Fresh Water

Module 6 • i2P • H2O Tour

"Be praised, my Lord, through Sister Water; she is very useful, and humble, and precious, and pure."

- Francis of Assisi (1181 - 1226) Canticle of the Sun circa 1225

FRESH WATER

The second leg of the impossible2Possible World Tour is focused on water, and involves expeditions to the largest freshwater lake in the world, followed by the driest hot desert in the world. i2P purposely chose these two locations to highlight what many people feel is a growing global water crisis. The juxtaposition of Lake Baikal and the Sahara Desert may unfortunately be emblematic of the past and future of world fresh water resources.

All living things need water. Humans require *fresh* water. The basic definition of freshwater is water that is free of salt, however, freshwater can be defined according to a variety of other criteria as well, for example: the number of parasites and microorganisms, the amount of chemical and industrial contaminants, the mineral content, or even amount of trace radioactive material. Because water has a remarkable capacity to dissolve a great number of substances, it is frequently 'contaminated' with impurities. Although an ideal definition of freshwater might be water free of *any* contaminants, for practical purposes this is unrealistic. Beautiful fresh spring water very suitable for human consumption inevitably contains natural contaminants (minerals, benign microorganisms). Even 'fresh' municipal water that you drink from your tap usually contains substances like chlorine and fluoride that are added to render the water safe or better for human consumption. For our purposes perhaps a more functional definition of freshwater is *water that is safe for human consumption*.

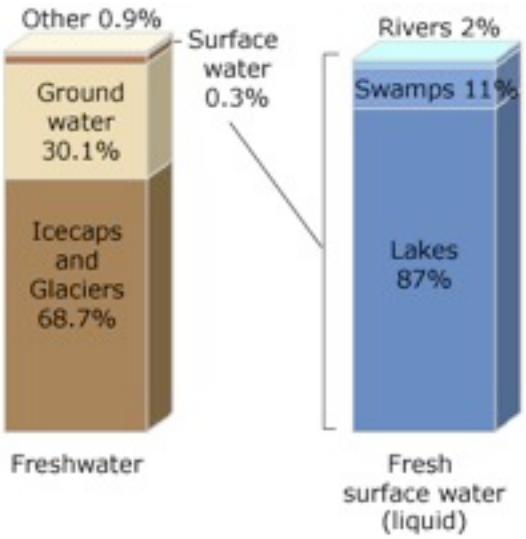

Figure 1: Distribution of freshwater in the world (source: United States Geological Service)

FRESH WATER FACTORY

Freshwater is the ultimate renewable resource. As we learned in module 4 (Water Cycle), although the absolute amount of water in the world is fixed, freshwater is continually being renewed. This is very

fortunate, because freshwater would long ago have run out on the Earth if it were not renewable. Freshwater is renewed through precipitation, and is captured in lakes, rivers, swamps, bogs, aquifers and glaciers.

Given that freshwater is renewable, if we use it slower than it is renewed by the water cycle and we will never run short. Unfortunately this simple premise does not work very well, because world water distribution is unequal, and population demands, industrialization and climate change are adversely impacting water distribution, demand, quality, and resources.

TABLE 1: TOTAL RENEWABLE FRESHWATER SUPPLY, AND POPULATION BY SELECTED COUNTRIES (TOP 5 / TUNISIA / BOTTOM 5 COUNTRIES BY VOLUME OF WATER

Country	Fresh Water Resources km3 / year	Population millions
Brazil	6,950	192
Russia	4,498	141
Canada	2,901	33
China	2,800	1,345
Indonesia	2,530	229
United States	2,478	308
Tunisia	4.1	10.4
Libya	0.6	6
United Arab Emirates	0.2	6
Bahrain	0.1	0.8
Qatar	0.1	1.4
Kuwait	0	2.9
Malta	0	0.4

WHERE IS THE WATER?

Fresh water is found in three principal locations; the majority is frozen in ice caps, about a third is groundwater, and less than 1% is liquid surface water (figure 1). Liquid freshwater (ground and surface) constitutes the worlds 'useable' water resource. The vast majority of liquid freshwater in found as groundwater, and is addressed in detail in two modules; Groundwater and Vanishing Water.

Most of the world's freshwater resources are concentrated in a handful of countries. Brazil has the greatest renewable freshwater reserves in the world (Table 1), while Iceland and Canada have the greatest amount of fresh water per capita. Furthermore, although countries like China and the United States have some of the largest renewable fresh water reserves in the world, they are beginning to experience significant water shortages. At the other extreme are countries like Libya and Kuwait that have virtually no renewable fresh water

Definition: Renewable Freshwater
Freshwater resources that are renewed through precipitation.

resources at all (for a complete list of freshwater reserves by country see: freshwater reserves). As you can see from Table 1, the countries visited by i2P on this set of expeditions, Russian and Tunisia, are respectively among the wettest and driest on the planet.

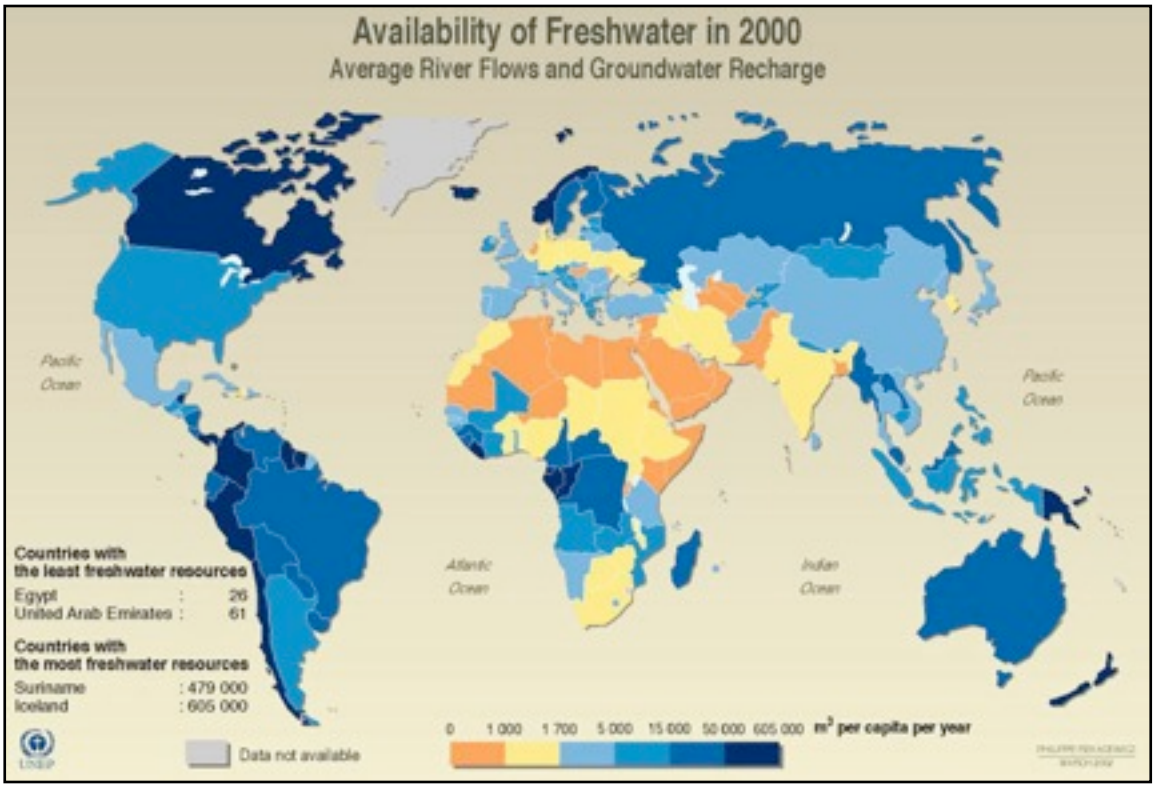

Figure 2: Availability of freshwater by country (source: United Nations Environment Program)

Quenching the Thirst

Fresh water is needed by all land plants and animals to survive. Human beings share this need, and as the earth's human population has increased so has the human demand for fresh water. In the past 50 years the human demand for water has tripled while the population has doubled. What accounts for this rapidly increasing human demand for water?

According to the The United Nations World Water Development Report 3 (see: UN water report 2009), the principal reason that human water demand is increasing is because of increasing world wealth. It appears that as people become wealthier they consume more water. This means that historically, people living in North America and Europe have consumed more water than people in the developing world. However as the standard of living in countries with large populations like China and India increase, the world consumption of water is rising rapidly. Why do increases in wealth translate

Did You Know?

According to the UN, Planet Earth's mean annual renewable volume of water is 43,000 cubic kilometers. This is about half of all the fresh water contained in all the Earth's natural lakes and about ten times the volume of all man-made reservoirs. Groundwater recharge accounts for about 10,000 cubic kilometers annually, (c. 0.1% of all groundwater resources). Thus, only a tiny proportion of the total volume of groundwater reserves is recharged each year, compared to the large volume in stock. (see: groundwater)

into increases in water consumption? To understand this let us look at what human beings use water for.

Fresh Water Withdrawal

The principal human uses of freshwater are:

•domestic use - meaning cooking washing and direct consumption;

•agriculture - the growing of food, both plants and animals;

•industry - the production of goods and energy.

Of these three categories, agriculture takes up the lions share of human freshwater resources, about 70 percent. Industrial use - meaning the production of everything from computer chips to paper, and diamonds to chemicals - accounts for 20 percent of human water consumption. Domestic use accounts for only 10 percent off all freshwater consumption world wide.

Table 2: Categories of World Human Water Use By percent.

World Human Water Use	Percent
Agriculture	70
Industry	20
Domestic	10

Agriculture

When farmers grow vegetables and care for animals water is required. Without water there is drought, and crops will not grow and livestock will die. All plants grow by harnessing the energy of the sun through *photosynthesis*. Photosynthesis converts carbon dioxide and *water* into sugar and oxygen using the energy of sunlight. Animals in turn feed off the energy trapped in plants, or in other animals that have eaten plants. Virtually all the energy captured by plants and animals in the world directly or indirectly comes from three essential components: sunlight, carbon dioxide and *water*.

Plants use water far more efficiently than animals to produce energy as they can photosynthesize directly using sunlight. A significant amount of energy trapped in a plant is lost when an animal consumes the plant, and consequently more water is required to sustain an animal per unit of energy than a plant. What this means in simple terms is that it requires much more water to produce a hamburger, or a piece of chicken, than an apple, or grain for making bread. In fact it will take roughly 10 times more water to produce hamburger than rice with the same energy content. As people become

Does it take more water to produce a liter of beer or a liter of coffee? For a complete list of the water required to produce many foods and products see: water content of things

wealthier they expect and demand a more varied diet, often rich in meat. This demand is driving up the use of water.

Industrialization

Another reason that increasing standards of living are driving up human water use is the growing demand for products like computers and televisions and other conveniences of modern living. Water is used in many manufacturing processes for heating and cooling, to dissolves chemicals in, or to wash manufactured products. For example computer chips made by Intel at their factory in Phoenix Arizona are washed with water during the manufacturing process. At the plant Intel uses 2 million gallons of water a day (see: computer chip manufacturing). Some industries, like pulp and paper use huge volumes of water in their manufacturing.

Figure 3: Thirsty cows plowing a rice paddy. The cows require more water than the rice to produce an equal amount of energy (source: NeuCeu - Wikimedia Commons)

In years gone by, when life was simpler and we lacked many of the products that are now commonplace, like computers, newspapers, and air conditioners, global water use was significantly less.

Moving Fresh Water

The unequal distribution of fresh water in the world has compelled humans to find ways to move freshwater to where it is needed. As far back as the Roman Empire great efforts were made to build aqueducts - open channels of water that work by gravity - to flow water from its source to a city or region in need.

More recently great water diversion projects have been built to redirect water to thirsty populations. The Three Gorges Dam in China is the largest ever water diversion project

Figure 4: Pont De Gard - famous aqueduct built by the Roman Empire. The bottom level carries a road, the top level a water conduit (source: w:fr:utilisateur:Bouba)

in the world and will supply an extra 11 billion cubic meters of water annually to needy residents in the region. In the United States a series of dams , reservoirs, and channels aimed at diverting water from the Colorado River system to dry regions of Arizona have been built over the past 100 years. The most recent upgrade to the system, completed in 1993 diverts 489 billion gallons of water from the Colorado River for irrigation of dry land (see: colorado diversion). Unfortunately the overuse of the Colorado River along its length has led to it being virtually dry where it used to empty in to the Pacific Ocean. The Colorado River is not the only major world river to be over-tapped; the Ganges, Indus, Rio Grande and Yellow Rivers are also beginning to run dry for part of the year.

Will There be Enough Fresh Water?

The United Nations has suggested, based on current trends that up to half the world population will experience severe water shortages by 2050 (see: UN report). The principal factor sited for this shortage will be growing wealth and demand for food and industrial products by a growing population. However there are other factors that may influence the world freshwater resources that we have not mentioned.

Did You Know?

In 1977 an enterprising gentleman developed a scheme to solve the fresh water shortages in the Middle East. Prince Faisel of Saudi Arabia sponsored a conference that looked at the practicality of dragging icebergs from Antarctica to the Middle East to provide clean water for the region. Despite the Prince's enthusiasm for the idea, most felt that the iceberg would melt long before it reached its destination (see: iceberg).

Global warming threatens to shift the balance of fresh water reserves by liberating water from glaciers, and changing weather patterns. The impact of global warming on fresh water resources is a subject of some debate, and will be dealt with in detail in module 18, Hot Water. However one fact seems irrefutable; that glacial melt that has long provided fresh water to millions of people

world-wide is accelerating at such a rate that it will dry up in many parts of the world in the next fifty years. Combined with issues of water pollution (dealt with in module 13: Dirty Water), there is grave concern about the future of world-wide fresh water resources.

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