

The Coming Freshwater Crisis is Already Here

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Introduction

Fresh Water Is A Critical Resource Issue

Fresh water is emerging as the most critical resource issue facing humanity. While the supply of fresh water is limited, both the world's population and demand for the resource continues to expand rapidly. As Janet Abramovitz has written: "Today, we withdraw water far faster than it can be recharged—unsustainably mining what was once a renewable resource" (Abramovitz, 1996). Abramovitz estimates that the amount of fresh water withdrawn for human uses has risen nearly 40-fold in the past 300 years, with over half of the increase coming since 1950 (Abramovitz, 1996).

The world's rapid population growth over the last century has been a major factor in increasing global water usage. But demand for water is also rising because of urbanization, economic development, and improved living standards. Between 1900 and 1995, for example, global water withdrawals increased by over six times—more than double the rate of population growth (Gleick, 1998). In developing countries, water withdrawals are rising more rapidly—by four percent to eight percent a year for the past decade—also because of rapid population growth and increasing demand per capita (Marcoux, 1994). Moreover, increasing pollution is shrinking the supply of fresh water even further. In many countries, lakes and rivers are used as receptacles for an assortment of wastes—including untreated or partially treated municipal sewage, industrial poisons, and harmful chemicals that leach into surface and ground water during agricultural activities.

Caught between (a) finite and increasingly polluted water supplies, and (b) rapidly rising demand from population growth and development, many developing countries face difficult and uneasy choices. As the World Bank has warned, lack of water is likely to be the major factor limiting economic development in the decades to come (Serageldin, 1995).

Population and Fresh Water

Population and water resources are closely connected. The availability of fresh water limits how many people an area can support, while population growth, urbanization, and migration all affect the availability and quality of water resources. Population growth increases demand for water for food production, household consumption, and industrial uses. At some point, however, this increased demand becomes overuse, leading to depletion and pollution of surface and groundwater supplies that can cause chronic water shortages. Scarce and degraded water supplies also often cause critical health problems. Polluted water, water shortages, and unsanitary living conditions kill over 12 million people a year (WHO, 1997) and cause a great deal of illness such as cholera, hepatitis A, amoebic dysentery, schistosomiasis, and dengue and malaria fevers. And this increasing competition for limited water supplies also causes social and political tensions. River basins and other

water bodies do not respect national borders: one country's use of upstream water often removes that water from use by downstream countries. There remains a real risk across the globe of escalating tension and perhaps conflict over access to freshwater supplies.

Slowing population growth, conserving water. In less than 30 years, 50 countries could face serious water shortages, affecting more than 3.3 billion people—40 percent of the projected global population (Gardner-Outlaw & Engleman, 1997). The world, especially water-scarce countries (those with less than 1,000 cubic meters per person per year) that are afflicted with rapid population growth, must slow the growth in demand for water by slowing population growth as soon as possible. Family-planning services will empower millions of couples to space and limit their births if they so desire.

At the same time, the world's "water profligacy" must end as soon as possible. Throughout the world, enormous amounts of water are wasted due to inappropriate agricultural subsidies, inefficient irrigation systems, imprudent pricing of municipal water, poor watershed management, pollution, and other practices. The world can no longer afford to waste its precious supplies of fresh water.

Freshwater Availability and Us

While 70 percent of the earth's surface is water, only three percent of it is fresh water—and almost all of that three percent is inaccessible for human use (Lean & Hinrichsen, 1994; Lefort, 1996). About three-quarters of all fresh water on earth is locked away in the form of ice caps and glaciers located in polar areas far from most human habitation. In all, only about 0.01 percent of the world's total water supply is considered available for human use on a regular basis. If the world's freshwater supply amounted to the contents of a bathtub, the amount easily accessible to humanity would fill a thimble.

Nevertheless, even this thimble full of water is, in theory, enough to sustain an estimated 20 billion people. But in reality, only a small amount of the freshwater supply is reliable enough to be considered accessible year after year. Globally, 505,000 cubic kilometers of renewable fresh water shifts from the sea to the land every year as rain or snow via the hydrological cycle; but only 47,000 cubic kilometers per year can be considered accessible for human use (Gleick, 2000).

Freshwater Distribution

The world's available fresh water supply is also distributed extremely unevenly around the globe. About three-quarters of global annual rainfall comes down in areas containing less than one-third of the world's population. More than half the global runoff occurs in Asia (31 percent) and South America (25 percent). *Runoff* is defined as water originating as precipitation on land that then runs off the land into rivers, streams, and lakes, eventually reaching the ocean, inland seas, or aquifers. That portion of the runoff that can be used year after year by human beings is known as *stable runoff* (Hinrichsen, Robey & Upadhyay, 1998). While North America has the most fresh water available (at over 19,000 cubic meters per capita as estimated in 1990), Asia has only 4,700 cubic meters of fresh water per capita (Population Reference Bureau, 1998). This disparity is a function both of differences in population density and available water resources.

About 80 percent of the world's water runoff is concentrated in northern and equatorial zones, which have relatively small populations. The Amazon Basin alone, a vast region with less than 10 million people, accounts for 20 percent of the global average runoff each year. In Africa, the Congo River and its tributaries account for 30 percent of the entire continent's annual runoff; but the Congo's area contains only 10 percent of Africa's population. Even more dramatic water disparities hold at the country level—ranging from 46,000 cubic meters per person in Brazil (much of it accounted for by the sparsely-

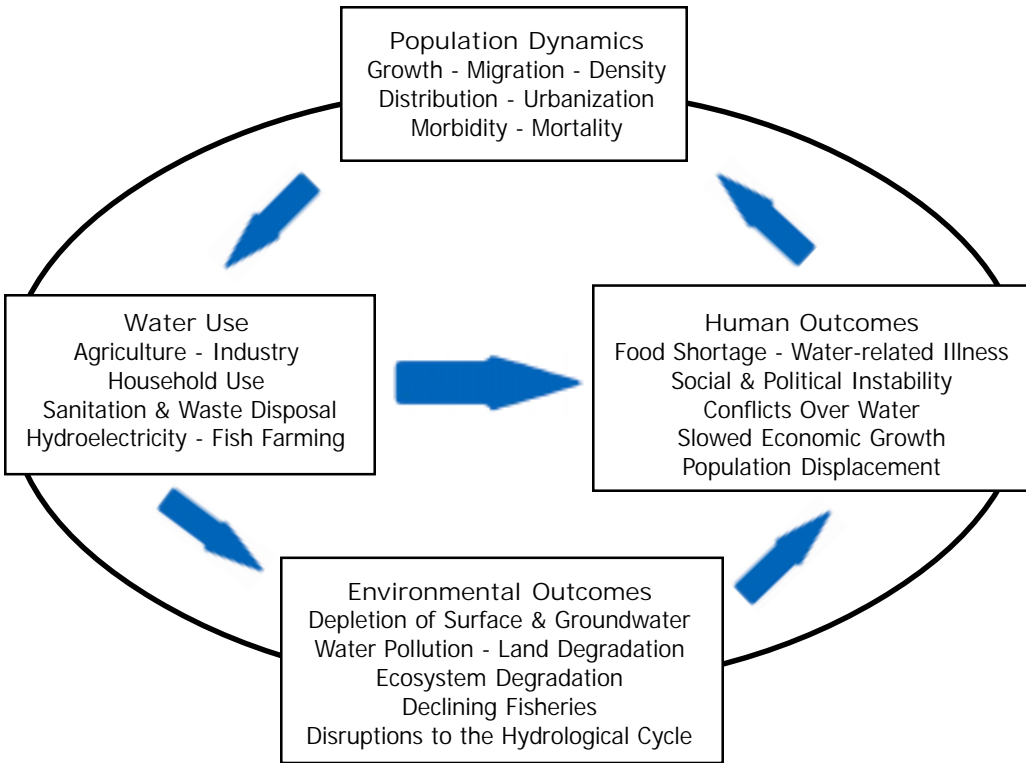
populated Amazon River Basin) to only 75 cubic meters per person in Kuwait (Gardner-Outlaw & Engelman, 1997). There are also striking differences in water availability within countries. In Mexico, for instance, less than 10 percent of the land area provides more than half of the national rainwater runoff every year. Despite the fact that 90 percent of Mexico is chronically water-short and arid, its total per capita water availability in 1990 was over 4,000 cubic meters. Such a figure is grossly misleading as a measure of actual

Map 1. The Philippines



Source: *The Times Atlas of the World* (1999)

Figure 1. Links Between Population and Fresh Water



Source: IUCN et al. (1996)

water availability for most Mexicans.

In addition, freshwater supplies throughout much of the developing world comes in the form of seasonal rains. Because rains often run off too quickly for efficient use (as during Asia's monsoons), some developing countries can use no more than 20 percent of their potentially available water resources. India, for instance, gets 90 percent of its rainfall during the summer monsoon season.

Altering Natural Supply Systems

Dams. As water-short societies have done for centuries, many countries attempt (a) to move water from where it occurs in nature to where people want it, and (b) to store water for future use. Dams have emerged over the last 50 years as the major strategy for such alteration. There are some 40,000 dams worldwide that are higher than 15 meters. India, for example, has come to rely increasingly on dams and impoundments to meet its water needs. By the year 2000, the Indian government had built over 4,000 large dams to store water from the monsoon season for use during the dry season (World Commission on Dams, 2000). But although dams insure a steady water supply, they often imperil aquatic ecosystems by disrupting flood cycles, blocking river channels, and altering water flows in rivers, floodplains, deltas, and other natural wetlands. In India, deforestation in watersheds has caused massive siltation of water reservoirs and reduced the lifespan of many hydroelectric dams and irrigation schemes.

Desalination. Some countries have so little fresh water available that they must resort to the costly conversion of sea water into fresh water. Without desalination, the Arab states of the Persian Gulf could not support a number anywhere close to their current populations. Without desalination, 40 Saudis would have to share the same amount

of water that is available to one Malaysian (about 14,000 cubic meters per year) (Gardner-Outlaw & Engelman, 1997). And Bahrain has virtually no fresh water at all; its population depends completely on desalination of seawater from the Gulf.

At present, desalination is far too expensive and impractical for widespread use. Despite falling prices—the costs of desalination are down to US\$1.00-to-\$1.60 per cubic meter—the technology is highly energy intensive and beyond the reach of most poor water-short countries, not to mention land-locked countries. Three oil-rich Arab states—Saudi Arabia, Kuwait, and the United Arab Emirates—accounted for close to half the world's 1993 desalination capacity (Gleick, 2000). These countries are, in effect, turning oil into water.

How Water is Used

People use water for agriculture, industry, and domestic (municipal) purposes. As population grows, requirements for basic personal use rise proportionately. Rising living standards, which bring such amenities as running water to homes, dramatically increase per capita water consumption. Increasing agricultural and industrial water consumption also reflects changing living standards. Agriculture dominates global water use, accounting for 69 percent of all annual withdrawals. Industry accounts for about 23 percent, followed by municipal (domestic) consumption at 8 percent (Engelman & LeRoy, 1993; European Schoolbooks, 1994).

But global averages conceal important regional and national differences in the way water is used. In Asia, for example, a higher percentage of water withdrawal (86 percent) goes for agriculture, while industry accounts for 8 percent and domestic use just 6 percent. (India uses 90 percent of all water withdrawals for agricultural purposes). In Africa, 88 percent of water withdrawals go for agriculture, 7 percent for domestic purposes, and 5 percent for industry. In contrast, most of Europe's water use (54 percent) is for industry, while agriculture accounts for 33 percent and domestic use 13 percent (European Schoolbooks, 1994). As these regional statistics suggest, developing countries devote most of their water supplies to agriculture.

A Future of Scarcity

Years of rapid population growth and increasing per capita consumption have squeezed the world's freshwater resources. As global population has grown to nearly 6.1 billion today (and continues to grow by about 78 million people each year), the demand for fresh water in some areas exceeds nature's capacity to provide it. A growing number of countries are expected to face water shortages in the near future—shortages that will be fueled by problems both on the demand side (notably rapid population growth) and on the supply side (mainly inadequate water supplies and poor policies).

Declining Water Availability Per Capita

There is no more water on earth now than there was 2,000 years ago, when the population was less than 3 percent of its current size. Fresh water's per capita availability, which has been falling for centuries, has been dropping more precipitously in recent years as the globe's population growth has exploded. Unsurprisingly, the availability of fresh water has also fallen, from 17,000 cubic meters per person in 1950 to 7,044 cubic meters in 2000 (World Resources, 2000). The supply of fresh water per capita is one-third lower now than it was as recently as 1970, a direct result of the nearly 2 billion people added to the planet since.

While population growth rates are slowing in most developing countries, absolute numbers of people added each year remain near historic highs. As a result of projected

population growth, global per capita availability of fresh water is likely to be no more than 5,100 cubic meters in the year 2025 (Gardner-Outlaw & Engelman, 1997). China and India, the world's first and second most populous countries, respectively, provide examples of how even modest population growth rates can translate into large absolute numbers because of an already-enormous population base. China's population growth rate in 2000 was only 0.9 percent—but, with China's total population at over 1.2 billion, even this small growth rate translates into an additional 12 million people each year. Similarly, India's population growth rate of about 1.8 percent means that about 18 million people a year will be added to its current population of one billion. The world's annual population growth of 78 million a year (as of 2000) implies an increased demand for fresh water on the order of 64 billion cubic meters a year—an amount equivalent to the entire annual flow rate of the Rhine River, assuming countries continue to withdraw water at current rates (Clarke, 1991). And, as noted above, rapid population growth not only makes it increasingly difficult to provide adequate supplies of fresh water; it can also strain resources for proper sanitation, housing, health care, education, employment, and food supplies.

Rising Demand for Fresh Water

But as rapid population growth shrinks per-capita water availability, per-capita water demand is rising as countries develop economically. Global withdrawals of water have grown dramatically because of factors such as (a) the growth of industrial uses, (b) rising demand for domestic purposes, and (c) increasing reliance on irrigation to produce food.

As countries develop, water use soars. Consider the United States: while the average American in 1900 withdrew just 10 cubic meters of water a year for personal and household use, that figure had jumped by 1994 to an average of over 200 cubic meters a year (European Schoolbooks, 1994). Why? A century ago, most Americans used well water or public standpipes. Running water was largely unavailable to households except in big cities, while most people lived in rural areas. Today, of course, virtually every American—rural or urban—has running water.

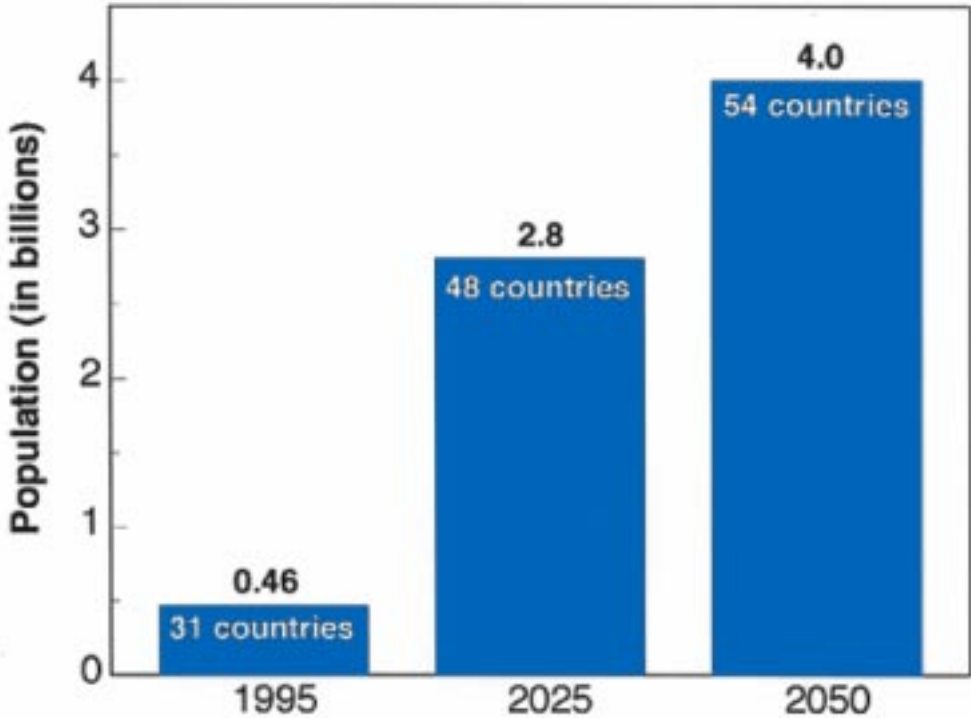
But developing regions today still use far less water per capita than do developed regions. In Africa, for example, annual water withdrawals average only 17 cubic meters of water per capita; in Asia, the figure is 31 cubic meters (Clarke, 1991). Household use in developing countries is especially scarce. Water use by either developing-country agriculture or developed-country households far exceeds household water use in many developing countries—reflecting the difficulty many people have in obtaining clean water for personal use. Most people in developing countries get their water from a public standpipe, a community well, rivers and lakes, or rain collected from roof runoff. Running water is still a rare commodity in developing rural areas.

This pattern is changing dramatically, however, as developing countries become predominately urban and individual households gain access to piped water through city water systems. As cities grow ever larger, their demand for water increases substantially. Such demand growth is putting tremendous pressure on urban water supply systems, most of which are totally inadequate to meet such demand.

Between 1950 and 1980, for instance, Latin American cities such as Bogota, Mexico City, Sao Paulo, and Managua tripled and even quadrupled their populations. Some African cities (such as Nairobi, Dar es Salaam, Lagos, and Kinshasa) grew sevenfold. This explosive growth, the result of a rural exodus, is making the world predominately urban. In the 1990s, Third World cities have had to cope with around 60 million new arrivals every year (UNCHS, 2001).

Figure 2. Water Scarcity and Stress

Population in Water-Scarce and Water-Stressed Countries, 1995-2050



Source: Abramovitz (1996)

The Era of Water Shortages

Hydrologists consider a country to be under *water stress* when its annual water supplies drop to between 1,000 and 1,700 cubic meters per person. In turn, countries face *water scarcity* when their annual water supplies drop below 1,000 cubic meters per person. Once a country enters the water-scarce category, it faces severe constraints on food production, economic development, and protection of natural ecosystems.

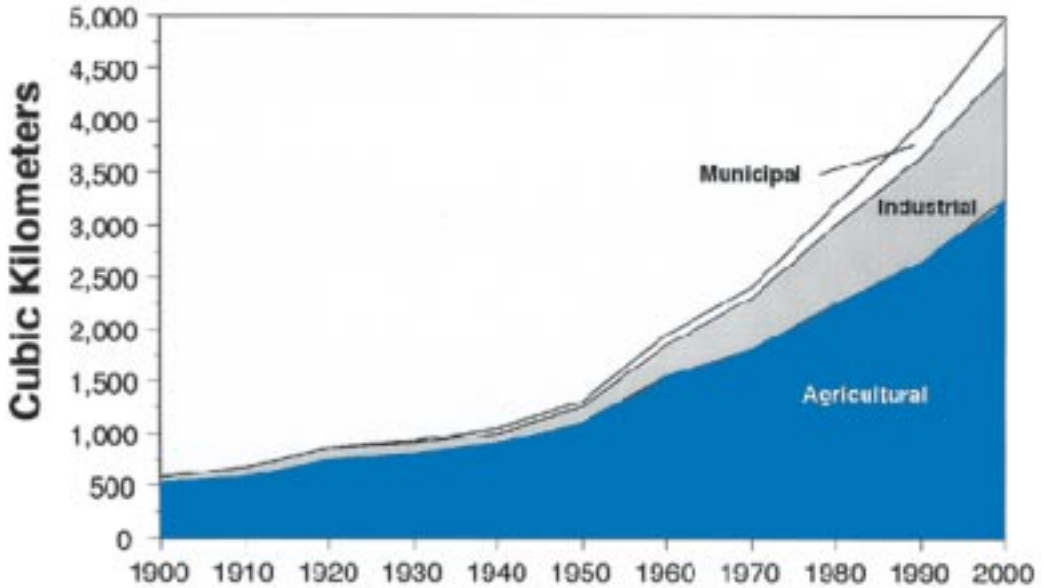
More and more countries are facing water stress and scarcity as their populations grow, urbanization accelerates, and water consumption increases. Thirty-one countries (with a combined population of close to half a billion) faced water stress or scarcity as of 1995. The number of people estimated to live in water-short countries increased by nearly 125 million between 1990 and 1995 (see Table 1).

By 2025, 50 countries and more than 3.3 billion people will face water stress or scarcity. By 2050, the number of countries afflicted with water stress or scarcity will rise to 54, and their populations to 4 billion people—40 percent of the projected global population of 9.4 billion. The majority of these countries—40 of them—are in the Near East, North Africa, and sub-Saharan Africa (see Figure 3) (Gardner-Outlaw & Engelman, 1997; UNFPA, 1997).

It is no coincidence that nearly all countries with looming water shortages also suffer from rapid population growth rates. The population in sub-Saharan Africa is growing, on average, by 2.5 percent a year. Populations in the Near East and North Africa are expanding by two percent a year.

The Near East and North Africa. The 20 countries of the Near East and North Africa region face the worst prospects. Annual per-capita water availability in the region already has fallen to only 1,250 cubic meters—60 percent less water per-capita than in

Figure 3. Rising Water Use
Global Annual Water Withdrawal by Sector, 1900-2000



Source: Abramovitz (1996)

1960. By 2025, per-capita supplies in this region are projected to fall almost 50 percent to 650 cubic meters (Gardner-Outlaw & Engelman, 1997).

According to Tony Allan of the University of London, in 1972 the entire Near East “ran out of water” (i.e., the region was using more water than could be replenished every year from rainfall, in effect mining its aquifers down). At the time, the region’s total population was only 122 million (Mitchell, 1998). Since then, the Near East has continued to withdraw more water from its rivers and aquifers every year than it replenishes (Mitchell, 1998). Jordan and Yemen currently withdraw 30 percent more water from ground water aquifers every year than they replenish. Israel’s annual water use already exceeds its renewable supply by 15 percent, or some 300 million cubic meters. And Saudi Arabia represents one of the worst cases of unsustainable water use in the world. This extremely arid country, squeezed between the Red Sea and the Arabian Gulf, now mines a non-renewable resource (fossil ground water) for three-quarters of its water needs. It takes tens of thousands of years for these deep aquifers to replenish themselves, while ground water depletion currently averages around 5.2 billion cubic meters a year and is expected to keep on increasing well into this century.

Nine out of 14 countries in the Near East also already confront water scarcity, making the Near East the most water-short region in the world. Worse, populations in six Near Eastern countries are expected to double within two decades. Water is one of the major political issues confronting the region’s leaders. Since virtually all rivers in the Near East are shared by several nations, current tensions over water rights could escalate into outright conflicts.

Sub-Saharan Africa. Much of Africa also faces serious water constraints. In 2000, 250 million people in Africa were living in water-stressed countries—150 million of them in water-scarce countries. And because of rapid population growth, this problem will worsen over the next two decades. By the year 2025, as many as 1.1 billion people—two-thirds of the region’s projected population—will live under conditions of water scarcity (Falkenmark, 1994).

Southeast Asia. In densely populated Asia, home to 60 percent of the world’s people, water resources are in critical shape—especially in Southeast Asia. As elsewhere,

the booming population has intensified water usage. In Vietnam, for instance, increasing population has reduced per capita water volume: from 14,520 cubic meters in 1945 to only 4,840 cubic meters in 2000. Experts contend that, although Asia is relatively well-endowed with water resources, many of the continent's countries will in the near future experience water shortages for all or part of the year (Asian Development Bank, 1999). Currently, Asia's per capita water resources are only slightly above half the world's average. In terms of water resources per person, the groups of the Indian subcontinent, Eastern Asia, and the Far East have the lowest figures, while Southeast Asia has much more water per person than the world average (see Table 2) (Facon, 2000).

But total water availability is a grossly misleading statistic, and some Asian countries are already feeling the thirst. In Malaysia, for instance, rapid population growth and a better standard of living over the last three decades have resulted in a heavy demand for water (Malaysian Water Partnership, 2000). The problem of population growth is felt particularly in urban areas because of rural-urban migration and the rapid urbanization of surrounding countryside. The exponential growth in the world's urban population has stretched many governments' ability to provide the infrastructure and service needs as well as the necessary environmental conditions for a better living.

The Kuala Lumpur-based Malaysian Water Partnership asserts that the increased demand for a limited and diminishing supply of clean water in Malaysia has led to competition for water there—and that the country's continued economic growth will magnify this problem even more acutely (Malaysian Water Partnership, 2000). In addition, as the readily-available portion of Malaysia's water resources has already been developed for use in practically all regions of the country experiencing high-water demand, future water-resources development there will require the construction of more storage dams. Such dams are costly, both financially and environmentally.

This recent development worries Singapore, which imports water from neighboring countries (particularly Malaysia). Since attaining its independence in 1963, Singapore has seen its water consumption increased 10-fold. The Philippines is also a major consumer of water (see Box 1). Faucet water flows from the Philippine city of Cebu average 19 hours daily, and Metro Manila average 17—high numbers compared with six hours in Indonesia's Bandung or New Dehli's mere four hours. Region-wide, the average number of hours of water supplied per day is only 11.4 hours.

In Asia as a whole, competition among water users is also increasing. Almost 84 percent of the water withdrawal in the region is used for agricultural purposes, compared to 71 percent for the world. The Indian subcontinent (92 percent) and Eastern Asia (77 percent) have the world's highest level of regional water withdrawal for agriculture (World Resources Report, 1998). The two regions together represent about 82 percent of the total irrigated area in Asia.

More and more water is demanded from all sectors. In Malaysia, for instance, the annual water demand for the domestic and industrial sectors has been expanding at the rate of 12 percent due to the rapid population increase and the rapid growth of industries. By 2020, the domestic and industrial sectors are expected to be the main water users in the country (Malaysian Water Partnership, 2000). This is also true in Thailand, the Philippines, and other Asian countries.

As noted above, global water demand is increasing for various reasons such as population growth and expansion of industrial and municipal services. At the same time, in recent years, many areas face water shortage for some economic activities (especially agriculture) as well as domestic water during their dry season.

Water problems within countries. Regions and states of many large countries (such as India, China, and the United States) could also join the water-stressed category. Already, 19 major Indian cities face chronic water shortages, and India as a whole is

expected to enter the water-stressed category by 2030 (Gardner-Outlaw & Engelman, 1997). China, which has 22 percent of the world's population but only seven percent of all freshwater runoff, will be just above the 1,700 cubic meters per capita line that designates "water-stress." And United States groundwater reserves are also being depleted in many areas. According to researchers David and Marcia Pimentel, the United States' "mammoth groundwater aquifers are being mined at an alarming rate" (Pimentel et al., 1997). The amount of ground water withdrawn in the United States is currently 25 percent greater than its replenishment rate. The western half of the country is depleting groundwater aquifers at even faster rates in some areas (such as parts of the huge Ogallala aquifer that lies under parts of six states).

Box 1. Water Crisis: The Case of the Philippines

The Philippines is a country where diarrhea remains a leading killer of children, where water-borne diseases are more common than sanitary toilets, and where farmers cannot water their own crops. Experts prescribed one possible solution to these problems: access to potable water for all 80 million residents of the country. If the Philippine government could only supply its population with sufficient and clean water, it could trigger a chain reaction of major successes in improving the country's health and well-being (Gorecho, 1998, p. 21).

But the stark reality is that clean and accessible water remains an elusive commodity for the Philippines. In the 1950s, according to Dr. Rafael D. Guerrero III, executive director of the Philippine Council for Aquatic and Marine Research and Development, the Philippines had as much as 9,600 cubic meters of clean water per person. Four decades later, the citizens must make do with little more than a third of that volume—3,300 cubic meters of water per capita (Rafael Guerrero, personal communication, 2000). "The image of a water-rich Philippines is a mirage," declares Gregory C. Ira, former head of the Water Equity in the Lifescape and Landscape Study (WELLS) of the International Institute of Rural Reconstruction (Gregory C. Ira, personal communication, 2000). "There is a water crisis in the Philippines, one of the wettest countries of Southeast Asia."

The water crisis is more transparent in metro Manila, home to more than 10 million people. Residents of the middle-class Better Living Subdivision on the southern flank of the metropolis consider themselves lucky to have water from the Metropolitan Waterworks and Sewerage System (MWSS), touted as the "first modern water system in Asia." No matter that the water flows from their faucets for just a few hours per day, and only every other day (Maniquis, 1996). Up until the mid-1980s, residents had to make do with water from pump wells and delivery services. The water still had to be boiled for drinking. Residents often drove to work with car trunks full of water containers to be filled.

For people in the lower-income neighborhoods around the subdivision who do not have service from MWSS, pushcart vendors are still the main source of water. And they pay the vendors much more for water than their neighbors in Better Living pay for water from the faucet. The situation is even worse in Manila's poor Tondo district, where residents in one area have to take a boat ride just to get water (Maniquis, 1996).

For poor people in Manila, the price of water is exorbitant. For example, water costs the family of Winnie Madera, a resident of Cainta, Metro Manila, US\$20 per month—or 7 percent of the couple's total income of US\$300 (Asian Development Bank, 1999). Madera used to pay US\$12.50 per month for a metered piped supply

from a deep tubewell operated by a private contractor. However, the supply was only for one hour twice a day. She paid another US\$7.50 per month for drinking water purchased by the container from another contractor. The source was purported to be from the concessionaire's piped supply. In 1999, however, there was trouble with both sources of water at the same time. The deep tubewell closed down due to pump problems. Diarrhea and typhoid broke out in Madera's neighborhood, and one of her sons had to be hospitalized.

In areas where water still springs in the Philippines, that water is often polluted and contaminated. The country's water is supplied by rainfall along with rivers, lakes, springs, and groundwater. But changing weather patterns worldwide have affected the Philippines as well: rainfall is growing scarcer, and what falls is collected or wasted in watersheds with balding forests. As a result, there has been a dramatic drop of from 30 to 50 percent in the country's available stable water resources in the past three decades (Rafael Guerrero, personal communication, 2000).

A recent report released by the Philippines Department of Environment and Natural Resources (DENR) said that 90 percent of the 99 watershed areas in the country are "hydrologically critical" (Langit, 1996) due to their degraded physical condition. Massive destruction of the once-productive forested watersheds by illegal loggers and uncontrolled land use from mining, overgrazing, agricultural expansion, and industrialization have contributed to water depletion (Environmental Management Bureau, 1996).

Worse, excessive soil erosion is hastening the destruction of watershed areas. The DENR report stated that 36 of the country's 75 provinces are severely affected by soil erosion. Two provinces—Cebu and Batangas—have lost more than 80 percent of their topsoil to erosion. In Luzon, the four major basins (Bicol, Magat, Pampanga, and Agno) are in critical condition due to acute soil erosion and sedimentation (Public Affairs Staff, Manila Department of Environment and Natural Resources, personal communication, 1998).

River pollution also contributes to the country's current water problem. Another DENR report classifies 37 of the 418 rivers in the Philippines as polluted, while the rest are slightly polluted. Eleven rivers are considered "biologically dead." Fifty-two percent of the country's water pollution load is attributable to domestic wastes, while industry accounts for 48 percent.

There is more bad news. Water levels in the Philippines' major freshwater sources have been dropping at the rate of 50 percent over the past 20 years. Excessive pumping of ground water has caused water depletion and consequent decline in water levels (Tacio, 1994). In less than 20 years, water levels in wells have dropped from an average of 20 meters below land surface to more than 120 meters in some areas, particularly in the industrialized areas of Paranaque and Taguig (both in metro Manila). As a result, wells that used to yield one to two cubic meters per minute can now barely produce more than 0.3 cubic meters per minute.

The problem confronting the country's water supply will also dry up agriculture, which accounts for 86 percent of the country's total water use. During the 1997-1998 El Nino climate phenomenon, water ordinarily used to irrigate farmlands in Candaba, Pampanga was diverted for household use, resulting in the destruction of 17,000 hectares of rice land.

The forthcoming water crisis in the Philippines will likewise cause industry to grind to a halt. Commercial and industrial users consume up to eight percent of the

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national water supply. Only the balance of six percent remains for domestic or municipal use. But that relatively smaller portion carries with it heavier implications for the country's health (Department of Environment and Natural Resources, 1998).

Currently, only 63 percent of the country's total population has access to safe water. Almost 30 percent of households in the Philippines do not have sanitary toilets. This gives rise to a host of health problems, from waterborne diseases to the persistence of diarrhea as a leading killer of children in the country (Environmental Management Bureau, 1996). In November 2000, 1,500 people were brought to overflowing hospitals and clinics in Zamboanga City after drinking water contaminated with rota virus and *E. coli*. Two children were reported dead (Agence France Presse, 2000).

What is the government of the Philippines doing to solve the problem of water shortage? In 1974, it created the National Water Resources Board (NWRB), an authoritative national organization that coordinates and integrates all activities in water resources development and management. It has also passed several water laws and regulations and created various organizations to oversee particular bodies of water like the Laguna Lake Development Authority (LLDA) and the Agno River Basin Development Commission. Likewise, the government foresees that, by 2025, "water of sufficient quantity and acceptable quality are in place for all stakeholders with provisions for water-related disasters so as to meet present and future needs" (National Water Resources Board, 2000, page 12). During the national consultation on water-sector mapping and visioning, participants forwarded this vision: "By the year 2025, water resources in the Philippines are being used efficiently, allocated equitably and managed sustainably" (National Water Resources Board, 2000, page 12).

Meanwhile, at the home of Rosa Andal in the poverty-stricken Sapu Masla village in the southern part of Mindanao, there is no water: the tap has long been dry. She must get up in the dark of night and, laden with plastic pails, walk for three kilometers to fetch water from a river. "Nobody does anything," Andal laments. "Politicians come, make promises, take votes and go. What else can the government claim to do when it cannot even provide a glass of clean drinking water for my children?" (Rosa Andal, personal communication, 2000)

Competition for Scarce Water Supplies

In developed and developing countries alike, fierce competition among water users is rising as people demand more and more from limited water resources. Tensions are particularly severe in places that face population pressures, rapid urbanization, and urgent development needs.

A number of developed, water-short countries—including Belgium, the United Kingdom, Poland, and Singapore—have faced tensions over water. The western United States has witnessed tension between (a) farmers with irrigation needs, and (b) urban areas with municipal demands. San Diego, California is a classic case, but the city negotiated a landmark deal with vegetable growers in the Imperial Valley. The farmers now conserve water and sell the surplus to the city (Purdum, 1997).

China is already practising what many water experts call the "zero-sum game" of water management. The zero sum game—when authorities increase water supply to one user by taking it away from another—involves both competing areas and competing types of use, as when cities compete with farmers or when human needs compete with those of ecosystems. China's freshwater supplies have been estimated to be capable of supporting 650 million people sustainably—only half of the country's current population of

1.2 billion (Qu Geping, personal communication, 1993). Across northern and central China some 300 major cities, including Beijing, face critical shortages. There is simply not enough water to meet the competing needs of the country's cities, industries, and agriculture. China has depleted underground aquifers and dammed, diverted, and drained surface waters. The water table under China's capital has dropped by roughly two meters a year for the last decade. One-third of the wells dried up because the pipes no longer reach the shrinking aquifer (Brown & Halweil, 1998). As the influx of China's rural farm workers seeking urban jobs grows ever larger, Beijing's water shortages are expected to worsen. The government is planning a huge aqueduct that will ferry water from the Danjiangkou Reservoir in Henan Province to Beijing, across 1,300 kilometers of heavily farmed agricultural land—land that also needs the water for food production.

China's Yellow River is a classic case of the zero-sum game in operation. The river is so over-subscribed that, for an average of 70 days a year for the past decade, its waters have dried up before reaching the Bohai Sea. In 1995, this dry period lasted for 122 days. In May 1996, one of the few years when farming villages near the river's mouth could take water to feed their crops, the government told them not to touch a drop. Instead, all of the water went to a state-owned oil field further downstream, bypassing hundreds of parched farms and factories along a 400-kilometer stretch of the river (Tyler, 1996).

India faces similar strains over water. In the last few years, India's states have become embroiled in disputes over water rights and dams that might provide more water for one state at the expense of another. According to Mohan Katarki, a lawyer who represented the Indian state of Karnataka in a dispute with its neighboring state Andhra Pradesh: "Water disputes, if not attended to, will become a major headache for the stability of Indian society" (Patel, 1997, p. 12). Karnataka and Andhra Pradesh are arguing in court over the height of a dam on the Krishna River. Andhra Pradesh, which lies downstream of the dam, claims that the dam's top five meters could rob it of water that it is entitled to under a 1976 water tribunal decision. Karnataka counters that the extra height will be used for generating power, not for irrigation (Patel, 1997).

Regional tensions. Regional tensions over limited water supplies are an emerging issue in nearly all water-short areas. For example, 54 of Africa's rivers are shared by two or more countries, and the region has one-third of the world's major international river basins. The Nile, Zambezi, Niger, and Volta River Basins all have the potential to ignite serious disputes.

The Aral Sea Basin is already beset by mounting international tensions over limited supplies of water. Turkmenistan, Uzbekistan, Kazakstan, Kyrgyzstan, and Tajikistan depend on the waters of the Amu Darya and Syr Darya Rivers for their very survival. But these countries find themselves increasingly at odds over the division of the rivers' waters. The water demands of all five nations are sparking disputes. Kyrgyz and Uzbeks disagree over water and land in the fertile Fergana Valley, while Kyrgyz and Tajiks argue over the allocation of irrigation water from the Syr Darya. In addition, Turkmens and Uzbeks cannot agree on the distribution of irrigation and drainage water from the Amu Darya (Postel, 1996b). Worse, in most years neither the Syr Darya nor the Amu Darya reaches the Aral Sea. The flow of both rivers, wholly diverted to feed water-intensive crops such as cotton and rice, now disappears in the desert about 100 kilometers from their former deltas.

Many other rivers are also becoming flash points for interstate disputes. The Colorado River, which flows through the southwestern United States and fed the explosive growth of Phoenix and other southwestern desert cities, is now so depleted from constantly escalating irrigation and urban demands that its waters no longer reach the Gulf of California. Instead, it trickles out somewhere in the desert south of the U.S.-Mexican border, and is now a constant source of bickering between the United States and its downstream neighbor (Postel, 1996b).

Ecosystems and Pollution

In 1996, the world's human population used an estimated 54 percent of all the fresh water contained in rivers, lakes, and aquifers (Postel et al., 1996). This percentage is conservatively projected (merely using population growth estimates) to climb to at least 70 percent by 2025. The figure will be more if per capita consumption continues to rise (Postel et al., 1996). By the year 2025, when the world is expected to have about eight billion people, more than 70 percent of all accessible fresh water could be used by humanity (Postel et al., 1996).

Endangered Ecosystems

Homo sapiens, of course, is not the only species that needs nature's supply of fresh water. A substantial portion of the total fresh water available in the hydrological cycle is needed to sustain natural aquatic ecosystems—marshes, rivers, coastal wetlands—and the millions of species they contain. Thus, as humankind uses a growing share of all water, less remains to maintain vital ecosystems. Of the world's 734 species of endangered fish in 1996, 84 percent are found in freshwater environments. Globally, over 20 percent of all freshwater fishes are endangered, vulnerable, or recently extinct (Brautigam, 1999).

Natural, healthy ecosystems are indispensable regulators of water quality and quantity. Flood-plain wetlands store water when rivers flood their banks, reducing downstream damage. The value of these services can be considerable. New York City, for example, recently invested several billion dollars to conserve and protect water catchment areas in upstate New York—the source of the city's drinking water. The alternative was to spend \$7 billion on water treatment facilities (Revkin, 1997).

The world has few examples of successful ecosystem management. Instead, careless overuse of water resources is harming the environment in virtually all regions of the world:

- Diverting water from the Nile River, along with build-up of sediments trapped behind dams and barrages, has caused the fertile Nile Delta in Egypt to shrink. Some 30 out of 47 commercial species of the river's fish have either become extinct or virtually extinct. Delta fisheries that once supported over a million people have been wiped out (Abramovitz, 1996).
- Lake Chad, in Africa's Sahel region, has shrunk in area by 75 percent—from 25,000 square km to just 2,000 square km—in the last three decades, not only because of periodic droughts but also because of massive diversions of water for irrigated agriculture. The lake's once rich fisheries have collapsed entirely (Abramovitz, 1996).
- Despite cleanup efforts, the Rhine River, which runs through the industrial heartland of Western Europe, has lost 8 of its 44 species of fish. Another 25 are rare or endangered (Abramovitz, 1996).
- In Colombia, fish production in the Magdalena River has plunged from 72,000 metric tons in 1977 to 23,000 metric tons by 1992—a two-thirds drop in 15 years. The main causes have been pollution from agriculture and urban and industrial development, plus deforestation in the river's watershed (Abramovitz, 1996).
- Southeast Asia's Mekong River has had a two-thirds drop in fisheries production due to dams, deforestation, and conversion of 1,000 square kilometers of mangrove swamps into rice paddies and fish ponds (Abramovitz, 1996).
- In the United States, California has lost over 90 percent of its wetlands, and nearly two-thirds of the state's native fish are extinct, endangered, threatened, or in decline. Also, in most years the Colorado River completely dries up before reaching its once rich and thriving delta in the Gulf of California. The delta that once supported thousands of

wetland species of plants and animals is now desiccated and dead (Postel, 1997).

Water Pollution

Water pollution has become a major problem for both developed and developing countries. When coupled with the enormous quantities of water withdrawn for human use, water pollution has reduced the capacity of waterways to assimilate or flush pollutants from the hydrological system.

Water engineers like to say that “the solution to pollution is dilution.” In today’s world of mounting pollution, this saying has taken on new and frightening connotations. Roughly 450 cubic km of wastewater are discharged globally into rivers, streams, and lakes every year. Another 6,000 cubic km of clean water are needed to dilute and transport this dirty water before it can be used again (Shiklomanov, 1997). This amount equals about two-thirds of the world’s total available runoff. Hydrologist M. I. L’Vovich has estimated that, if current trends continue, the world’s entire stable river flow would soon be needed for pollutant transport and dilution (FAO, 1990).

Industrialized countries. Industrialized countries in Europe and North America face enormous water pollution problems. Over 90 percent of Europe’s rivers have elevated nitrate concentrations, mostly from agrochemicals; and five percent have concentrations 200 times greater than background levels found in unpolluted rivers (WHO, 1992). Over half of Europe’s lakes are eutrophied, the result of a glut of nutrients from agriculture and municipalities (WHO, 1992). Excess nutrients stimulate the growth of algae, which rob the water of oxygen when they die and decay. This process—known as eutrophication—has become one of the most serious problems affecting freshwater and near-shore marine environments.

Groundwater pollution in Europe is also worsening. Within 50 years, some 60,000 square km of groundwater aquifers in Western and Central Europe are likely to be contaminated with poisons from pesticides and fertilizers (Niemczynowicz, 1996). Of Hungary’s 1,600 well-fields tapping groundwater, 600 of them are contaminated, mostly with agricultural chemicals (Havas-Szilagyi, 1998). In the Czech Republic, 70 percent of all surface waters are heavily polluted, mostly with municipal and industrial wastes (Nash, 1993). A full 30 percent of the country’s rivers are so fouled with pollutants that they can no longer sustain fish. And in the United States, 40 percent of all surface waters are unfit for bathing or fishing, while 48 percent of all lakes are eutrophied (EPA, 1994; WHO, 1997).

Developing countries. Pollution is a vexing problem wherever populations are growing rapidly, development demands are great, and governments cannot afford to invest in proper sanitation and waste treatment facilities. In developing countries on average, 90 to 95 percent of all domestic sewage and 75 percent of all industrial waste on average is discharged into surface waters without any treatment whatsoever (Carty, 1991).

Consider the following examples:

- All of India’s 14 major rivers are badly polluted. Together they transport 50 million cubic meters of untreated sewage into India’s coastal waters every year. India’s capital, New Delhi, dumps 200 million liters of raw sewage and 20 million liters of industrial wastes into the Yamuna River every day as it passes through the city on its way to the Ganges (Harrison, 1992).
- Thailand and Malaysia have such heavy water pollution that their rivers often contain 30 to 100 times more pathogens, heavy metals, and poisons from industry and agriculture than government standards permit (Niemczynowicz, 1996).
- Fully 80 percent of China’s 50,000 km of major rivers are so filled with pollution and

sediment that they can no longer support fish life. In 1992, China's industries discharged 36 billion metric tons of untreated or partially treated effluents into rivers, streams, and coastal waters. In 1986, sections of the Liao River, which flows through a heavily industrialized part of northern China, died as a result of the over one billion tons of industrial wastes dumped into it. Nearly every aquatic organism within one hundred km died (Hinrichsen, 1998).

- The Tiete River, which passes through Greater Sao Paulo, Brazil, receives 300 metric tons of untreated effluents from 1,200 industries every day. The river contains high concentrations of heavy metals, such as lead and cadmium. The city also dumps some 1,000 metric tons of sewage a day into its waters. Only 12 percent of the sewage receives any treatment (WHO, 1992).
- The Tunjuelito River, a tributary of the Bogota River, is nearly biologically dead from all the industrial wastes from tanneries and petrochemical industries flushed into it as it passes through Bogota, Colombia.

Industrial and municipal pollutants. Recent decades have seen an enormous increase in pollution of many kinds from industry and municipalities. Industrial pollutants (such as wastes from chemical plants) are often dumped directly into waterways. Oils and salts are washed off city streets, while others (such as heavy metals and organochlorines) are leached from municipal and industrial dumpsites.

Secondary pollutants such as sulfur dioxide and oxides of nitrogen combine in the atmosphere to form acid rain, with pervasive effects on both freshwater and terrestrial ecosystems. Acid rain lowers the pH of rivers and streams. Unless buffered by calcium (i.e., limestone), acidified waters cause many acid-sensitive fish, like salmon and trout, to



In developing countries on average, 90-95 percent of all domestic sewage and 75 percent of all industrial waste is discharged into surface waters without any treatment whatsoever.

die off. Once in soil, acids can release heavy metals, such as lead, mercury, and cadmium, which can then percolate into watercourses.

Some of the worst pollutants are synthetic chemicals. More than 700 chemicals have been detected in drinking water in the United States alone; 129 of them are considered highly toxic. Some 70,000 different chemical substances are in regular use throughout the world. Every year around 1,000 new compounds are introduced into the market (World Resources Report, 1987).

A number of these pollutants, particularly halogenated hydrocarbons and organochlorines (such as DDT and PCBs), are long-lived and highly toxic in the environment. They do not break down under natural processes and thus tend to bio-accumulate up the food chain, where they pose risks to human health. For example, Beluga whales swimming in the highly polluted St. Lawrence Seaway (which connects the Atlantic Ocean to North America's Great Lakes) have such high levels of PCBs in their blubber that, under Canadian law, they qualify as "toxic waste dumps." Indigenous communities that once hunted these cetaceans had to stop because of the health risks (Pullen & Hurst, 1993).

Agricultural pollution. Agricultural activity is the world's largest polluter. In virtually every country where farmers use them, agricultural fertilizers and pesticides have contaminated groundwater aquifers and surface waters. What little water trickles back into rivers and streams after irrigation is often severely degraded by excess nutrients, higher salinity, more pathogens, more sediments, and less dissolved oxygen.

Water quality standards lacking. Pollution is pervasive throughout the world. Few developing or industrialized countries have paid adequate attention to safeguarding water quality and to controlling water pollution. Many countries do not have standards to control water pollution adequately, nor do they have the capacity to enforce existing pollution standards. Increasingly, international development agencies such as the World Bank are urging developing countries to devote more attention and funds to improving water quality. But the developed world must also spend more money on cleaning up its degraded waterways. Without clean water, future economic development will stall.

Policy Options

1. The Population Imperative

Over the next two decades, projected population increases alone will push most African countries and all of the Near East into water scarcity—that is, having less than 1,000 cubic meters of fresh water available per capita per year. To prevent this projection from becoming a reality, the world must stabilize population growth as soon as possible. At the same time, everyone—the international community as well as national and local governments—needs to manage water better and to take broad-scale conservation measures.

Nearly three-quarters of the world's people live in developing countries, and the developing world also accounts for over 90 percent of population growth. At current fertility rates, populations in sub-Saharan Africa, the Middle East, and parts of South Asia will double in 20 to 40 years. At projected growth rates, by the year 2050 the global population is expected to be 9.4 billion, of which 8 billion will live in developing countries (UN Population Division, 2001).

The world likely will be unable to stretch freshwater resources to accommodate another three billion people, which makes a water crisis nearly inevitable. Thus, a comprehensive water-management strategy must include efforts to slow population growth. Stretching limited supplies to serve more people is only part of the equation; bringing down birth rates will relieve pressure on the demand side of the water equation. As part of this strategy, family-planning and reproductive health services must be extended. In

the developing world, at least 100 million married women (and millions more unmarried women) who want to plan, limit, or space their births do not currently use contraception. This unmet need would account for about one-third of the projected population increase in developing countries over the next half century. Thus, providing family-planning services to these women should be an urgent concern.

Providing better reproductive health care will also help improve people's ability to manage limited supplies of water. Studies have found that a person's ability to manage natural resources, particularly water and land, depends in part on his or her level of education and overall health status (Robey et al., 1992).

In much of the developing world, where piped water is unavailable, women and female children usually have the job of fetching water. UNICEF estimates that they spend 40 billion hours a year fetching water, which often requires walking half a kilometer or more to the nearest source of fresh water (UNICEF, 1997). Giving women more choices about childbearing, improving education, and providing opportunities to participate in development conveys many benefits, including improved household hygiene. But no amount of education can compensate for lack of adequate clean water supplies.

2. The Need For New Policies


Without better policies for managing scarce water resources, the prospect of conflict becomes greater. As Swedish hydrologist Malin Falkenmark has admonished: "We have to stop living as if we had unlimited water supplies and start recognizing that we must deal with serious water constraints" (Falkenmark, 1991). In Falkenmark's view, the relevant question to ask about water is not how much water do we need and from where do we get it, but rather how much water there is and how can we best benefit from it.

Ismail Serageldin, vice president for environmentally sustainable development at the World Bank, cites four principal policy failures underscoring the world's general inability to manage water supplies sustainably (Serageldin, 1995):

- First, water management is "fragmented among sectors and institutions." Governments make few efforts to develop an integrated response to water management. Instead, too many ministries and agencies continue to hold their fingers on the tap, with no one coordinating sectoral water policies. Worse, issues of water quality and health often go unaddressed since they do not fall within the mandate of any one government entity.
- Second, there is a "heavy dependence on centralized administration to develop, operate and maintain water systems." In many countries, agencies charged with managing water supplies are often overextended and lack the technical competence needed for the tasks confronting them. At the same time, governments do not involve stakeholders in setting water policies and regulating use. Water projects often do not meet consumers' needs.
- Third, most countries "do not treat water as an economic good." It is not valued properly, and many heavy water-users (such as farmers) do not pay for the amount of water they use. Instead, they rely on government subsidies and often waste enormous quantities of water by growing water-intensive crops in areas better suited to dryland farming. Unfortunately, governments find it easier to develop new water supplies than compel users of large water quantities to pay for the water they actually use.
- Fourth, and perhaps most serious, current water-management policies neglect to link the quality of water to human health, the environment, and the quality of life. Water resources are degraded nearly everywhere. In Poland, for instance, three-quarters of the country's river water is too polluted even for industrial use. In India,

a country highly dependent on irrigated agriculture for food supplies, farmers have abandoned more than four million hectares of high quality land because of salinization and waterlogging.

The world's failure to manage water adequately has spilled over into land and coastal management, affecting many other economic sectors and disrupting natural ecosystem functions on a massive scale.

The world needs nothing less than a Blue Revolution—a more comprehensive approach to water management that takes account of the needs of various users and apportions water accordingly. But water needs to be managed sustainably for the benefit of all, not treated solely as a free commodity. Water must be regarded and managed as a vital resource basic for all development. In short, we need water managers to take the broad perspective. Managing supplies without regard for reducing demand will simply aggravate the trends described above and result in a deepening water crisis, ultimately affecting everyone and everything on this blue planet. 

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(References continued on page 26)

Table 1. Growing Water Shortages

Population Size and Growth and Renewable Freshwater Availability in Water-Short Countries, 1995 and 2025

Country	Population 1995 (millions)	Water Per Capita^a	Population 2025 (millions)	Water Per Capita 2025^a	TFR 1998	% Pop. Growth Rate 1998
Water Scarcity in 1995 and/or 2025						
Algeria	28.1	527	47.3	313	4.4	2.4
Bahrain	0.6	161	0.9	104	3.2	2.0
Barbados	0.3	192	0.9	169	1.7	0.5
Burundi	6.1	594	12.3	292	6.6	2.5
Cape Verde	0.4	777	0.7	442	5.3	2.9
Comoros	0.6	<i>1,667</i>	1.3	760	5.1	2.7
Cyprus	0.7	<i>1,208</i>	1.0	947	2.1	0.7
Egypt	62.1	936	95.8	607	3.6	2.2
Ethiopia	56.4	1,905	136.3	807	7.0	2.5
Haiti	7.1	<i>1,544</i>	12.5	879	4.8	2.1
Iran	68.4	1,719	128.5	916	3.0	1.8
Israel	5.5	389	8.0	270	2.9	1.5
Jordan	5.4	318	11.9	144	4.4	2.5
Kenya	27.2	<i>1,112</i>	50.2	602	4.5	2.0
Kuwait	1.7	95	2.9	55	3.2	2.3
Libya	5.4	111	12.9	47	6.3	3.7
Malawi	9.7	1,933	20.4	917	5.9	1.7
Malta	0.4	82	0.4	71	2.1	0.6
Morocco	26.5	<i>1,131</i>	39.9	751	3.3	1.8
Oman	2.2	874	6.5	295	7.1	3.9
Qatar	0.5	91	0.8	64	4.1	1.7
Rwanda	5.2	<i>1,215</i>	13.0	485	6.0	2.1
Saudi Arabia	18.3	249	42.4	107	6.4	3.1
Singapore	3.3	180	4.2	142	1.7	1.1
Somalia	9.5	<i>1,422</i>	23.7	570	7.0	3.2
South Africa	41.5	<i>1,206</i>	71.6	698	3.3	1.6

Country	Population 1995 (millions)	Water Per Capita^a	Population 2025 (millions)	Water Per Capita 2025^a	TFR 1998	% Pop. Growth Rate 1998
Tunisia	9.0	434	13.5	288	3.2	1.9
United Arab Emirates	2.2	902	3.3	604	4.9	2.2
Yemen	15.0	346	39.6	131	7.3	3.3
Water Stress in 1995 and/or 2025						
Afghanistan	19.7	2,543	45.3	<i>1,105</i>	6.1	2.5
Belgium	10.1	<i>1,234</i>	10.3	<i>1,217</i>	1.6	0.1
Burkina Faso	10.5	2,672	23.5	<i>1,194</i>	6.9	2.9
Eritrea	3.2	2,775	6.5	<i>1,353</i>	6.1	3.0
Ghana	17.3	3,068	36.3	<i>1,464</i>	5.5	2.9
India	929.0	2,244	1,330.2	<i>1,567</i>	3.4	1.9
Lebanon	3.0	1,854	4.4	<i>1,261</i>	2.3	1.6
Lesotho	2.0	2,565	4.0	<i>1,290</i>	4.3	2.1
Mauritius	1.1	1,970	1.5	<i>1,485</i>	2.0	1.0
Niger	9.2	3,552	22.4	<i>1,452</i>	7.4	3.4
Nigeria	111.7	2,506	238.4	<i>1,175</i>	6.5	3.0
Peru	23.5	<i>1,700</i>	35.5	<i>1,126</i>	3.5	2.2
Poland	38.6	<i>1,458</i>	40.0	<i>1,406</i>	1.6	0.1
South Korea	44.9	<i>1,472</i>	52.5	<i>1,258</i>	1.7	1.0
Tanzania	30.7	2,964	62.4	<i>1,425</i>	5.7	2.5
Togo	4.1	2,938	8.8	<i>1,370</i>	6.8	3.6
Uganda	19.7	3,352	45.0	<i>1,467</i>	6.9	2.7
United Kingdom	58.1	<i>1,222</i>	59.5	<i>1,193</i>	1.7	0.2
Zimbabwe	11.2	1,787	19.3	<i>1,034</i>	4.4	1.5

Water-stressed countries are those with annual water resources of between 1,000 and 1,700 cubic meters per person, shown in *italic*. Countries suffering from water scarcity are those with annual supplies of less than 1,000 cubic meters per person, shown in **dark type**.

TFR = Total Fertility Rate

^aIn cubic meters per year

Source: Gardner-Outlaw & Engelman, (1997). Gardner-Outlaw and Engelman base their calculations on UN Population Division population estimates. The growth rate and TFR data come from Population Reference Bureau (1998).

Table 2. Renewable Water Resources in Asia

Country	Population (1996)	Precipitation (mm)	Internal*	
			million m ³	m ³ per inhab (1996)
<i>(Formula)</i>	(1)	(2)	(3)	(4)=3*10 ⁸ /(1)
Bangladesh	120,073,000	2,320	105,000	874
Bhutan	1,812,000	4,000	95,000	52,428
Brunei	300,000	2,654	8,500	28,333
Cambodia	10,273,000	1,463	120,570	11,737
China	1,238,270,000	648	2,812,000	2,271
India	944,580,000	1,170	1,260,540	1,334
Indonesia	200,453,000	2,700	2,838,00	14,158
Japan	125,351,000	1,728	430,000	3,430
Korea, DPR	22,466,00	1,054	67,000	2,982
Korea, Rep.	45,314,920	1,274	64,850	1,431
Lao, DPR	5,035,000	1,600	190,420	37,782
Malaysia	20,581,000	3,000	580,000	28,183
Maldives	263,000	1,883	30	114
Mongolia	2,515,000	251	34,800	13,837
Myanmar	45,922,000	2,341	880,600	19,176
Nepal	22,021,000	1,500	198,200	9,000
Papua New Guinea	4,400,000	3,500	801,000	182,045
Philippines	69,283,000	2,373	479,000	6,914
Sri Lanka	18,100,000	2,000	50,000	2,762
Thailand	58,703,000	1,485	210,000	3,577
Vietnam	75,181,000	1,960	366,500	4,875

* *Internal*: Originating within a country.

** *External*: Originating outside a country.

Country				External Dependency Ratio (%)
	External **	Total		
	million m ³	million m ³	m ³ per inhab (1996)	
	(5)	(6)=(3)+(5)	(7)=(6)*10 ⁸ /1	(5)/(6)
Bangladesh	1,105,644	1,210,644	10,083	91.3
Bhutan	0	95,000	52,428	0.0
Brunei	0	8,500	28,333	0.0
Cambodia	355,540	476,110	46,346	74.7
China	17,169	2,829,569	2,285	0.6
India	647,220	1,907,760	2,020	33.9
Indonesia	0	2,838,000	14,158	0.0
Japan	0	430,000	3,430	0.0
Korea, DPR	10,135	77,135	3,433	13.1
Korea, Rep.	4,850	69,700	1,538	7.0
Lao, DPR	146,130	331,550	66,181	42.9
Malaysia	0	580,000	28,183	0.0
Maldives	0	30	114	0.0
Mongolia	0	34,800	13,837	0.0
Myanmar	165,001	1,045,601	22,769	15.8
Nepal	12,000	210,200	9,545	5.7
Papua New Guinea	0	801,000	182,045	0.0
Philippines	0	479,000	6,914	0.0
Sri Lanka	0	50,000	2,762	0.0
Thailand	199,944	409,944	6,983	48.8
Vietnam	524,710	891,210	11,854	58.9

Source: Facon (2000).

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