models is a necessary first step in the development of that new vision.

1. Introduction

When Cynthia Hunt and Robert Garrels described water as the web of life, they struck on what are perhaps the most appropriate words to describe a substance whose presence on Earth is synonymous with life itself (Hunt and Garrels 1972). Water connects all parts of the life support system, from the weather to transportation routes, from plants to animals to humans. Indeed, when humans search for signs of life, current or past, in other planets, they look for evidence that water is or used to be there. Fresh water has thousands of uses. The human body is at least 2/3 water. To keep it alive it must be continually supplied with the liquid directly through drinking and indirectly through the ingestion of food containing significant amounts of water. Lettuce, cucumbers, spinach and asparagus are 95 percent water. Humans can survive up to eighty days without food, but only ten without water. Sanitation is maintained largely through the use of water. Indeed, human development is, in part, a function of the ratio of water used for hygiene to total domestic consumption. In developed countries the ratio exceeds 90% compared to less than 10% in several parts of the Third World. Economic progress and human development advance where water is plentiful, and possibly diminish where and when it is scarce.

The multiple roles played by water are at once its greatest asset and its worst liability. Almost every usage produces contaminated water as a by-product and in the process water is a threat to itself and to all systems and processes which depend on it. Municipal, industrial and agricultural wastes contribute toxins, heavy metals, bacteria and nutrients which poison the quality of water to a point where it cannot be safely used without substantial treatment. In the 1800s, water borne diseases were so rampant in England, that water was declared a public enemy.

Canada and the United States are fresh water rich. Canada has the lowest prices for water in the industrialized world, with consumers paying about 25 percent the average price paid by Europeans. The United States is the world’s foremost economic power. In the nineteen nineties, The United Nations persistently ranked Canada the number one country in human development. The role played by water abundance in those premier positions has yet to be determined. When it is, it is likely to be substantial.

The outlook on fresh water supply in the two countries, while not bleak, shows several disturbing emerging trends. These include: a redistribution of population away from water rich regions to water deficient ones especially in the United States; rising agricultural, industrial and domestic demand; surface and groundwater pollution; acid rain; land and wetland degradation; and climate change. Water, as commonly regarded, is a renewable resource. While this statement may be valid in a global sense, it is not always applicable at the local and regional levels. There are areas in the United States where groundwater is currently mined with little or no prospect of full renewal in the immediate future. Replacement period for mined water can exceed 200 years for shallow reservoirs and more than 10 000 for deeper ones.

Canada and the United States recognize that water is a sacred heritage, as they are constantly reminded by their aborigines. It is a heritage that must be handed over to the next generation in conditions that enable them to profit from it in much the same way as the present generation has. Hopefully, that generation will do the same for the succeeding one. This relay can only be accomplished by prudent management of existing supplies, protection of the physical environment which sustains and renews fresh water, rectifying past errors, and, most important, Canadians and Americans must learn to give fresh water the respect it deserves. Cooperation among all stakeholders, new and insightful multi-disciplinary research, public education, and new investment on technology and other programs designed to sustain the long term future of water, are all vital components of policies needed to preserve the freshwater heritage.

2. The Physical Resource

2.1. Water Defined

Normally, water is a liquid substance made of molecules containing one atom of oxygen and two atoms of hydrogen. Pure water has no color, no taste, no smell, turns to solid at 0^oC and vapor at 100^oC at sea level. It is an extremely good solvent. Because numerous substances dissolve in it, pure water is rare. In the atmosphere, water bonds with many chemicals, some of them toxic. Thus when it arrives on the ground as precipitation, it is not a pure substance. In industrialized parts of North America, air pollution causes acid rain. The most pristine rivers and lakes in Canada and the US contain many naturally occurring substances such as bicarbonates, sulfates, sodium and chlorides scoured off the earth by water flowing over land, as well as organic matter from vegetation and animals.

2.2. Freshwater Defined

There is no one definition for fresh water. Outside sea water and water in saline lakes and underground reservoirs, most earth waters can be described as fresh. The degree of freshness is measured by the quality of water. Quality must be adequate for the use intended. Water fit for one use may be unacceptable for other uses. Water in a lake may be unsuitable for drinking without significant treatment but may be adequate for swimming. However, there may be parts of the lake where the water quality is too poor to swim in. Water that may be suitable for irrigation may carry severe health risks if drunk. On land, water serves several functions that help sustain life. Whatever the function, the quality of the water must be adequate for the intended purpose. In the present context, fresh water is defined as water whose quality is adequate for the intended use on land.

2.3. Fresh Water Resources of the United States and Canada

Classification of freshwater according to source is not entirely satisfactory because of the considerable overlap among the categories. For convenience, the sources are separated into precipitation, runoff and streamflow, groundwater, icefields, and freshwater lakes.

2.3.1. Precipitation and Evaporation

The US and Canada average 700 mm of precipitation annually, nearly 800 mm or 25 000 m^3 per capita for the US, and 607 mm or 18 000 cubic meters per capita for Canada. But the resource is unevenly distributed spatially. In the United States, the Atlantic coast and most of the southern states receive between 1 500 and 3 500 mm. Amounts are similar on the west coast, from Washington to Northern California. Drier climates occur in the middle of the country and the southwest. The so-called American dry belt stretches funnel-like from the southern tip of Alberta and Saskatchewan in Canada, to the US-Mexico border In much of the sunbelt, southern California, New Mexico, Arizona, Nevada, and western Texas, for example, precipitation averages from less than 100 mm to just over 1500 mm annually. (See figure 1 in *Demographic dynamics and sustainability in Canada and the United States*, for a map of North America showing the location of states (United States of America) and provinces (Canada).

In Canada, both the east and west coasts receive annual precipitation ranging from 1500 mm to more than 4 500 mm. In parts of British Columbia (B.C) values exceed 4 000 mm annually. Ocean Fall, B.C., with an annual normal of 4387 mm, is the wettest place in the sub continent. Much of the southern Prairies is dry. There, precipitation averages less than 1000 mm. In the Palliser triangle, a dry zone wedged between southern Saskatchewan and Alberta, annual precipitation is lower than 500 mm. Above the Arctic Circle, Tundra climate prevails. Even though this vast region is officially classified as a cold desert (Eureka in the Northwest Territories receives only 64 mm annually), air temperature is so low that in many parts icefields can be sustained year round. Permafrost is a common feature. Thirty-six percent of Canada’s annual precipitation is snow. In the North, which includes Canada’s Northwest Territories, Nunavut and the Yukon and United States’ Alaska, snow accounts for at least 50% of the annual precipitation load compared to 25% in the Prairies, and 10% in southern Ontario and eastern Canada.

Evaporation rates increase generally southwards. In the US southeast, annual potential evapotranspiration (atmospheric demand) averages 1300 mm annually. Values are similar in much of the west coast. In the southern dry belt, atmospheric demand generally exceeds 1500 mm. Because of its colder climate, Canada’s potential evapotranspiration is about one-half its US equivalent.

2.3.2. Runoff and Stream Flow

Continent	mean precipitation (mm)	mean evaporation (mm)	Precipitation/ evaporation ratio	Stable runoff per capita (m^3/year)

US-Canada	700	380	1.84 (1)	8 420 (2)
Europe	734	415	1.77 (2)	2 100 (4)
Asia	726	433	1.67 (3)	1 960 (5)
South America	1648	1065	1.55 (4)	21 100 (1)
Oceania	736	510	1.44 (5)	2 750 (4)
Africa	686	547	1.25 (6)	5 550 (3)

(X) World Ranking

Based on A. Baugmater and E. Richel, The world Water Balance, Elsevier Scientific Publishing, Co., New York.,1975.

Table 1: Precipitation effectiveness for Canada and the US in a global context

Canada and the United States average 700 mm of precipitation annually but only 380 mm of evaporation. With a precipitation to evaporation ratio of better than 1.8, the two countries are rich in renewable atmospheric water. This richness is reflected in their favorable per capita share of the world's stable runoff (Table 1.). Because of their land area, drainage basins in Canada and the US tend to be large and main streams long. Eight of the world's thirty longest rivers are found in Canada and the US. The Mississippi-Missouri is the world's fourth largest basin. Canada's rivers discharge 9% of the world's runoff, equivalent to the nation's world share of renewable water. The Mackenzie is the world's 13th longest river.

2.3.3. Groundwater

The United States has at least 125 000 trillion liters of groundwater equal to the amount of water discharged into the Gulf of Mexico by the Mississippi in the past 200 years (Leeden et. al). In major aquifers, porosity and permeability are sufficient for most uses. Two contrasting spatial profiles can be distinguished. The Atlantic and Gulf coastal plains contain the largest reserves of the nation's groundwater. Present pumpage represents a small percentage of those reserves. Moreover, because of its wet climate, aquifers in the east have good recharge potential. The west, on the other hand, has geological formations whose water-holding and transmission qualities match those in the east but because of its drier climate, recharge potential is limited. The High Plains aquifer, commonly known as the Ogallala which extends south from South Dakota through Nebraska to Arizona, is estimated to contain as much water as Lake Huron.

There are no reliable estimates of groundwater volumes for Canada but its world share is believed to be proportionally lower than its 7% world total land area. This is primarily attributed to the lack of significant recharge throughout much of Canada owing to permafrost in the North and low precipitation in the Prairies, and to the fact that the massive igneous rock formations of the Canadian Shield, the Cordilleran, and Rocky Mountain regions have low porosity and therefore low reserves. However, much of the rest of the country is underlain by aquifers that yield 0.4 liters/sec or more. In British Columbia, Quebec and Labrador, yield exceeds 0.5 liters/sec. The origin and composition of the high yield aquifers vary. Many, especially in southern Ontario and New Brunswick, are composed of thick deposits of sands and gravel laid down by periglacial rivers. The Carberry aquifer of Manitoba is an old delta lying on what was formerly Lake Agassiz. Outwash sand and gravel are the major aquifer types in the Fraser valley of British Columbia.

2.3.4. Ice Fields and Lakes

The ice fields in the Arctic and mountains contain significant quantities of fresh water, but contribute little to the renewable water resources of both countries due to their long replacement period. Canada and the United States have numerous fresh water lakes. The Great Lakes which straddle their border contains 18% of the world's freshwater. Canada alone has more lakes than any other country in the world, with 565 of them larger than 100 square kilometers.

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Biographical Sketches

Mark Peterson majored in environmental science with a minor in chemistry at the University of Calgary. His primary area of interest focuses on the effects of industrial pollutants on terrestrial biological systems. Mark is currently employed in the private sector researching the impact of contaminants on the environment.

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