Water Scarcity:

Threats, Links to Food Shortage, and Impact on the International Level

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Table of Contents

> Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases.[2]

Introduction

World water demand has tripled over the last 50 years.[3] This is based in large part on the explosion of population growth; the world population is currently growing by more than 75 million people per year.[4] Water stress transcends national boundaries and is apparent today across arid and semiarid regions as well as in many densely populated parts of the humid tropics and temperate zone.[5] The major increases in relative water demand documented throughout this paper reveal that much of the world will face substantial challenges to water infrastructure and associated water services. While we continue to develop and refine technologies for capturing and storing water, and for making more efficient use of it, no technology can significantly expand this finite resource base.[6] In truth, there is essentially the same amount of freshwater on

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[2] Agenda 21, United Nations Conference on Environment and Development, sec. 2, ch. 18.2, U.N. Doc. A/CONEF.151/L.3/Add.18 (1992).

[3] Lester Brown, Earth Policy Institute, *World Creating Food Bubble Economy Based on Unsustainable Use of Water* (March 13, 2003), available at http://www.casavaria.com/eco/epi/030313food-bubble.htm (last visited November 18, 2009).

[4] United States Census Bureau, International Database Information Gateway, World Population Summary, *World Population Trends* (page last modified September 10, 2009), available at http://www.census.gov/ipc/www/idb/worldpopinfo.php (last visited November 24, 2009).

[5] Charles J. Vorosmarty, Pamela Green, Joseph Salisbury, and Richard B. Lammers, *Global Water Resources: Vulnerability from Climate Change and Population Growth*, 289 *Science* 284-88 (July 14, 2000).

[6] The use of ocean desalinization technology currently supplies 1/1000th of the fresh water used worldwide, but the practice of extracting salt from seawater remains limited by the amount of energy required to purify saltwater and the cost of that energy. For further discussion on this

the planet that there was 2,000 years ago. Yet this supply, then shared by no more than 300 million people, today must sustain a population of approximately 6 billion, which is expected to further grow to 10 billion by 2050. Potentially large economic costs are likely to be associated with the implementation of response strategies[7] or the consequences of inaction.[8]

Hydrologists and other water experts agree that when certain ratios of people to renewable water supplies are exceeded, water stress and, later, outright scarcity occur.[9] A majority of the projected increase in scarcity will be focused on rapidly expanding cities. Much of the world's population growth over the next few decades will occur in urban areas, which are projected to double in size to nearly 5 billion by 2025[10] and will inevitably face major challenges in coping with a decreased supply of water, as well as increased water pollution and incidence of waterborne disease. However, rural areas will also feel this pinch, as arid and semiarid regions also face the possibility of absolute water scarcity.

Water scarcity, once a local issue, is increasingly crossing international boundaries via the international grain trade. Because it takes one thousand tons of water to produce one ton of

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process and its uses, *see* Peter H. Gleick, Water and Energy, in Water in Crisis: A Guide to the World's Fresh Water Resources 67, 69 (Peter H. Gleick ed., 1993).

[7] Examples include expansion of facilities, new water-pricing policies, innovative technology, and mismanagement.

[8] Examples include deterioration of water quality and reduction in irrigated crop yields; *see also* P. Gleick, *The World's Water: The Biennial Report on Freshwater Resources (1998-1999)*, (Island, Washington, D.C., 1998).

[9] Marlin Falkenmark & Carl Widstrand, *Population and Water Resources: A Delicate Balance*, Population Bulletin, 1992, at 19.

[10] *World Resources: A Guide to the Global Environment 1996-97* (World Resources Institute, Washington, DC, 1996).

grain,[11] importing grain is the most efficient way to import water.[12] As water shortages intensify, so too will the competition for grain in world markets. This paper will focus on the worldwide water shortage crisis and its relation to the growing international food shortage, and will conclude by proposing possible solutions to this rapidly growing problem.

The Vital Nature of Water

Since the dawn of man, water has been recognized as the essential life-giving element on earth. Benjamin Franklin is quoted as having said that only "[w]hen the well is dry, [will] we know the worth of water." Former Secretary General of the United Nations Kofi Annan once stated:

> Water is an essential life-sustaining element. It pervades our lives and is deeply embedded in our cultural backgrounds. The basic human needs of a secure food supply and freedom from disease depend on it. Social development – endeavors such as the smooth functioning of hospitals – likewise relies on the availability of clean water. Economic development requires energy resources and industrial activities, and both are in turn water-dependent.[13]

Water is essential to human health and development, as well as to life itself. However, many analysts still fail to recognize the critical impact that increased pressure on the world's water supply can have on human health and the environment. In addition, the growing number of

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[11] Lester Brown and Brian Halweil, Worldwatch Institute, *Populations Outrunning Water Supply as World Hits 6 Billion* (September 23, 1999), available at http://www.worldwatch.org/node/1661 (last visited November 3, 2009).

[12] Lester Brown, *supra* note 3 (Also noting that "[C]ountries that are pressing against the limits of their water supply typically satisfy the growing need of cities and industry by diverting irrigation water from their agriculture, and then they import grain to offset the loss of the agricultural productive capacity.").

[13] U.N. Educational, Scientific, and Cultural Organization [UNESCO], *The United Nations World Water Development Report 2: Water, a Shared Responsibility* (2006).

people experiencing water stress and scarcity has important implications for international security.[14]

The Problem of Water Shortage

Nearly 450 million people in 29 countries face water shortage problems; this number is expected to increase to 2.5 billion people by 2050.[15] In addition, over a billion people do not have access to safe drinking water and sanitation is minimal for more than half the world's population.[16] Experts predict that worldwide freshwater shortages will remain an enormous problem in the coming decades.[17] In addition, a recent United Nations report notes that eighty

[14] "International security" is used broadly to include economic, social, and ecological problems that reduce the quality of life and increase competition, tensions, and conflicts among national or subnational populations. *See generally* Peter H. Gleick, Water and Conflict, 1 Occasional Paper Series of the Project on Environmental Change and Acute Conflict, A Joint Project of the University of Toronto and the American Academy of Arts and Sciences 3 (1992).

[15] Press Release, World Water Council, *The World Water Gap: World's Ability to Feed Itself Threatened by Water Shortage* (March 20, 1999), available at http://www.worldwatercouncil.org/press.htm (last visited November 7, 2009).

[16] Second World Water Forum, Declaration of the Hague, *Ministerial Declaration of the Hague on Water Security in the 21st Century*, available at http://www.worldwaterforum.net/index2.htm (last visited November 7, 2009).

[17] *See* Frank Clifford, *Tapped Out? Shortage of Water Looms as one of the World's Most Critical Problems in the Next Century*, L.A. Times, February 15, 1996, at B2; *see also* Pamela LeRoy, *Troubled Waters: Population and Water Scarcity*, 6 COLO. J. INT'L. ENVTL. L. & POL'Y 299 (1995). These water shortages can lead not only to disease, environmental degradation, food shortages, and economic dislocation, but also to war. In the words of former United Nations Secretary General Boutros-Boutros Ghali, "[t]he next war in the Middle East will be fought over water, not politics." Pritt J. Vesilind, *Water: The Middle East's Critical Resource*, National Geographic Magazine, May 1993, at 47. For additional perspectives on potential conflicts over water rights, *see generally* Raed M. Fathallah, *Water Disputes in the Middle East: An International Law Analysis of the Israel-Jordan Peace Accord*, 12 J. LAND USE & ENVTL. L. 119, 120-26 (1996) (discussing tensions over water resources in the Middle East); Christopher L. Kukk and David A. Deese, *At the Water's Edge: Regional Conflict and Cooperation Over Fresh Water*, 1 UCLA J. INT'L L. & FOREIGN AFF. 21 (1996) (discussing how water scarcity can lead to

countries, comprising 40% of the world's population, are already suffering from water shortages that limit economic and social development.[18] These shortages greatly impact developing countries; some of these countries utilize only 20% of their potential water resources because they lack the capital and the technology to capture more.[19]

At a time when many countries are approaching or exceeding the limits of their renewable water resources, world population is growing by larger and larger increments than before. For each new person, water remains among the absolute necessities of life. Already some 80 countries comprising 40% of the world's population suffer from water shortages at some point during the year.[20] Chronic water shortages are expected to occur in much of Africa and the Middle East, northern China, parts of India and Mexico, the western United States, northeastern Brazil, and the former Soviet central Asian republics.[21]

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conflict and outlining possibilities for cooperation); Niveen Tadros, Comment, *Shrinking Water Resources: The National Security Issue of This Century*, 17 NW. J. INT'L L. & BUS. 1091 (1996-97) (examining the possibilities of avoiding tension over the shortage of freshwater in the Nile River Basin States); Elizabeth Burleson, *Middle Eastern and North African Hydropolitics: From Eddies of Indecision to Emerging International Law*, 18 GEORGETOWN INT'L ENV. L. REV. 385 (2006) (discussing how Middle Eastern co-aquifer states can address trans-boundary natural resource issues through flexible water use provisions, equitable distribution of water benefits, and strong dispute resolution mechanisms).

[18] Paul Lewis, *U.N. Report Warns of Problems over Dwindling Water Supplies*, N.Y. Times, January 20, 1997, at A6.

[19] Marlin Falkenmark, *supra* note 9, at 26.

[20] Karina Porcelli, *The Thirst for Water*, Scanorama, July/Aug. 1993, at 20, 22.

[21] Arun P. Elhance, *Central Asia's Looming Water Wars*, Christian Science Monitor, Jan. 11, 1993, at 19; *see also* James Brooke, *In Brazil, Too, the Withered Land Cries for Rain*, N.Y. Times, Apr. 8, 1993.

Focusing on water scarcity indirectly focuses on food scarcity, as 70% of the water which is diverted from rivers or pumped from underground is used for irrigation.[22] Worldwide, the are of irrigated land has increased fivefold since 1900, exceeding 240 million hectares in the early 1990's.[23] In effect, governments are satisfying the growing demand for food by overpumping groundwater, a measure that virtually assures a drop in food production when the aquifer is depleted. The reliance on water for agricultural production is rarely appreciated fully, although it accounts for some 70% of drinkable water usage.[24] However, this increase in water use has not led to increased production. Measured in terms of days of consumption, world grain stocks now stand at half the levels of the mid-1980s and are lower than at any time since the 1970s.[25]

This is coupled with increased poverty levels worldwide. According to author Richard Manning, "[P]eople are hungry because they can't afford to buy food, not because there isn't food to buy."[26] People are short of food not only because there is not enough food, but also because they either cannot afford it or the government (whether theirs or someone else's) keeps it from them.[27] The American style of agricultural production is also having deleterious effects

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[22] Lester Brown, *supra* note 3.

[23] Sandra Postel, Last Oasis: Facing Water Scarcity 28 (1992); *see also* Robin Clarke, Water: The International Crisis 20 (1993).

[24] *Supra* note 13.

[25] Robert Lee and Terry Marsden, *The Globalization and Re-localization of Material Flows: Four Phases of Food Regulation*, 36 J. L. & SOC. 129 (2009).

[26] Richard Manning, Against the Grain 72 (2004).

[27] *Id*. at 72-73 (blaming famine on "bad government").

on the world's food supplies, specifically grain.[28] However, populations will continue to increase and the resultant demand for food will continue to increase.[29] An increased demand for foodstuffs necessitates greater production of crops around the world, resulting in farmers who use more irrigation techniques.[30]

Agriculture is the single biggest source of water pollution in the United States.[31] This pollution is, in turn, causing water itself to be depleted at an alarming rate. The Colorado River no longer has any water left by the time it gets to the Sea of Cortez; this lack of water is responsible for the decline of marine life in the bay.[32] Americans use four hundred to six hundred liters of water per person, per day – twice that of Europeans and more than anywhere else in the world.[33] Also, it is important to keep in mind what we are really exporting and importing when international food trade occurs. Corn and other grain exports, and to a greater extent beef and other meat exports, are really exports of water, oil, and topsoil. The water

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[28] For example, it takes seven pounds of grain to grow one pound of beef; *see* Richard Manning, Food's Frontier: The Next Green Revolution 5 (2000). Worse yet, it takes 21.4 pounds of feed grain protein to produce a single pound of beef. *Id*. at 7.

[29] *Winning the Food Race*, Population Reports, Ser. M, Num. 13, available at http://www.infoforhealth.org/pr/m13edsum.shtml#top.

[30] *Id*.

[31] Christopher B. Connard, Note, *Sustaining Agriculture: An Examination of Current Legislation Promoting Sustainable Agriculture as an Alternative to Conventional Farming Practices*, 13 PENN ST. ENVTL. L. REV. 125, 125 (2004); *see also* Logan L. Hollers, *Agricultural Nonpoint Source Pollution: Modern Farming Practice and its Impact on Water Pollution* (2008).

[32] Richard Manning, *supra* note 26.

[33] Michael Specter, *The Last Drop: Confronting the Possibility of a Global Catastrophe*, New Yorker, October 23, 2006, at 61.

component of this transfer is referred to as "virtual water."[34] This concept cuts both ways: when you drink a cup of coffee, you are consuming 140 liters of Columbian water.[35]

Finally, agriculture, and specifically wasteful American-style agriculture, is a major contributor to global warming, which then contributes to both water and food shortage.

> In terms of energy, U.S. agriculture is the least efficient in the world … [I]f the entire world population were fed a U.S. diet and foodstuffs produced under conditions identical to those in the United States, total world oil reserves would run out in only 13 years when used for agricultural purposes alone.[36]

One author has claimed that "U.S. grain, free or otherwise, puts Third World farmers out of business."[37] Subsidized American agricultural exports have an international impact, and seriously affect local farmers. The World Bank predicts that the North American Free Trade Agreement (NAFTA) will displace 300,000 Mexican farmers, pushing them out of the farming business and marginalizing them into the already overcrowded urban areas.[38]

Only 3% of the planet's water is even theoretically available to drink.[39] As stated earlier, Americans use four hundred to six hundred liters of water per person, per day; by comparison,

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[34] *Id*. at 70-71.

[35] *Id*.

[36] Arturo Warman, Corn and Capitalism: How a Botanical Bastard Grew to Global Domination 194 (Nancy L. Westrate trans., Univ. of N.C. Press 2003) (1988) (citing David Pimental & Marsha Pimental, *Counting the Kilocalories*, Ceres 10, no. 5 (September – October 1977) at 17-21).

[37] Richard Manning, *supra* note 26, at 134.

[38] *Id*. at 133.

[39] Most of the planet's water is, of course, in the ocean, but much of it is frozen in ice caps and glaciers or deep in rock. *See* Michael Specter, *supra* note 33, at 64.

many Indians get by on forty liters a day.[40] India, with 20% of the world's population, has 4% of its water, and China has less water than Canada but forty times the number of people.[41] Half the people in the world today don't have the quality of water that was available to the citizens of ancient Rome two centuries ago.[42] Agriculture, consuming two-thirds of the world's fresh water, is certainly a major part of the problem and any solution.[43] It is vital to keep in mind that while it takes a thousand tons of water to grow a ton of grain, it takes fifteen thousand tons to grow a ton of beef.[44] These modern agricultural practices, combined with the distinct shortages of water seen throughout the world, have had disastrous impacts on numerous countries. The next section details some of these impacts.

Specific Examples

Yemen

Yemen is one of the most water scarce countries in the world; the average per capita share of renewable water resources is 125 cubic meters per year.[45] In addition, the water table is

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[40] *Id*. at 61.

[41] *Id*. at 62.

[42] *Id*. at 63.

[43] *Id*.

[44] *Id*. at 64. Astoundingly, this equates to 1,300 gallons of water to grow one hamburger.

[45] IRINNews.Org, U.N. Office for the Coordination of Humanitarian Affairs, *Water shortages a looming disaster, say experts* (Jan. 24, 2006), available at http://www.irinnews.org/report.asp?ReportID=51296&SelectRegion=Middle_East&SelectCountry=YEMEN (last visited November 18, 2009) (noting that "[T]his represents one-tenth of the average in most countries of the Middle East and North Africa, and one-fiftieth of the world average.").

falling by roughly two meters per year.[46] With a population of 19 million growing at 3.3 percent per year, one of the highest rates in the world, Yemen is fast becoming a hydrological disaster.[47]

China

In China, the combination of aquifer depletion, the diversion of irrigation water to cities, and lower grain prices are shrinking the grain harvest.

> Water tables are falling throughout the northern half of China. As aquifers are depleted and irrigation wells go dry, farmers either revert to low-yield dryland farming or, in the more arid regions, abandon farming altogether. In the competition for scarce water, China's cities and industry invariably get first claim, leaving farmers with a shrinking share of a shrinking supply. Losing irrigation water may mean either abandoning land or less double cropping.[48]

After peaking at 392 million tons in 1998, the harvest dropped to 322 million tons in 2003.[49] China has thus far covered its grain shortfall by drawing down on its water supply, but will likely soon have to turn to the world market to fill this deficit. When China turns to the world market, it will necessarily turn to the United States, which controls nearly half of world grain exports. This presents an unprecedented geopolitical situation in which 1.3 billion Chinese consumers

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[46] Lester Brown, *supra* note 3 (also containing a statement by World Bank official Christopher Ward, in which he observes that "groundwater is being mined at such a rate that parts of the rural economy could disappear within a generation.").

[47] *Id*.

[48] Lester Brown, Earth Policy Institute, *China's Shrinking Grain Harvest: How Its Growing Grain Imports Will Affect World Food Prices* (March 10, 2004), available at http://www.earth-policy.org/index.php?/plan_b_updates/2004/update36 (last visited November 3, 2009).

[49] *Id*.

will compete with Americans for U.S. food, likely driving up food prices for the United States and the world.[50]

China is also an excellent example of how populations influence the amount of water availability. China and Canada receive similar amounts of precipitation per year, both in total amount and quantity per hectare.[51] But with forty times more people than Canada, China offers each citizen only 2.2% of the water that each Canadian can claim.[52] As world population continues its rapid, yet uneven, growth, such inequities will only increase. Already, over-exploitation of water in Bangkok is causing parts of the city to sink at a rate of 14 centimeters per year, leading to cracked pavements, broken sewer and water main pipes, seawater intrusion, and flooding.[53] At least 24 million of acres of agricultural land in China is now polluted[54]; many of their rivers are polluted, most drinking water is contaminated with bacteria, and excessive nitrogen is showing up in well water.[55]

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[50] *Id*.

[51] World Resources Institute, *World Resources 1988-1989*, at 129 (1988).

[52] Robert Engelman & Pamela Leroy, Sustaining Water: An Update (1995).

[53] World Bank, *Water Resources Management: A World Bank Policy Paper* 26, at 96 (1993).

[54] Thomas Friedman, Op-Ed, *Bring in the Green Cat*, N.Y. Times, November 15, 2006, at A27.

[55] *Id*.; *see also* Jim Yardley, Jake Hoover, & Lin Yang, *China's Path to Modernity, Mirrored in a Troubled River*, N.Y. Times, November 19, 2006, at 11 (reporting that the Yellow River, the source of water for 140 million people and already one of the mot polluted rivers in the world, is in danger of drying up).

Mexico

In Mexico – home to a population of 104 million that is projected to reach 150 million by the year 2050 – the demand for water is outstripping supply.[56] In some agricultural states, for example, the water table is falling by more than two meters per year. At the national level, 52 percent of all water extracted from underground is coming from aquifers that are being overpumped.[57]

India

India, now home to more than 1 billion people, is overdrawing aquifers in several key states, including the Punjab, home to India's breadbasket.[58] David Seckler, former head of the International Water Management Institute, estimates that aquifer depletion could reduce India's grain harvest by one fifth.[59] India is among the countries expected to fall into water stress before 2025, and is currently the second most populous country in the world.[60] Despite tremendous economic growth, "India's share of malnourished children remains among the worst in the world," with one in three children under the age of three clinically underweight.[61] Yet India is a

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[56] Lester Brown, *supra* note 3.

[57] *Id*.

[58] *Id*. (Other areas of India that have been significantly affected include Haryana, Gujarat, Rajasthan, Andhra Pradesh, and Tamil Nadu.).

[59] *Id*.

[60] China-Profile, Analyses: Tables, Figures, and Maps, Total Population (April 11, 2009), available at http://www.china-profile.com/data/fig_WPP2008_TotPop_Top20.htm, (last visited on November 20, 2009).

[61] Somini Sengupta, *India Prosperity Creates Paradox; Many Children Are Fat, Even More Are Famished*, N.Y Times, December 31, 2006, at 1.8; *see also* Somini Sengupta, *Even Amid Its*

net exporter of grains.[62] India is simultaneously experiencing a dramatic increase in food prices caused by inflation in its rapidly growing economy.[63]

Pakistan

Pakistan, a country with 140 million people and still growing by 4 million people per year, is also overpumping its aquifers. Similar to India, Pakistan's portion of the fertile Punjab plain is seeing a precipitous drop in the water table.[64]

United States

In the United States, the underground water table has dropped by more than 30 meters (100 feet) in parts of Texas, Oklahoma, and Kansas.[65] These areas represent key grain-producing states and will have a significant impact on agriculture and food production. In addition, almost 50% of United States waterways are polluted.[66] Such a water crisis in effect slashes the United States in two based upon the country's distribution of water. While "the

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Wealth, India Finds, Half Its Small Children Are Malnourished, N.Y. Times, January 10, 2007, at A7 (noting that among children under three, nearly half are clinically underweight).

[62] *See* Sengupta, *India Prosperity Creates Paradox*, *supra* note 61, at 1.8 (stating that India has long had a surplus of food grains).

[63] Keith Bradsher, *India Finds Its Economy on the Verge of Overheating*, N.Y. Times, February 10, 2007, at C1.

[64] Lester Brown, *supra* note 3 (Also at risk is the water table around the provincial capital of Quetta, which is falling by 3.5 meters per year. Richard Garstang, a water expert with the World Wildlife Fund, says that "within 15 years, Quetta will run out of water if the current consumption rate continues.").

[65] *Id*.

[66] World Bank, *supra* note 53, at 32.

United States' average daily precipitation equals 4.2 trillion gallons,…enough annual precipitation to cover the entire country to a depth of 30 inches,"[67] such numbers are misleading due to a disproportionate allocation of freshwater east of the Mississippi River. "About one-third of the United States, including most of the are west of the 100th Meridian (which passes through the Dakotas, Nebraska, Kansas, Oklahoma, and Texas), requires irrigation to sustain tilled agriculture.[68] Citizens of the East Coast enjoy vast quantities of water, while Mountain State and West Coast citizens often hover on the brink of water shortage and rely heavily on irrigation techniques. Drought is endemic to the American West and Southwest.[69]

Implications

Although many Americans remain unaware, the risk of water shortage is an increasingly important issue all around the world.[70] As the rest of the world becomes richer and populations continue to increase, heavier demands will be made on increasingly scarce water supplies.[71] Some countries have already made slight gains in raising irrigation efficiency and recycling wastewater, but the general response to water scarcity has been to build more dams or drill more wells. However, this "expanding the supply" model cannot last forever. The only other option is

[67] U.S. EPA Region 5 and Agricultural & Biological Engineering, Purdue University: Ground Water. Primer (1998), http://www.purdue.edu/dp/envirosoft/groundwater/src/supply.htm # budget (last visited November 21, 2009).

[68] William E. Warne, The Bureau of Reclamation 6 (Praeger Publishers 1973).

[69] *Risk-Based Decision Making in Water Resources VI* 165 (Yacov Y. Haimes, David A. Moser, & Eugene Z. Stakhiv eds., American Society of Civil Engineers 1994).

[70] John Vidal, *Cost of Water Shortage: Civil Unrest, Mass Migration and Economic Collapse*, Guardian Unlimited, August 17, 2006.

[71] *Id*.

to reduce demand by stabilizing the population and raising water productivity. With nearly all the 3 billion people that are projected to be added to the planet by 2050 being born in developing countries where water is already scarce, achieving an acceptable balance between water and people may now depend more on stabilizing population than on any other single action,[72] including raising water productivity.[73]

Pollution and disease is a grave concern that must be considered when discussing water scarcity. Deteriorating water quality is a critical problem in developing countries, where hundreds of millions of people lack access to clean drinking water and most sewage is discharged into surface waters without wastewater treatment.[74] In many developing countries, river pollution from raw sewage reached levels far higher than those determined safe for drinking and bathing. Without a sewage disposal system, Bangkok alone discharges an estimated 10,000 metric tons of raw sewage and municipal waste daily into rivers and canals.[75] In India, bathers, cremated corpses, and millions of tons of raw sewage pollute the waters of the Ganges.[76]

In addition to health concerns, water scarcity exacerbates pre-existing tensions and invites new ones. As populations grow and standards of living rise, raising demand for clean

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[72] Lester Brown, *supra* note 3.

[73] Although this approach has proven effective before. For example, after World War II, with population projected to double by 2000 and with little new land to devote to agriculture, the world raised a major effort to raise cropland productivity; as a result, cropland productivity nearly tripled between 1950 and 2000. This same type of effort can, and should, be dedicated to water productivity.

[74] Robin Clarke, *supra* note 23.

[75] World Resources Institute, *World Resources 1992-1993*, at 328, 329 (1992).

[76] John Ward Anderson, *The Great Cleanup of the Holy Ganges*, Washington Post, September 25, 1992, at A1, A28.

water with them, the intensity of competition over the world's finite and increasingly degraded water resources is likely to escalate, raising the probability of a violent conflict. This has been demonstrated before.[77] When water demarcates an international border, changes of land caused by erosion and sedimentation can cause controversy; when aquifers cross international borders, disputes often arise when one country either pumps the water, or interferes with the pumping, of another.

It is in the arid, water-scarce Middle East in which water has been the most significant source of tension, with relations between the countries in the Jordan River Basin marked by military conflict over its waters.[78]

> Since water is a scarce resource to every country in the region, access to enough water to meet the demands of households and economic sectors is a main concern for all governments involved. The demand for water is rising, due to population growth and economic development. Pressure on the natural resources is high, and Israel, Jordan and Palestine are already facing a situation where water consumption is close to or exeeding [sic] the renewable amount available.[79]

Hostilities among the nations in the Basin have been ongoing since the 1960's, with each nation competing for the available water resources. Palestinians continue to argue with Israelis over access to failing groundwater supplies in the aquifers; Israel depends on these aquifers for 25-40% of its water needs, and its Water Commission has strictly controlled Arab water use in the

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[77] Most notably in the Persian Gulf War, when Saddam Hussein directed his forces to dismantle the desalination plants of Kuwait, just as his opponents had targeted Baghdad's water and sanitation systems. Similarly, the United States bombed North Vietnamese irrigation systems in the late 1960's.

[78] The Jordan River basin is shared by 5 different countries: Lebanon, Syria, Jordan, Palestine and Israel. As a resource for freshwater it is vital for most of the population of Palestine, Israel and Jordan, and in a lesser extend for Lebanon and Syria.

[79] Waternet, *Jordan River Basin*, (2008), available at http://www.waternet.be/jordan_river/, (last visited November 27, 2009).

West bank since Israel captured the area in 1967.[80] Because they enjoy more generous water allocations, Jewish settlers consume, on a per capita basis, about four times as much water as West Bank Arabs.[81] Tensions will certainly intensify if Palestinians allege that deep wells which are dug for the Jewish settlers sap the yields of their own shallow wells.

As water scarcity increases, water allocation and distribution play an increasingly vital role. Economic theory shows that supply and demand are brought into equilibrium by price.[82] Scarcity is a restriction on supply. The price for scarce goods increases until demand comes into equilibrium with supply.[83] Water rights are the rights of an individual to use water from a given water source.[84] Therefore, as the scarcity of water increases, so does the value of water.[85] In turn, as the value of water increases, so too does the role and importance of water rights.[86]

Solutions

As evidenced by the oncoming water crisis demonstrated through this piece, the need for new water law is clear. Despite the emphasis placed on the differences between countries and regions of the world, some central principles will be found applicable to every water law. Any

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[80] Miriam Lowi, *West Bank Water Resources and the Resolution of Conflict in the Middle East*, 1 Occasional Paper Series 33, at 41-43 (1992).

[81] *Id*.

[82] GCSE Economics, *Demand and Supply: Price Equilibrium* (2006), http://www.tutor2u.net/economics/gcse/revision_notes/demand_supply_price_equilibrium.htm.

[83] Michael Lynn, *Scarcity's Enhancement of Desirability: The Role of Naïve Economic Theories*, 13 BAS. & APP. SOC. PSYC. 67 (1992).

[84] *Id.*

[85] *Id*.

[86] *Id*.

new water law must define its scope, the waters, the uses and the users it will cover. A modern water law should be comprehensive, remaining broad enough to apply to almost all situations and countries. This new water law should be overseen by an international organization that respects the preservation of existing uses while at the same time dictating appropriate future uses. This new water law must have as its central goal the achievement, or at the very least the promotion, of the efficient allocation of water resources – that combination of labor, capital, and effective long-term resource management which will produce the greatest net benefits.

> A water law must be designed to promote "comprehensive development" and achieve "efficient use of resources." But why? To increase the nation's welfare. For whom? The people who form that nation. How? By offering them opportunities and incentives to participate in that development and enjoy the fruits of that use.[87]

Perhaps countries around the world would be best served through an administrative allocation system, where some kind of authorization from the government is necessary before any public water can be used.[88] This authorization traditionally takes the form of a permit, which is short-term and easily revocable, or a concession, which grants long-term rights.[89] The main problems associated with the administrative allocation system, however, relate to which waters are considered public and which, if any, are considered private. Some states, such as Israel and the former Soviet Union, solved this problem by essentially declaring all water, in whatever

[87] Frank J. Trelease, *New Water Legislation: Drafting for Development, Efficient Allocation and Environmental Protection*, 12 LAND & WATER L. REV. 385, 429 (1977).

[88] Ludwick A. Teclaff, Abstraction and Use of Water: A Comparison of Legal Regimes, at 8, U.N. Doc. ST/ECA/154 (1972).

[89] *See id*.

form, to be public water.[90] Most countries have taken a more moderate approach that vests rights to the most important and easily usable water sources in the government, but allows certain minor water sources to remain private.[91] A key feature of this administrative system is the general permit requirement of beneficial use. Given the level of shortages we are seeing worldwide, statutes that specifically outline uses allowed may be needed.

To date, countries have forged more than 300 treaties to deal with specific international water issues and 2,000 treaties with at least some provisions related to water.[92] Most of these agreements adhere to the principle that one state may not significantly harm another through any actions it takes that affect an international watercourse.[93] The most common type of disputes are those between upstream water users[94] and downstream water users[95]. Agreements, though often

[90] *See id*. at 51-52 (discussing Israeli law); *see also* O.S. Kolbasov, Soviet System of Water Law, in Proceedings: International Conference on Global Water Systems 416, 419 (1976).

[91] For example, Spanish law limits private waters to flowing surface-waters that begin on private land for as long as they remain on such land, to standing water on private land, and to rainwater falling on private land. French law defines public streams as those that are navigable or have been deemed navigable; all other streams are private. Italian law claims as public water, belonging to the State, all water which is useful to the public interest. In South Africa, a stream is public if it has a permanent source and can be used in common; private streams are those that are not susceptible to use by more than one user.

[92] World Bank, *supra* note 53, at 38.

[93] *See* Stephen C. McCaffrey, *Water, Politics, and International Law*, in Water in Crisis: A Guide to the World's Fresh Water Resources 92-100 (Peter H. Gleick ed., 1993).

[94] These upstream water users traditionally claim sovereign rights to use, store, divert, or pollute the water that originates or flows through their territories.

[95] Downstream water users, on the other hand, traditionally want the water maintained in its natural state.

difficult to enforce, are possible.[96] These agreements and negotiations are most difficult when the upstream users see no benefit from the expense of curbing their use or pollution. Agreements have the best chance of success when there has been a continuous history of cooperation between the states, a mutual interest in ending the dispute, a scientific basis for action, or a mediating body[97]. The United States, as a developed and successful leader on the world stage, must make a significant push at this time to create awareness and address the impending problem of water shortage as applicable to the American West, the United States, and the world as a whole.[98]

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[96] For example, in the case of the Colorado River, the United States, as the upstream polluter, agreed to pay for the costs of providing Mexico, its downstream neighbor, with clean water; *see* Agreement Regarding the Problem of the Salinity of the Waters of the Colorado River, November 15, 1970, U.S.-Mexico 21U.S.T. 2478 (also referred to as the Colorado Salinity Agreement). In the case of the Rhine River, the Netherlands, a downstream country, agreed to pay part, although not all, of the cleanup costs; *see* International Commission for Protection of the Rhine Against Pollution, April 29, 1963, 994 U.N.T.S. 3 (entered into force May 1, 1965).

[97] The success of using a mediating body was demonstrated through the World Bank's nine year effort to facilitate the 1960 Indus Water Treaty between India and Pakistan, which resulted in the establishment of a successful international water agreement; *see* Indus Waters Treaty, April 1, 1960, India-Pakistan, 419 U.N.T.S. 125 (entered into force September 19, 1960); *see generally* Scott Barrett, *Conflict and Cooperation in Managing International Water Resources*, Policy Research Working Paper 1303, May 1994, at 12.

[98] Even though political forces have resulted in the division of the Earth into separate countries that have an abundance of some resources and a scarcity of others, the world has come together in times of global crisis and has dealt with these crises with varying degrees of success. When chlorofluorocarbons ("CFC's") were found to be a major reason for growing holes in the ozone layer over the polar ice caps, the world united to develop the Montreal Protocol which gradually phased out CFC's. *See* Montreal Protocol on Substances that Deplete the Ozone Layer, September 16, 1987, 26 I.L.M. 1541 (1987) (providing phase-in times for compliance). Over time, this effort proved to stabilize the depletion of the ozone layer and has been viewed as a success. Presently, emission of carbon dioxide into the atmosphere through the burning of fossil fuels has been found to be a major reason for increasing temperatures known as global warming. *See generally* Intergovernmental Panel on Climate Change, Climate Change 2001: Synthesis Report (2001), available at http://www.ipcc.ch/pub/un/syreng/spm.pdf (explaining anthropogenic impact on global warming). As a result, the world united to develop the Kyoto Protocol which created an intricate system to phase out the emission of carbon dioxide. *See* Kyoto Protocol to the United Nations Framework Convention on Climate Change, December 10, 1997, 37 I.L.M. 22, available at http://unfccc.int/essential_background/Kyoto_protocol/items/1678.php. Lack of

Recent history has shown that the American government will take action, unilateral if need be, when national security is threatened.[99] Adequate water supply should be included as part of America's national security agenda.

Any recommendation of increased government regulation is ambitious, but the large size of such a collective action problem[100] and the fact that water plays such an integral role in the survival of humanity makes the creation of further regulation necessary. Failure to address the issue of international water supply could have severe consequences like increased health problems, food and water shortages, competition between citizens for the right and use of water, competition between states and regions of countries, competition between countries for the right and use of water, and the like.[101] Federal legislation that creates a "Water Bureau" to enforce water guidelines and work in tandem with federal and state environmental agencies remains imperative.

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support from the United States coupled with the exemption of many developing nations have proven to be significant impediments to achieving success in phasing out emissions of carbon dioxide, as treaty signatories have not seen or felt leadership and feel as if they carry an undue burden. *See* U.S. Withdraws from Kyoto Protocol, Greenpeace USA, April 5, 2001, available at http://www.greenpeace.org/usa/news/u-s-withdraws-from-kyoto-prot. Thus, although there are many factors that go into the successful recognition, analysis, and solution to global collective action problems, one of the most significant is leadership from the United States in efforts that have been legitimized via scientific data.

[99] *See* Richard Falk, *The New Bush Doctrine*, The Nation, June 27, 2002 (discussing the Bush administration's doctrine of preemption).

[100] *See* Elinor Ostrom, International Food Policy Research Institute, *Collective Action and Property Rights for Sustainable Development* (2004) (discussing collective action problems and possible solutions).

[101] *Water Crisis Hits Rich Countries*, World Wildlife Federation, August 16, 2006, available at http://www.panda.org/downloads/rich_countries_poor_water_final_170706.pdf.

Conclusion

Impending global-scale changes in population and economic development over the next 25 years will dictate the future relation between water supply and demand to a much greater degree than will changes in mean climate. To secure a more complete picture of future water vulnerabilities, it will be necessary to consider interactions among climate change and variability, land surface and groundwater hydrology, water engineering, and human systems, including societal adaptations to water scarcity.[102] As stated in the United Nations World Water Development Report, "[There is] clear and convincing evidence that data on almost every subject related to water issues is usually lacking, unreliable, incomplete, or inconsistent."[103]

Pursuit of the goal of limiting water scarcity worldwide will be limited by outdated and nonexistent socioeconomic data and information from a progressively deteriorating global network of hydrometric monitoring stations[104] unless a commitment is made by the water sciences community to collect, standardize, and widely disseminate such information to governments and individuals. While there is no guarantee of public support, it seems clear that knowledge in the hands of everyday citizens could lead to the political force necessary to address water issues around the world.

Questions of food and water waste will become key concerns for international governments as they consider the management of material flows and redistributions of costs and benefits along their supply chains. An integrated approach bringing together the climate change,

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[102] *See* D. Conway, *et al*., *Ambio* 25, 336 (1996); *see also* K. M. Strzepek *et al.*, *World Water Scenarios: Analyses*, F. R. Rijsberman, Ed. (Earthscan, London, 2000), pp. 120-159.

[103] *Supra* note 13.

[104] J. C. Rodda, *Water: A Looming Crisis* (International Hydrological Program, United Nations Educational, Scientific, and Cultural Organization, Paris, 1998).

water resources, and socioeconomic communities appears essential to future progress. In 1966, American Congressman Jim Wright wrote that, "American can solve its water crisis before it becomes a widespread, irreversible famine – if we act with bold imagination, determined resolution, and a sufficient sense of urgency."[105] These words, applied now on an international level, still ring true today.

[105] Congressman Jim Wright, The Coming Water Famine 232, 234-35 (Coward-McCann, Inc. 1966).